DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Office of Federal Housing Enterprise Oversight

12 CFR Part 1750

RIN 2550–AA02

Risk-Based Capital

AGENCY: Office of Federal Housing Enterprise Oversight, HUD.

ACTION: Notice of proposed rulemaking.

SUMMARY: The Office of Federal Housing Enterprise Oversight (OFHEO) is directed by the Federal Housing Enterprises Financial Safety and Soundness Act of 1992 to develop a risk-based capital regulation for Freddie Mac and Fannie Mae (collectively, the Enterprises). The regulation specifies the risk-based capital stress test that will determine the amount of capital an Enterprise is required to hold to maintain positive capital throughout a ten-year period of economic stress. The results of the risk-based capital stress test will be used to determine each Enterprise's risk-based capital requirements and, along with the minimum capital requirement, to determine each Enterprise's capital classification for purposes of possible supervisory action.

This Notice of Proposed Rulemaking is the second of two notices of proposed rulemaking pertaining to the risk-based capital regulation, both of which respond to comments received on the Advance Notice of Proposed Rulemaking. The first Notice of Proposed Rulemaking describes the methodology and rationale OFHEO used to identify the proposed benchmark loss experience, which is used to determine Enterprise credit losses during the stress test, and proposes the use of OFHEO's House Price Index in the stress test. The second Notice of Proposed Rulemaking specifies the interest rate risk and other components of the stress test, as well as the overall structure of the test.

DATES: Comments regarding this NPR must be received in writing on or before August 11, 1999.

ADDRESSES: Send written comments to Anne E. Dewey, General Counsel, Office of General Counsel, Office of Federal Housing Enterprise Oversight, 1700 G Street, NW., Fourth Floor, Washington, D.C. 20552. Written comments may also be sent by electronic mail at RegComments@OFHEO.gov.

FOR FURTHER INFORMATION CONTACT: Patrick J. Lawler, Director of Policy Analysis and Chief Economist; David J. Pearl, Director, Office of Research, Analysis and Capital Standards; or Gary L. Norton, Deputy General Counsel, Office of General Counsel, Office of Federal Housing Enterprise Oversight, 1700 G Street, NW., Fourth Floor, Washington, D.C. 20552, telephone (202) 414–3800 (not a toll-free number). The telephone number for the Telecommunications Device for the Deaf is (800) 877–8339.

SUPPLEMENTARY INFORMATION: The Supplementary Information is organized according to this table of contents:

I. Introduction

A. Background

The Office of Federal Housing Enterprise Oversight (OFHEO) was established by title XIII of the Housing and Community Development Act of 1992, Pub. L. No. 102–550, known as the Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (1992 Act). OFHEO is an independent office within the U.S. Department of Housing and Urban Development (HUD) with responsibility for ensuring that the Federal Home Loan Mortgage Corporation (Freddie Mac) and the Federal National Mortgage Association (Fannie Mae) (collectively, the Enterprises) are adequately capitalized and operating in a safe and sound manner. Included among the express statutory authorities of OFHEO's Director (the Director) is the authority to issue regulations establishing minimum and risk-based capital standards.[1]

Fannie Mae and Freddie Mac are Government-sponsored Enterprises with important public purposes.[2] These include providing liquidity to the residential mortgage market and increasing the availability of mortgage credit benefiting low-and moderate-income families and areas that are underserved by lending institutions. The Enterprises engage in two principal businesses: investing in residential mortgages and guaranteeing securities backed by residential mortgages. The securities the Enterprises guarantee and the debt instruments they issue are not backed by the full faith and credit of the United States and nothing in this document should be construed otherwise.[3] Yet financial markets accord the Enterprises' securities preferential treatment relative to securities issued by potentially higher-capitalized, fully private, but otherwise comparable firms. The market prices for Enterprise debt and mortgage-backed securities, and the fact that the market does not require that those securities be rated by a national rating agency, suggest that investors perceive that the government implicitly guarantees those securities. This perception evidently arises from the public purposes of the Enterprises, their Congressional charters, their potential direct access to U.S. Department of Treasury (Treasury) funds, and the statutory exemptions of their debt and mortgage-backed securities (MBS) from otherwise mandatory investor protection provisions.[4]

Congress created OFHEO as the safety and soundness regulator of the Enterprises to reduce their risk of failure. Although each Enterprise at the time had experienced profitability and sustained growth, Congress determined that there was a need for a strong and independent regulator to promote the capital adequacy of the Enterprises. This determination was grounded in the recognition of many factors, including (1) the important public purpose served by the Enterprises in the secondary market for residential mortgages, and (2) the Enterprises' important role in providing access to mortgage credit in central cities, rural regions, and underserved areas.

Another important factor leading to OFHEO's creation was the recognition that the Enterprises are largely insulated from private market discipline relative to fully private firms. This insulation results from the apparent investor perception of an implied guarantee, and is best exemplified by the market's acceptance of Fannie Mae securities in the early 1980s and the Farm Credit System's securities in the mid-1980s when these GSEs were experiencing financial difficulties. The absence of normal market discipline on risk-taking is a strong argument for effective government regulation, including capital regulation.

Congress was also concerned about the serious disruptions to the nation's housing markets that could result from an Enterprise's failure. In introducing legislation in the House of Representatives, then House Banking Committee Chairman Henry Gonzalez noted that—

> The savings and loan crisis and the large losses incurred by the Federal Government to resolve the crisis, raises concerns about the scope of other potential liabilities of the United States, including the liabilities of Fannie Mae, Freddie Mac, and the [Federal Home Loan] banks. These entities are privately owned federally chartered enterprises established to meet certain credit needs. Together they have more than $800 billion in mortgage-related liabilities.[5]

In expressing his view that the legislation did not go far enough to ensure the Enterprises' safety and soundness, then Ranking Minority Member Jim Leach stated that—

> If there is a singular lesson of the 1980's, it is that prudential capital ratios are critical not only for providing a cushion between an institution's liabilities and the taxpayer's pocket book, but they ground institutional decision-making in less risky behavior. Where there is minimal private capital at risk there is always an inordinate incentive to bet the bank on speculative investments or interest rate moves. And perhaps most consequently, capital ratios determine constraints on growth. If institutions are allowed 50 or 100 to 1 leveraging, as occurred so recently in the thrift industry, imprudent or conflict driven decision making can too quickly cause disproportionate growth in certain institutions, industries and parts of the country, with the taxpayer on the line for management stupidity, foul play or bad luck.
>
> Fortunately, both GSEs are well run today. Fannie, in particular has been a major market winner as the cost of funds has declined with more restrained levels of inflation. But Congress must understand that if interest rates had gone up rather than down in the 1980's, Fannie Mae would be the single largest institutional liability the U.S. government would ever have been forced to oversee.[6]

Similarly, the Senate Report[7] stated that—

> Past performance indicates that [the risks of an Enterprise's failure] are not just hypothetical. While both GSEs are currently very prosperous, HUD estimated in a 1986 report to Congress, that Fannie Mae was insolvent on a marked-to-market basis at year-end 1978 and did not return to solvency until 1985. Its negative net worth reached a peak of more than $20 billion in 1981, which was roughly 20 percent of its outstanding liabilities. Its recovery owed partly to improved management, but also, in considerable measure to fortuitous declines in interest rates.[8]

Because of Congress' concerns, OFHEO was established as the safety and soundness regulator of Fannie Mae and Freddie Mac. OFHEO is responsible for conducting examinations to ensure the Enterprises' safety and soundness and establishing and enforcing compliance with two types of capital

[1] 1992 Act, section 1313(b)(1) (12 U.S.C. 4513(b)(1)).

[2] 1992 Act, sections 1331–38 (12 U.S.C. 4561–67, 4562 *note*).

[3] *See,* Federal Home Loan Mortgage Corporation Act, section 306(h)(2) (12 U.S.C. 1455(h)(2)); Federal National Mortgage Association Charter Act, section 304(b) (12 U.S.C. 1719(b)); and 1992 Act, section 1302(4) (12 U.S.C. 4501(4)).

[4] *See, e.g.,* 12 U.S.C. 24 (authorizing unlimited investment by national banks in obligations of or issued by the Enterprises); 12 U.S.C. 1455(g), 1719(d), 1723(c) (exempting securities from oversight from Federal regulators); 15 U.S.C. 77r–1(a) (preempting State law that would treat Enterprise securities differently from obligations of the United States for investment purposes); 15 U.S.C. 77r–1(c) (exempting Enterprise securities from State blue sky laws).

[5] Comments by Rep. Gonzalez upon introducing H.R. 2900, 137 Cong. Rec. H5497 (July 16, 1991).

[6] Dissenting views of Rep. Leach, *Government-Sponsored Housing Enterprises Financial Safety and Soundness Act of 1991,* H.R. Rep. No. 102–206 on H.R. 2900, at 114 (1991) (House Report).

[7] *Federal Housing Enterprises Regulatory Reform Act of 1992,* S. Rep. No. 102–282 (1992) (Senate Report).

[8] S. Rep. No. 102–282, at 10 (1992).

standards required by the 1992 Act. The first is the minimum capital standard.[9] Using this standard, which is based on a set of leverage ratios, OFHEO has classified each Enterprise's capital position every quarter since OFHEO's inception. After initially using an interim procedure, OFHEO published a rule regarding minimum capital, which incorporates a more careful evaluation of the credit risks associated with swaps and other off-balance sheet obligations.[10] The resulting standard is comparable in its construction to the risk-based capital standards of other financial institution regulators.

The second capital standard required by the 1992 Act is the risk-based capital standard. This standard requires each Enterprise to hold sufficient capital to survive a ten-year period characterized by adverse credit losses and large movements in interest rates, plus an additional amount to cover management and operations risk.[11] The level of capital [12] required under this standard for an Enterprise will reflect that Enterprise's specific risk profile at the beginning of each quarter for which the stress test will be run.

The risk-based standard is an essential component of the safety and soundness regulation of the Enterprises. Without the risk-based standard, an Enterprise might adopt risk positions of sufficient magnitude to make a capital level that just meets the minimum standard inadequate for maintaining a safe and sound financial condition.

However, the risk-based standard cannot, by itself, ensure sufficient capital to meet all contingencies. While the interest rate and credit stresses that are incorporated in the stress test, as specified by statute, are historically unprecedented, future economic environments may be even more adverse. Additionally, the nature of actual future stresses may differ from the precise stresses incorporated in the model. Furthermore, the model contains factors such as mortgage default and prepayment rates that are based on historical experience and therefore may be less adverse than those actually occurring in future economic environments. Similarly, the consequences of risks other than interest rate and credit risks may also prove more serious than the fixed proportional amount allowed for management and operations risk.

In addition to the risk-based standard, there is a minimum capital standard, which requires that in the absence of large measurable risks, the Enterprise maintain a minimally acceptable level of capital. Complementing the two capital standards are OFHEO's examination and enforcement authorities, which provide the knowledge and authority necessary to require prudent management practices in all environments. All of these regulatory mechanisms operate in tandem to promote the safety and soundness of the Enterprises.

B. Statutory Requirements for Risk-Based Capital

The 1992 Act requires that OFHEO, by regulation, establish a risk-based capital test (known as the stress test) which, when applied to an Enterprise, shall determine that amount of total capital for the Enterprise that is sufficient for the Enterprise to maintain positive capital during the stress period. The 1992 Act also provides that, in order to meet its risk-based capital standard, each Enterprise is required to maintain an additional 30 percent of this amount to protect against management and operations risk.[13]

The 1992 Act requires that the stress test subject each Enterprise to large credit losses on mortgages it owns or guarantees. The frequency and severity of those losses must be reasonably related to the highest rates of default and severity of mortgage losses experienced during a period of at least two consecutive years in contiguous areas of the United States that together contain at least five percent of the total U.S. population.[14] OFHEO is required to identify what it has characterized as the ''benchmark loss experience'' that resulted in the highest loss rate.[15] In this context, default and severity behavior means the frequency, timing, and severity of losses on mortgage loans, given the specific characteristics of those loans and the economic circumstances affecting those losses.

The 1992 Act also prescribes two interest rate scenarios, one with rates falling and the other with rates rising.[16] The risk-based capital amount is based on whichever scenario would require more capital for the Enterprise. In prescribing the two scenarios, the 1992 Act describes the path of the ten-year constant maturity yield (CMT) for each scenario and directs OFHEO to establish the yields on Treasury instruments of other maturities in a manner reasonably related to historical experience and judged reasonable by the Director.

In the falling or down-rate scenario, the ten-year CMT decreases during the first year of the stress period and then remains constant at the lesser of (a) 600 basis points below the average yield during the nine months preceding the stress period or (b) 60 percent of the average yield during the three years preceding the stress period. However, the 1992 Act limits the decrease in yield to 50 percent of the average yield in the nine months preceding the stress period.[17]

In the rising or up-rate scenario, the ten-year CMT increases during the first year of the stress period and then remains constant at the greater of (a) 600 basis points above the average yield during the nine months preceding the stress period or (b) 160 percent of the average yield during the three years preceding the stress period. However, the 1992 Act limits the increase in yield to 175 percent of the average yield over the nine months preceding the stress period.[18] The 1992 Act recognizes that interest rates can affect credit risk, specifically requiring that credit losses be adjusted for a correspondingly higher rate of general price inflation if

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[9] 1992 Act, section 1362 (12 U.S.C. 4612).

[10] 12 CFR 1750.4; see Minimum Capital, Final Rule, 61 FR 35607, July 8, 1996.

[11] 1992 Act, section 1361 (12 U.S.C. 4611).

[12] For purposes of the risk-based capital standard, the term ''capital'' means ''total capital'' as defined under section 1303(18) of the 1992 Act (12 U.S.C. 4502(18)) to mean the sum of the following:

(A) The core capital of the enterprise;

(B) A general allowance for foreclosure losses, which—

(i) shall include an allowance for portfolio mortgage losses, an allowance for nonreimbursable foreclosure costs on government claims, and an allowance for liabilities reflected on the balance sheet for the enterprise for estimated foreclosure losses on mortgage-backed securities; and

(ii) shall not include any reserves of the enterprise made or held against specific assets.

(C) Any other amounts from sources of funds available to absorb losses incurred by the enterprise, that the Director by regulation determines are appropriate to include in determining total capital.

The term ''core capital'' is defined under section 1303(4) of the 1992 Act (12 U.S.C. 4502(4)) to mean the sum of the following (as determined in accordance with generally accepted accounting principles):

(A) The par or stated value of outstanding common stock.

(B) The par or stated value of outstanding perpetual, noncumulative preferred stock.

(C) Paid-in capital.

(D) Retained earnings.

The core capital of an enterprise shall not include any amounts that the enterprise could be required to pay, at the option of investors, to retire capital instruments.

[13] 1992 Act, section 1361(c)(2) (12 U.S.C. 4611(c)(2)).

[14] 1992 Act, section 1361(a)(1) (12 U.S.C. 4611(a)(1)).

[15] In this document, the word ''benchmark,'' when used as an adjective or a noun, refers to the benchmark loss experience.

[16] 1992 Act, section 1361(a)(2) (12 U.S.C. 4611(a)(2)).

[17] 1992 Act, section 1361(a)(2)(B) (12 U.S.C. 4611(a)(2)(B)).

[18] 1992 Act, section 1361(a)(2)(C) (12 U.S.C. 4611(a)(2)(C)).

application of the stress test produces an increase of more than 50 percent in the ten-year CMT.[19]

The Act requires that the stress test take into account distinctions among mortgage product types and differences in seasoning. It may also take into account any other factors that the Director deems appropriate. The 1992 Act does not require a specific adjustment for any of these factors, allowing the Director to determine how best to account for them. Likewise, the 1992 Act requires the Director to determine losses and gains on Enterprise activities not specifically addressed, and all other characteristics of the stress test not explicitly defined in the 1992 Act, on the basis of available information, in a manner consistent with the stress test.[20] These stress test characteristics could include, among others, mortgage prepayment rates and Enterprise funding activities, operating expenses, and capital distribution activities.

The 1992 Act requires the stress test to provide initially that each Enterprise will conduct no new business within the stress period, except to fulfill contractual commitments to purchase mortgages or issue securities. Four years after the final risk-based capital regulation is issued, OFHEO is authorized to modify the stress test to incorporate assumptions about additional new business conducted during the stress period.[21] In doing so, OFHEO is required to take into consideration the results of studies conducted by the Congressional Budget Office and the Comptroller General of the United States on the advisability and appropriate forms of new business assumptions. The 1992 Act requires that the studies be completed within the first year after issuance of the final regulation.[22]

In developing this proposal, OFHEO considered whether it would be permissible and appropriate not to propose a detailed risk model, and instead to rely on the risk models developed by the Enterprises themselves.[23] Under such a regulatory approach, OFHEO would specify only the basic interest rate and credit assumptions, rely on the Enterprises' internal modeling of these scenarios and review those models and the results.

OFHEO has thoroughly considered this approach and believes that it would not be consistent with the 1992 Act, which anticipates that a publicly-available, transparent and reproducible test would be applied to the Enterprises. The 1992 Act provides for both Enterprises to be subject to the same stress test;[24] that the full test be subject to notice and comment rulemaking;[25] that the risk-based capital regulation be sufficiently specific to permit anyone to apply the test, given relevant Enterprise data;[26] and that OFHEO must make the stress test model public.[27] Relying on the Enterprises to compute their own capital requirements with their proprietary models would be inconsistent with all of these provisions.

Moreover, a rule that specifies the details of the model will provide a more consistent and effective capital regulation and will not place undue burdens on the Enterprises. The structure of OFHEO's regulatory and enforcement authorities presumes a strong risk-based capital standard. The level of the minimum (leverage) capital standard was established with the assumption that there would be a meaningful risk-based standard that would address actual or potential risk not addressed by simple leverage ratios. In addition, important OFHEO enforcement authorities are tied to the risk-based capital requirement. An Enterprise's failure to meet these requirements triggers two important enforcement authorities: the ability to reduce or eliminate the Enterprise's dividends and the ability to require a capital restoration plan acceptable to OFHEO. Also, the grounds for a cease and desist action vary depending on whether an Enterprise meets the risk-based standard. Thus, a weaker standard would weaken OFHEO's enforcement authorities.

These objectives are best obtained by a clear standard that is presented to the public for comment and then employed consistently to evaluate both Enterprises. Reliance instead on Enterprise models would likely result in a weaker inconsistently-applied standard. Use of Enterprise models would give the Enterprises broad discretion to determine their own risk-based capital requirements because stress test details beyond basic assumptions and modeling techniques can have a substantial cumulative effect on the results. Existing market distortions would give the Enterprises incentives to adjust those details to produce low requirements.

The Enterprises' status as government-sponsored-enterprises attenuates market discipline of Enterprise capital levels. The Enterprises are highly leveraged financial institutions. Fully private firms that depend heavily on debt markets are inhibited from taking on large amounts of risk relative to their equity capital. Interest rates on debt or guaranteed securities are sensitive to the perceived credit quality of the issuers or guarantors. However, because investors treat Enterprise obligations as implicitly guaranteed by the Federal government, the normal linkage between the adequacy of an Enterprise's capital and the interest rates on its obligations is severed. Thus, because of the perceived implicit guarantee, the Enterprises have an incentive to hold less capital, relative to their risk levels, than they would if their debt costs were subject to normal market forces. A strong risk-based capital standard can address this distortion, but the Enterprises have little incentive to assist in producing such a result.

Reliance on different Enterprise internal models would also result in unequal treatment. The nature of business risks and risk management techniques are very similar at the two Enterprises. It is most appropriate and most fair to determine each Enterprise's capital adequacy in the same way. However, capital models developed by the two Enterprises would likely differ significantly. Differences in resulting standards could easily mask significant differences in true capital adequacy between the Enterprises. Furthermore, a lower effective standard at one Enterprise could give that Enterprise important business advantages over the other. The resulting competitive pressures would give the Enterprise with the higher standard an incentive to conform with the lower standard.

A model fully specified in regulation and administered by OFHEO, on the other hand, does not suffer these disadvantages. Such a model is feasible

[19] 1992 Act, section 1361(a)(2)(E) (12 U.S.C. 4611(a)(2)(E)).

[20] 1992 Act, sections 1361(b) and (d)(2) (12 U.S.C. 4611(b) and (d)(2)).

[21] 1992 Act, sections 1361(a)(3)(B) and (D) (12 U.S.C. 4611(a)(3)(B) and (D)).

[22] 1992 Act, section 1361(a)(3)(C) (12 U.S.C. 4611(a)(3)(C)).

[23] This approach, which OFHEO considered in detail as it began to develop the risk-based capital regulation, was raised most recently by Fannie Mae during the OMB review process. See the letters from Ms. Jamie S. Gorelick, Vice Chair, Fannie Mae of December 4, 1998 to various OMB officials; and of March 10, 1999, to Dr. Janet Yellen, Chair, Council of Economic Advisers.

[24] *See* 12 U.S.C. 4611(a) (''The Director shall, by regulation, establish a risk-based capital test for the Enterprises. When applied to an Enterprise, *the* risk-based capital test shall determine the amount of total capital for the Enterprise . . .'') (emphasis added). *See also* H.R. Rep. No. 102–206 at 62 (1991). (''Beyond these traditional capital ratios, the bill sets forth guidelines for the creation, in highly specific regulations, of a risk-based capital standard . . . *The* model, or stress test, will generate a number for *each* Enterprise, which will become the risk-based standard for *that* Enterprise.'') (emphasis added).

[25] Section 1361(e)(1), 12 U.S.C. 4611(e)(1).

[26] Section 1361(e)(2), 12 U.S.C. 4611(e)(2).

[27] Section 1361(f), 12 U.S.C. 4611(f).

because OFHEO regulates only two institutions, with similar risks and relatively narrow lines of business. The transparency of this approach allows all interested parties to comment meaningfully on the precise method of determining Enterprise capital requirements, and it gives the Enterprises the ability to internalize the model for planning purposes.

In analyzing this issue, OFHEO is aware that some Federal financial institution regulators make limited use of internal models. However, those uses of internal models are made in very different circumstances and by regulators with different authorizing statutes. Many of the institutions in which these regulators rely upon internal models are exposed to substantial market discipline of their capital and risk positions because they rely heavily on uninsured liabilities. Such discipline effectively forces large banks to hold capital well in excess of regulatory requirements.

Even in these circumstances, other regulators depend on internal models only to a small extent as a supplement to other measures of capital adequacy. Bank capital requirements are primarily based on overall or risk-weighted ratios that are substantially higher than those applied to the Enterprises under the minimum capital standard. To supplement those ratios, regulators require banks with significant market risk exposures (those that have large trading accounts) to use their internal value-at-risk models to calculate a market-risk capital component of their overall risk-based capital requirements. However, partly because of the uncertainties surrounding model construction and verification, bank regulators require a multiple of three or more times the amount of capital for market risk exposures that the internal models estimate.[28] This limited use of internal models in very different circumstances does not appear applicable to Enterprise capital regulation.

OFHEO considered whether an internal models approach could permit greater flexibility and innovation by the Enterprises, because they could modify their internal risk models at will. OFHEO believes the issues of flexibility and innovation have been appropriately addressed in the proposed regulation. In general, OFHEO expects that credit and interest rate risk of new Enterprise activities and instruments will be reflected in the stress test by simulating their credit and cash flow characteristics using the approaches described in the regulation. OFHEO will provide the Enterprises with its estimate of the capital treatment of new products, investments or instruments as soon as possible after the Enterprises notify OFHEO of the new activities. In addition, OFHEO will monitor the Enterprises' activities and, when appropriate, propose amendments to this regulation addressing the treatment of new instruments and activities.

For all the reasons described, OFHEO believes that the approach proposed in this Notice implements the requirement of the 1992 Act and provides an appropriate means for ensuring the capital adequacy of the Enterprises. In accordance with the requirements of the Administrative Procedure Act, OFHEO is requesting comments on all of the issues raised in this Notice of Proposed Rulemaking.

C. History of the Development of the Regulation

OFHEO's mission is to ensure that the Enterprises are adequately capitalized and operating in a safe and sound manner. The principal objective of the risk-based capital standard is to reduce the risk of Enterprise insolvency. Another important objective of the risk-based capital standard is to align the incentives reflected in the regulatory capital requirement with the incentives of prudent risk management. The ultimate goal is for the Enterprises to maintain the financial health necessary to fulfill their public purposes. Although the stress test produces a single capital requirement, it effectively creates incremental regulatory capital requirements for each additional dollar of business for every product type an Enterprise guarantees or holds in portfolio. Marginal capital requirements for mortgages held in portfolio will vary depending on the risk inherent in an Enterprise's funding strategy.

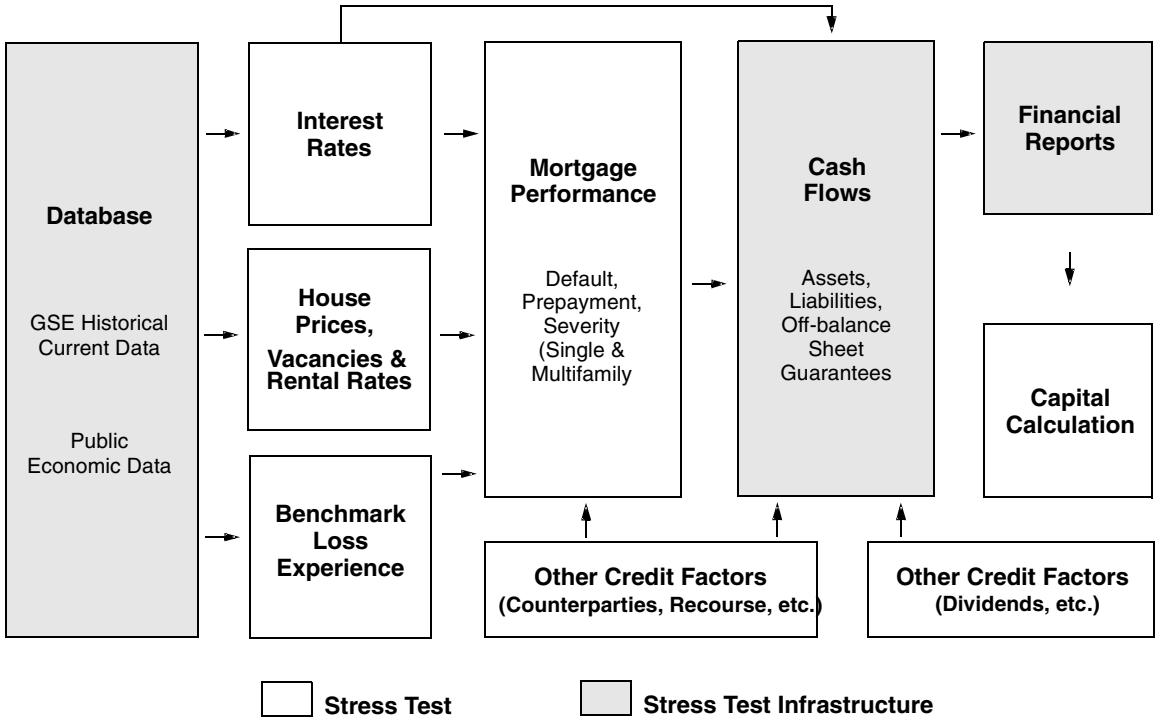
OFHEO designed the stress test so that the incentives it creates closely reflect the relative risks inherent in the Enterprises' different activities. To this end, the proposed regulation incorporates, to the extent feasible, consistent relationships between the economic environment of the stress period and the Enterprises' businesses. Doing so required OFHEO to model the Enterprises' assets, liabilities, and off-balance sheet positions at a sufficient level of detail to capture important risk characteristics.

However, as the level of detail of the stress test increased, so did its complexity, along with the time and other resources that were required to develop it. OFHEO also faced certain practical limits to the number of variables that could be modeled due to the limitations of existing data. Therefore, in developing this proposed regulation, OFHEO sought to achieve a level of complexity and realism in the stress test that appropriately balanced the associated benefits and costs.

OFHEO's stress test is comprised of a number of components, some that correspond to subjects specifically cited in the 1992 Act and others that represent the infrastructure that makes the stress test operational. Figure 1 illustrates these components and their interrelationships. The infrastructure components—database, cash flows, and financial reports—are shaded gray. The unshaded components implement the specific requirements of the 1992 Act, as well as the many other aspects of the stress test that the 1992 Act either requires or permits OFHEO to determine.

[28] See, for example, Darryll Hendricks and Beverly Hirtle, ''Bank Capital Requirements for Market Risk: The Internal Models Approach,'' in *Economic Policy Review*, Federal Reserve Bank of New York, December 1997, pp. 3–6.

Figure 1. Risk Based Capital Stress Test



On February 8, 1995, OFHEO published an Advance Notice of Proposed Rulemaking (ANPR) [29] as its first step in developing the risk-based capital regulation. The ANPR announced OFHEO's intention to develop and publish a risk-based capital regulation and solicited public comment on issues relating to that regulation.

The comment period for the ANPR ended on May 9, 1995, and was extended through June 8, 1995.[30] OFHEO received 17 comments on the ANPR from a variety of interested parties. Commenters included two Executive Branch Departments, HUD and Department of Veterans Affairs (VA); one Federal financial institution regulatory agency Office of Thrift Supervision (OTS); one Federal regulatory agency, U.S. Commodity Futures Trading Commission (CFTC); the Enterprises, Fannie Mae and Freddie Mac; four trade groups, Mortgage Bankers Association of America (MBA), America's Community Bankers (ACB), National Association of Realtors (NAR), and Mortgage Insurance Companies of America (MICA); two mortgage banking firms, PNC Mortgage Corporation of America and Norwest Mortgage, Inc.), one rating agency Standard and Poor's Ratings Group (S&P); one thrift institution, World Savings and Loan Association (MS&L); one private mortgage research firm, Mortgage Risk Assessment Corporation (MRAC); and one individual, Professor Anthony Yezer of George Washington University. The responses to the ANPR ranged from a comment on only one or two specific risk-based capital issues to an extensive analysis of every question or issue raised. OFHEO has considered these comments in the development of its risk-based capital regulation.

OFHEO determined that the scope of the regulatory project required the issuance of two separate Notices of Proposed Rulemaking (NPR), each addressing different components of the stress test. On June 11, 1996, OFHEO published a Notice of Proposed Rulemaking (NPR1),[31] which addresses two components. The first component is the methodology for identifying and measuring the benchmark loss experience, which provides the basis for determining credit losses that the Enterprises will experience during the stress period. The second is OFHEO's proposal to use the OFHEO House Price Index (HPI), which is a weighted repeat transactions house price index, rather than the Constant Quality Home Price Index (CQHPI) published by the Secretary of Commerce, to measure differences in seasoning of single family mortgages in the stress test.[32] NPR1 included OFHEO's responses to all of the ANPR comments that related to those two areas. The comment period for NPR1 ended on September 9, 1996, and was extended through October 24, 1996.[33] OFHEO received 11 written comments on NPR1 and will consider and respond to those in the final risk-based capital regulation.

This Notice of Proposed Rulemaking (NPR2) specifies and proposes for public comment all of the remaining aspects of the risk-based capital stress test not covered in NPR1. The notice includes an overview of the stress test, the stress test's sensitivity to risk, the implications of the stress test for the Enterprises, and specific issues related to the stress test. Among the specific issues discussed are mortgage performance (i.e., default, prepayment, and loss severity), interest rates, new debt and new investments, commitments, dividends and other

[29] Risk-Based Capital, ANPR, 60 FR 7468, February 8, 1995.

[30] Risk-Based Capital, Extension of Public Comment Period for ANPR, 60 FR 25174, May 11, 1995.

[31] Risk-Based Capital, NPR1, 61 FR 29592, June 11, 1996.

[32] 61 FR 29616, June 11, 1996.

[33] Risk-Based Capital, Extension of Public Comment Period for NPR, 61 FR 42824, August 19, 1996.

capital distributions, operating expenses, credit enhancements, liabilities and derivatives, non-mortgage investments, and capital calculation. The notice also includes a technical supplement that explains the derivation of equations used in the stress test. Finally the notice contains the regulatory text which includes the regulatory appendix that provides the technical details of the regulation.

OFHEO believes that it is important for this proposal to receive full public review and comment. Accordingly, OFHEO invites all interested parties to comment on the issues raised in this NPR. OFHEO will consider comments received, together with those received on NPR1, in the development of the final risk-based capital regulation.

II. Structure and Operation of the Regulation

A. Summary of the Stress Test

1. Introduction

OFHEO's risk-based capital regulation is part of a larger regulatory framework for the Enterprises that includes a minimum capital requirement and a comprehensive examination program. The purpose of this regulatory framework is to reduce the risk of failure of the Enterprises by ensuring that the Enterprises are adequately capitalized and operating safely, in accordance with the 1992 Act.

OFHEO's risk-based capital requirement differs from the minimum capital requirement by relating the required capital to the risk in an Enterprise's financial activities. In order to determine risk-based capital for the Enterprises, OFHEO has been charged with creating a stress test that simulates the effects of ten years of adverse economic conditions on the existing assets and obligations of the Enterprises. Both the minimum and the risk-based capital requirements work in conjunction with OFHEO's examination program to ensure that the Enterprises are adequately capitalized and operating safely.

In creating the proposed stress test, OFHEO had to ensure that it met all the statutory requirements outlined in the 1992 Act and that it accurately and appropriately captured the risks related to the business of the Enterprises. To accomplish this, OFHEO modeled both sides of the Enterprises' balance sheets, as well as their off-balance sheet obligations, at the level of detail necessary to capture the risk involved. In selecting among alternative approaches, OFHEO sought to minimize the possibility of perverse incentives in the stress test. The regulation was designed to ensure that stresses were appropriate in order to promote safety and soundness and ensure the Enterprises' ability to fulfill their important public missions.

The stress test determines, as of a point in time, how much capital an Enterprise requires to survive the economically stressful conditions outlined by the 1992 Act. At a minimum, the stress test would be run on a quarterly basis. The stress test takes as inputs data on an Enterprise's assets and obligations, operations, interest rates, and the housing market. These data are used in econometric, financial, and accounting models to simulate Enterprise financial performance over a ten year period called the ''stress period.'' The stress test then computes the amount of starting capital that would permit an Enterprise to maintain a positive capital position throughout the stress period. To determine the risk-based capital requirement, the 1992 Act requires that 30 percent of this amount is added to cover management and operations risk.

This summary provides a high level description of the stress test. For a more detailed description, refer to the Regulation Appendix. For explanations of the reasons for the approaches taken, refer to section III., Issues, Alternatives Considered. For detailed information on econometric models and historical property valuation-related indexes used in the stress test, refer to section IV., Technical Supplement. Throughout the summary, it may be helpful to refer to the stress test diagram, in section I., Introduction.

2. Data

The stress test utilizes data characterizing at a point in time an Enterprise's assets, liabilities, and off-balance sheet obligations, as well as data on economic conditions. The Enterprises submit data to OFHEO for mortgages, securities, and derivative contracts at the instrument level, that is, for individual mortgages, securities, and contracts. OFHEO obtains data on economic conditions from public sources. All these data are referred to as ''starting position data'' for the date for which the stress test is run.

For modeling efficiency, the stress test aggregates loans into groups of loans with common risk and cash flow characteristics (''loan groups''). For instance, 30-year fixed-rate mortgages for single family homes in the same geographic region, originated in the same year, with similar interest rates and LTVs,[34] and held in an Enterprise's portfolio, are grouped together in one loan group. In this way, over 24 million loans are aggregated into the minimum number of loan groups that captures important risk characteristics. These loan groups, instead of individual loans, are then used as inputs by the mortgage performance and cash flow components of the stress test.

In addition to starting position data for existing loans, the stress test creates loan group data for the new mortgages that will be added during the stress test. The 1992 Act requires that the stress test simulate the fulfillment of the Enterprises' contractual commitments, outstanding at the start of the stress period, to purchase and/or securitize mortgages. The new mortgages that the stress test adds consist of four single family loan product types: 30-year fixed-rate, 15-year fixed-rate, adjustable-rate, and balloon. The percentage of each type added is based on the relative proportions of those types of loans securitized by an Enterprise that were originated during the six months preceding the start of the stress period. The mix of LTV, region, guarantee fee, and other characteristics of these new loans also reflects the characteristics of the loans originated during the preceding six months. All new mortgages are securitized. In the down-rate scenario, 100 percent of these loans are added during the first three months of the stress period; in the up-rate scenario, 75 percent of these loans are added during the first six months. These loan groups are then treated like the loan groups created for loans on the Enterprise's books at the start of the stress period.

Because of the smaller number and greater diversity of the Enterprises' non-mortgage financial instruments (investments and debt), the stress test projects these cash flows at the individual instrument level, rather than at a grouped level. Data used for these projections include the instrument characteristics that are used to model securities, both investment and debt, as well as derivative contracts.

3. Stress Test Conditions

a. Benchmark Loss Experience

In NPR1, OFHEO proposed the methodology for identifying the benchmark loss experience, the stressful credit conditions which are the basis for credit losses in the stress test. With this methodology, OFHEO identified the worst cumulative credit losses

[34] LTV is the loan to value ratio, which is the loan balance divided by the value of the property securing the loan.

experienced by loans originated during a period of at least two consecutive years, in contiguous states encompassing at least five percent of the U.S. population. The performance of these loans (i.e., the frequency, timing and severity of their losses) and the related interest rate and housing market environment, comprise the benchmark loss experience.

The benchmark loss experience is based on newly originated, 30-year, fixed-rate, first lien mortgages on owner-occupied, single family properties. The performance of these benchmark loans was a function of their original LTVs and other characteristics, as well as the specific house price and interest rate paths they experienced. The stress test applies the path of house prices from the benchmark loss experience and the interest rate paths required by the 1992 Act. Furthermore, the stress test simulates the performance of an Enterprise's entire mortgage portfolio, including loans of all types, ages, and characteristics. Primarily for these reasons, overall Enterprise mortgage loss rates in the stress test are much lower than the loss rates OFHEO reported in NPR1 for benchmark loans.

When the mortgage performance models are applied to benchmark loans, using the benchmark pattern of interest rates, losses are very close to those identified in NPR1. The remaining difference results from the fact that OFHEO based its mortgage performance models on all Enterprise historical loan data, not just the limited data for benchmark loans, and that the benchmark loss experience was particularly severe. This difference is corrected by calibrating the single family mortgage performance models, resulting in slight upward adjustments of default and loss severity rates, so that they are consistent with the benchmark loss experience.

For multifamily loans, the stress test also incorporates patterns of vacancy rates and rent growth rates that are consistent with the benchmark loss experience. In this manner, the stress test relates the performance of multifamily loans to the benchmark loss experience.

b. Interest Rates

Interest rates are a key component of the adverse economic conditions of the stress test. The 1992 Act specifies two scenarios for the ten-year Constant Maturity Treasury yield (CMT) during the stress period. During the first year of the stress period, the ten-year CMT:

- falls by the lesser of 600 basis points below the average yield during the nine months preceding the stress period, or 60 percent of the average yield during the three years preceding the stress period, but in no case to a yield less than 50 percent of the average yield during the preceding nine months (down-rate scenario); or
- rises by the greater of 600 basis points above the average yield during the nine months preceding the stress period, or 160 percent of the average yield during the three years preceding the stress period, but in no case to a yield greater than 175 percent of the average yield during the preceding nine months (up-rate scenario).

Changes to the ten-year CMT occur in twelve equal monthly increments from the starting point for the ten-year CMT, which is the average of the daily yields for the month preceding the stress period. The ten-year CMT stays at the new level for the remainder of the stress period.

The stress test establishes the Treasury yield curve for the stress period in relation to the prescribed movements in the ten-year CMT. In the down-rate scenario the yield curve is upward sloping during the last nine years of the stress period. In the up-rate scenario the Treasury yield curve is flat for the last nine years of the stress period, that is, yields of other maturities are equal to that of the ten-year CMT.

Because many different interest rates affect the Enterprises' business performance, the ten-year CMT and the Treasury yield curve are not the only interest rates that must be determined. For example, current mortgage rates affect rates of refinancing of existing mortgages; adjustable-rate mortgages periodically adjust according to various indexes; floating rate securities (assets and liabilities) and many rates associated with derivative contracts also adjust; and appropriate yields must be established for new debt and investments. Thus, the stress test requires rates and indexes other than Treasury yields for the entire period of the stress test. Some of the key rates that are estimated are the Federal Funds rate, London Inter-Bank Offered Rate (LIBOR), Federal Home Loan Bank 11th District Cost of Funds Index (COFI), and Enterprise borrowing rates. The stress test establishes these rates and indexes by using Autoregressive Integrated Moving Average (ARIMA) procedures—time-series estimation techniques—to estimate their values based on historical spreads to yields on Treasuries of comparable maturities. The procedures use historical information to estimate values during the stress period. To reflect the market impact of stress test economic conditions on the Enterprises' costs of borrowing, beginning in the second year of the stress period, 50 basis points are added to the computed yields for Enterprise debt securities.

c. Property Values

In determining the performance (rates of default, prepayment, and of loss severity) of an Enterprise's mortgages in the stress test, the 1992 Act requires OFHEO to consider seasoning, which the stress test captures by the use of current LTVs. The stress test calculates the numerator of current LTV, the current loan balance, based on the unpaid principal balance of the loan at the start of the stress period (starting UPB) and the amortization of the loan based on product type. Both the starting UPB and the loan product type are included in starting position data. The stress test uses the OFHEO HPI for the relevant Census division to track changes in property values—the denominator of current LTV—from the time of loan origination through to the start of the stress period. During the stress period, changes in property values are computed by applying the pattern of house price changes from the benchmark loss experience.

The HPI values represent average property value appreciation. In simulating mortgage performance, the stress test also captures variations from average house price movements, called dispersion. For this purpose, the stress test uses the mathematical measures of dispersion that OFHEO publishes along with the HPI.

For multifamily properties, property values are derived from estimates of a property's net operating income and capitalization rate multipliers. The stress test uses loan data together with rent growth rate and vacancy rate indexes to derive estimates of net operating income (NOI) for multifamily loans. Index values from the benchmark loss experience are applied to starting property values to derive current estimates of NOI for each month of the stress period. NOI is multiplied by a capitalization rate multiplier, reflecting current interest rates, to generate a property value. For example, if annual NOI is $200,000 and the capitalization rate multiplier is ten, the property value is $200,000 x 10, or $2,000,000. This value is the denominator for current LTV for multifamily loans.

When the ten-year CMT increases by more than 50 percent over the average yield during the nine months preceding the stress period, the stress test takes general price inflation into consideration. Adjustments are made to the house price and rent growth paths of the benchmark loss experience equal to the percentage change in the ten-year

CMT in excess of 50 percent.[35] For example, if the ten-year CMT increases by 60 percent, house price and rent growth rates increase by ten percent. The stress test phases in this increase in equal monthly increments during the last five years of the stress period.

4. Mortgage Performance

To simulate how mortgages fare during the adverse conditions of the stress period, the stress test uses models of mortgage performance, that project default, prepayment and loss severity rates. These models simulate the interaction of the patterns of house prices, residential rents, and vacancy rates of the benchmark loss experience, as well as stress test interest rates, and mortgage risk factors, in order to determine the performance of Enterprise loans for each month of the stress test. As described below in further detail, the models are based on the historical relationship of economic and mortgage risk factors to mortgage performance, as reflected in the historical experience of the Enterprises.

a. Loan Groups

Rather than simulating the behavior of individual loans, the models simulate the behavior of groups of loans with common risk characteristics. The default and prepayment models calculate the proportion of the outstanding principal balance for each loan group that defaults, prepays, or makes regularly scheduled loan payments in each of the 120 months of the stress period. Single family loans are aggregated into loan groups based on key risk and cash flow characteristics: product type[36] (e.g., 30-year fixed-rate, 15-year fixed-rate, adjustable rate, balloon), original LTV, interest rate, origination year, remittance cycle[37] and Census division. Multifamily loans are similarly aggregated by product type, original LTV, origination year, interest rate, and Census region, as well as by debt coverage ratio (DCR)[38] and program type. Program type distinguishes between loans purchased individually rather than as part of a pool, and loans subject to recourse or repurchase.[39] These distinctions are associated with different risk characteristics.

b. Single Family Default and Prepayment

The single family models are estimated using historical data on the performance of Enterprise loans through 1995. To simulate defaults and prepayments, the stress test uses a 30-year fixed-rate loan model, an adjustable-rate loan (ARM) model, and a third model for other products, such as 15-year loans and balloon loans. Each of the three single family models was separately estimated based on data for the relevant product types. Each includes a calibration adjustment, so that the results properly reflect a relationship to the benchmark loss experience, as described earlier.

All three single family models simulate defaults and prepayments based on values for interest rates and property values, as described above, and variables capturing the risk characteristics of loan groups. The variables described below are the factors used to determine the rates of default and/or prepayment for single family loan groups:

- Mortgage Age—Patterns of mortgage default and prepayment have characteristic age profiles; defaults and prepayments increase during the first years following loan origination, and then peak between the fourth and seventh years.
- Probability of Negative Borrower Equity—Borrowers whose current loan balance is greater than the current value of their mortgaged property (reflecting negative equity) are more likely to default than those with positive equity in their properties. The probability of negative borrower equity within a loan group is a function of (1) house price changes (based on the HPI), and amortization of loan principal, which together establish the average current LTV, and (2) the dispersion of actual house price changes around the HPI value. Thus, even when the average current LTV for a loan group is less than one (positive equity), some percentage of the loans will have LTVs greater than one (negative equity).
- Relative Spread—This variable is an important factor in determining whether a borrower will prepay. It reflects the value to a borrower of the option to prepay and refinance. The stress test uses the relative spread between the interest rate on a loan and the current market rate on loans as a proxy for the mortgage premium value.
- Burnout—The value for this variable reflects whether a borrower has passed up earlier opportunities to refinance at favorable interest rates. Such a borrower is less likely to prepay the current loan and refinance, and more likely to default in the future.
- Yield Curve Slope—This variable reflects the relationship between short and long term interest rates. The shape of the yield curve, which reflects expectations for the future levels of interest rates, influences a borrower's decision to prepay a mortgage. Depending on the slope of the yield curve and the type of loan a borrower may have incentives to refinance to a fixed-rate or an adjustable-rate mortgage.
- Original LTV—The LTV at the time of mortgage origination serves as a proxy for factors relating to the financial status of a borrower, which can affect the borrower's future ability to make loan payments. Higher original LTVs, which generally reflect fewer economic resources and greater willingness to take financial risk, increase the probability of default and lower the probability of prepayment. The reverse is true for lower original LTVs.
- Occupancy Status—The value of this variable reflects the higher probability of default of investor-owners compared to that of occupant-owners. The stress test applies the portfolio-wide ratio of investor-to occupant-owners to each loan group. The single family default and prepayment variables are listed in Table 1.

[35] The stress test computes the difference between the level of the ten-year CMT in the last nine years of the stress period and the level of the ten-year CMT if it had increased 50 percent. The difference in yield is compounded over a nine-year period to determine the cumulative percentage adjustment to house prices at the end of the stress period.

[36] The 1992 Act requires that the stress test take into account appropriate distinctions among mortgage product types, including single or multifamily, fixed or adjustable interest rates and the term of the loans.

[37] For sold loans, the remittance cycle governs the length of time an Enterprise holds payments remitted by the seller/servicer before passing them through to the security investor.

[38] DCR is the ratio of property net income to debt service.

[39] Recourse refers to the sharing of credit risk with a seller/servicer; repurchase refers to the obligation of a seller/servicer to repurchase 90-day delinquent loans.

Table 1. Single Family Default & Prepayment Variables

Variables for All Single Family Models	Single Family Default Variables	Single Family Prepayment Variables
Mortgage Age	X	X
Probability of Negative Equity	X	X
Relative Spread		X
Burnout	X	X
Yield Curve Slope		X
Original LTV	X	X
Occupancy Status	X	X

c. Multifamily Default and Prepayment

The stress test utilizes two multifamily default models and five multifamily prepayment models to capture the behavior of loans purchased under different programs and loans at different stages in their life cycles. The models were estimated using historical data through 1995 on the performance of Enterprise multifamily loans. The stress test applies one default model to loans purchased under cash programs (i.e., loans purchased individually), and another to loans purchased under negotiated programs (i.e., loans purchased as part of a pool), because the programs have different risk profiles. The prepayment models distinguish among product types: fully-amortizing fixed-rate, balloon, and ARM loans; those with yield maintenance provisions (i.e., restrictions and/or penalties for prepaying a loan during a specified period of time); and balloon loans which have reached their stated maturity, because these distinctions affect the probability of prepayment.

As with the models of single family mortgage performance, the multifamily models simulate the probability of default and prepayment based on stress test conditions and loan group risk characteristics. To account for specific risks associated with multifamily loans, these loans are grouped somewhat differently from single family loans. Thus, multifamily loans are also grouped by original DCR and program type. All of the multifamily default and prepayment models include interest rates, rent growth rates, and vacancy rates to characterize stress test conditions.

The following variables are factors in determining default and prepayment rates for multifamily loan groups:

- Mortgage Age—As with single family loans, the risk of default and prepayment on multifamily loans varies over their lives.
- Relative Spread—As with single family loans, this variable reflects the value to the borrower of the option to prepay and refinance.
- Program Restructuring—This variable captures the difference between Enterprises' management of their original multifamily programs and current, restructured programs. That difference affects the probability of default.
- Joint Probability of Negative Equity and Negative Cash Flow—This variable plays a role similar to that of the probability of negative equity for single family loans. However, negative equity is not a sufficient condition for multifamily loan default. Residential rental property owners tend not to default unless a property's net cash flow is negative as well. This variable captures the joint probability of both conditions.
- Balloon Maturity Risk—To reflect the added risk of default at the balloon maturity date, this variable gives extra weight to the joint probability of negative equity and negative cash flow in the year before a balloon mortgage matures.
- Default Type—This variable distinguishes between loans for which the Enterprise is responsible for foreclosure and property disposition and loans for which the seller/servicer is responsible for repurchasing if the loan becomes 90 days delinquent.
- Current LTV—This variable captures the incentive for borrowers to refinance in order to withdraw equity from their rental property.
- Probability of Qualifying for Refinance—This variable captures the effect on prepayments of a borrower who would not qualify for a new loan (one that lacks an LTV of 80 percent or less and a DCR of 120 percent or more).
- Pre-balloon Refinance Incentive—This variable gives extra weight to the relative spread in the two years prior to the balloon maturity. This captures the additional incentive to prepay balloon loans after the date the yield maintenance period ends, but before the balloon maturity date.
- Conventional Market Rate for Mortgages—Similar to the single family yield curve slope variable, this variable reflects the incentives for borrowers with ARMs to refinance into fixed-rate mortgages.
- Value of Depreciation Write-offs—This variable captures the effect on default rates of the value to a new purchaser of the tax benefits associated with multifamily property ownership.
- Years-To-Go in the Yield Maintenance Period—This variable captures the decreasing effect of yield maintenance provisions during the yield maintenance period. As the cost of the provision declines in the later years of the yield maintenance period, the disincentive to prepay declines.

Just like the single family default and prepayment models, the multifamily models produce, for each loan group for each month of the stress period, default and prepayment rates which are used in the cash flow components of the stress test. Tables 2 and 3 list the variables included in the multifamily default and prepayment models.

Table 2. Multifamily Default Model Variables

Variables	Cash Program Loans	Negotiated Program Loans
Mortgage Age	X	X
Program Restructuring	X	
Joint Probability of Negative Equity and Negative Cash Flow	X	X
Balloon Maturity Risk	X	X
Default Type		X
Value of Depreciation Write-offs	X	

Table 3. Multifamily Prepayment Model Variables

Variables	All Fixed-Rate Loans in Yield Maintenance	Fully-Amortizing Fixed-Rate Loans Out of Yield Maintenance	Balloon Loans Out of Yield Maintenance & Before Maturity	Fully-Amortizing ARMs & Balloon ARMs Before Maturity	All Balloon Loans at or After Maturity[1]
Mortgage ge	XA	X	X	X	
Relative Spread	X	X	X	X	
Current TV	IX	X	X	X	
Probability of Qualifying for Refinance					X
Pre-balloon Refinance Incentive			X		
Conventional Market Rate for Mortgages				X	
Years-to-Go in the Yield Maintenance Period	X				

[1] The stress test reflects that the Enterprises may not foreclose on multifamily balloon loans if borrowers can continue to make payments at the then-current market rate of interest.

d. Loss Severity

Credit losses are determined by multiplying default rates by loss severity rates and loan group balances. Loss severity rates are computed as of the date of default, and are expressed as a percentage of unpaid principal balance of the defaulting portion of a loan group.

In general, losses comprise three elements—loss of principal, transactions costs, and funding costs. Loss of principal is the amount of defaulting loan UPB, offset by the net proceeds of the sale (disposition) of the foreclosed property. Transactions costs include

expenses related to foreclosure, property holding and disposition expenses. Funding costs are the costs of funding non-earning assets—first the defaulted loans, and then the foreclosed properties prior to disposition (except in the case of sold loans, for which four months of interest at the passthrough rate replace four months of funding costs).

For single family loans the stress test uses an econometric model to project the net proceeds from the sale of foreclosed properties. The model is based on historical data on defaulted Enterprise loans, and reflects the relationship between LTV at the time of loan default (based on a loan's original LTV, loan amortization, and house price changes and dispersion), and proceeds of property disposition. Just as with models of single family default and prepayment, this model includes a calibration adjustment to make the results consistent with the benchmark loss experience.

For multifamily loans, sale proceeds are a fixed percentage of the defaulting UPB, based on historical experience.

For both single family and multifamily loans, transactions costs are fixed amounts based on historical averages computed from Enterprise data. Funding costs are captured in a discounting process described in the following paragraph.

Foreclosure, disposition and associated costs occur over a period of time. In order to calculate losses associated with a default as of the time of the default, the stress test calculates loss severity rates by discounting the different elements of loss back to the time of default, based on stress period interest rates. The discounting process also captures funding costs at appropriate interest rates. For single family loans, the timing of each element is based on averages for the benchmark loans; for multifamily loans it is based on the historical average for the Enterprises, using data through 1995.

The calculation of loss severity rates for two types of multifamily loans differs from the general approach. In the case of 90-day delinquent loans that are repurchased from Enterprise security pools by seller/servicers, rates are a fixed amount based on Enterprise historical experience representing claims submitted by seller/servicers for reimbursement by the Enterprise. In the case of FHA-insured loans, the stress test reflects no losses.

The loss severity component of the stress test generates loss severity rates for each loan group for each month of the stress period, which are used in the cash flow components of the stress test to calculate credit losses for the Enterprises.

5. Other Credit Factors

a. Mortgage Credit Enhancements

In many cases, at least a portion of Enterprise losses on defaulted loans is offset by some form of credit enhancement. Credit enhancements are contractual arrangements with third parties that reduce Enterprise losses on defaulted loans. By including the effect of mortgage credit enhancements, the stress test more realistically reflects Enterprise risks related to mortgage defaults and credit losses during the stress period.

The stress test captures many types of credit enhancements, with differing depths and methods of coverage, for both single family and multifamily loans. These credit enhancements include private mortgage insurance, recourse to seller/servicers, indemnification, pool insurance, cash accounts, spread accounts, collateral accounts, and specific risk-sharing agreements for certain multifamily loans.

The stress test divides mortgage credit enhancements into two categories. One category is credit enhancements that cover losses on certain loans up to a specified percentage of the loss incurred. This category includes private mortgage insurance, unlimited recourse, unlimited indemnification and, for certain multifamily loans, risk-sharing agreements. The other category includes those credit enhancements that cover all losses on a specified set of loans, up to a specified total amount. This category includes limited recourse, limited indemnification, pool insurance, cash accounts, spread accounts and collateral accounts.

The benefits of the first category of credit enhancements are incorporated in the calculation of monthly loss severity rates. The loss severity rate for a specific loan group is reduced based on the credit enhancements from the first category associated with loans in that group. The benefits of the second category of credit enhancements are taken into account directly in the cash flow calculations. The dollar balance of these credit enhancements is tracked and drawn down to offset the amount of credit losses for the covered loans in a loan group.

b. Counterparty and Other Credit Risk

In addition to mortgage credit quality, the stress test considers the creditworthiness of companies and financial instruments to which the Enterprises are exposed. These include most mortgage credit enhancement counterparties (e.g., private mortgage insurance companies and seller/servicers), privately issued and municipal securities held as assets, derivative counterparties, and securities guaranteed for private issuers.

For credit enhancement counterparties, securities held as assets, and interest rate contract counterparties, the stress test reduces—or applies ''haircuts'' to—the amounts due from these instruments or counterparties according to their level of risk. The level of risk is determined by public credit ratings which the stress test classifies into four categories: AAA, AA, A and BBB. When no rating is available, the instrument or counterparty is rated BBB. The cash flow components of the stress test phase in the haircuts monthly in equal increments until the total reduction listed in Table 4 is reached in the final month of the stress period.

Table 4. Final "Haircuts" for Other Sources of Credit Risk

Rating Classification	Derivative Counterparties[1]	All Other Counterparties & Instruments
AAA	2%	10%
AA	4%	20%
A	8%	40%
BBB	16%	80%

[1] Haircuts for derivative counterparties are substantially less than those for other counterparties and instruments since derivative counterparties' credit risk is mitigated by agreements to post collateral, including provisions for frequent marks to market.

The stress test also applies haircuts to reflect the impact of impairment of counterparties for derivative contracts hedging foreign currency denominated debt. Since counterparty impairment would reduce the effectiveness of a hedge, the stress test reflects the associated risk by increasing the amounts owed by an Enterprise by the haircut percentage.

c. Other Off-Balance Sheet Guarantees

In addition to guaranteeing mortgage-backed securities they issue as part of their main business, the Enterprises occasionally provide guarantees for other securities. The guarantees provided by the Enterprises enhance the liquidity and appeal of these securities in the marketplace. These securities, notably single family and multifamily whole loan REMIC securities [40] and mortgage tax-exempt multifamily housing bonds, represent a small part of the Enterprises' business and have a significant level of credit enhancement that protects the Enterprises from losses. The performance of these securities is not explicitly modeled in the stress test. As a proxy for the present value of net losses on these guarantees during the stress test, the outstanding balance of these instruments at the beginning of the stress period is multiplied by 45 basis points. The resulting amount is subtracted from the lowest discounted monthly capital balance when calculating the risk-based capital requirement.

[40] Real Estate Mortgage Investment Conduit (REMIC) securities are multiclass mortgage passthrough securities. The classes of a REMIC security can take on a wide variety of attributes with regard to payment of principal and interest, cash flow timing (un)certainty, and maturity, among others.

6. Cash Flows

For each month of the stress period, stress test cash flow components apply projected default, prepayment, and loss severity rates to loan group balances to produce mortgage cash flows. The cash flow components also reduce projected mortgage losses resulting from offsetting credit enhancements that are not accounted for in loss severity calculations. In addition, the cash flow components calculate cash flows for securities that the Enterprises hold as assets, or have issued as liabilities. They generate cash flows for derivative instruments like interest rate swaps, caps, and floors; and they apply the haircuts to cash flows to reflect the credit risk of securities and counterparties other than mortgage borrowers. Projected cash flows are the principal inputs in the creation of monthly financial statements during the stress period, which are, in turn, the basis for the calculation of the risk-based capital requirement.

Cash flows are generated for each single family and multifamily loan group. For retained loans, cash flows consist of scheduled principal, prepaid principal, defaulted principal, default losses, and interest. For sold loans, cash flows consist of credit losses, guarantee fee income, and float income.

Because losses on sold loans are absorbed by the Enterprises and are not passed through to security holders, no credit losses are reflected in cash flows calculated for Enterprise-issued MBS held as investments (including those issued by an Enterprise and later repurchased). The credit risk is borne by the MBS issuer rather than the MBS investor, so the credit risk on MBS has already been taken into account in the credit risk of sold loans. Thus, cash flows for single class Enterprise-issued MBS held as investments consist only of principal and interest payments. Cashflows for private label securities consist of principal and interest payments and credit losses.[41] Principal payments are calculated by applying default and prepayment rates that are appropriate for the loans underlying the MBS (amounts of defaulted principal are assumed to be passed through to investors, as well as normal amortization). Interest is computed by multiplying the security principal balance by the coupon rate.

Multi-class mortgage securities such as REMICs and strips are treated in the same manner as single class MBS. The stress test generates cash flows for the underlying collateral, usually single class MBS, and applies the rules of the particular multi-class security that govern how these cash flows are directed to determine cash flows of the specific securities held by an Enterprise. In generating cash flows for mortgage-linked derivative contracts, where the notional amount of the contract is based on the declining principal balance of specified MBS, the stress test applies the terms of each contract and tracks the appropriate declining balances. The stress test generates cash flows for mortgage revenue bonds by treating the bonds like single class MBS backed by 30-year, fixed-rate single family mortgages maturing on each bond's stated maturity date.

For non-mortgage investments, outstanding debt securities and liability-linked derivative contracts, payments of principal and interest are calculated for each instrument based on its

[41] See section II. A. 5. c., Other Off-Balance Sheet Guarantees for a description of how credit losses for private label securities are calculated.

characteristics by applying the appropriate interest rates and principal payment rules. For asset-backed securities, one of two collateral prepayment speeds is applied, depending on the stress test interest rate scenario. The stress test computes cash flows for debt securities and liability-linked derivatives according to the rules and structure of each instrument.

7. Enterprise Operations & Taxes

The stress test simulates the income taxes, operating expenses, issuance of new debt or purchase of new investments, exercise of options to retire debt early or cancel derivative contracts, and payment of dividends by the Enterprises. The stress test computes Federal income taxes using an effective tax rate of 30 percent. Estimated income tax is paid by the Enterprises quarterly.

An Enterprise's operating expenses decline in proportion to the change in the size of its combined mortgage portfolio of retained and sold loans during the stress period. The baseline level of monthly operating expenses at the start of the stress period is equal to one-third of operating expenses reported by the Enterprise for the quarter preceding the stress period.

When necessary, the stress test simulates the issuance of new debt or purchase of new investments by the Enterprises. New debt is issued in months when there is a shortfall of cash. All debt issued during the stress period is six-month discount notes, at Enterprise borrowing rates projected from the estimated yield curve. Excess cash is invested in one-month securities bearing the six-month Treasury yield.

For each month during the stress period that a security is subject to early redemption (call) or a derivative contract is subject to cancellation, the stress test calculates the effective remaining yield-to-maturity [42] of that instrument and compares it to the yield of a replacement security, given current stress period interest rates. If the yield is more than 50 basis points below the cost of the existing instrument, the call or cancellation option is exercised.

Capital distributions are also made during the stress period. If an Enterprise's capital exceeds the minimum capital requirement in any quarter, dividends on preferred stock are paid, unless payment would reduce the Enterprise's capital to an amount below the minimum requirement. Common stock dividends are paid only in the first four quarters of the stress period (based on an estimate of how long capital would remain above the risk-based requirement), and only if capital remains above the minimum capital requirement before and after the dividends are paid. The amount paid is directly related to the earnings trend of the Enterprise. If the trend is positive, the dividend payout ratio is the same as the average of the four quarters preceding the stress test. Otherwise, dividends are based on the dollar amount per share paid in the last quarter preceding the stress test. The stress test does not provide for any other capital distributions, such as repurchases of common stock.

8. Financial Reporting

To the extent applicable, the stress test makes use of Generally Accepted Accounting Principles (GAAP). The cash flows from the financial instruments on the books of the Enterprises are the principal basis for the creation of pro forma financial statements that capture an Enterprise's performance over the stress period. In addition, the stress test accounts for numerous non-cash items on the Enterprises' balance sheets, such as receivables and unamortized and deferred balances. The balance sheets show the monthly total capital amount for each Enterprise, which is used in the final calculation of risk-based capital.

9. Calculation of the Risk-based Capital Requirement

The stress test determines the amount of capital that an Enterprise must hold at the start date in order to maintain positive capital throughout the ten-year stress period (stress test capital). Once stress test capital has been calculated, an additional 30 percent of that amount is added to protect against management and operations risk. This total is the risk-based capital requirement.

Using the financial statements generated by the stress test, the capital balance for each month is discounted back to the start of the stress period. This is done for both the up-rate and down-rate scenarios. The lowest discounted monthly capital balance is then decreased as described above to account for securities that are guaranteed by the Enterprises which are not explicitly modeled (other off-balance sheet guarantees). This lowest discounted monthly balance, if positive, represents a surplus of initial capital, that is, capital that was not ''used'' during the stress period. If negative, it represents a deficit of initial capital. The lowest discounted monthly balance is then subtracted from the Enterprise's initial capital. The resulting amount is the smallest amount of starting capital required to maintain positive capital throughout the stress period.

For example, if an Enterprise holds starting capital of $10 billion and the lowest discounted monthly balance is $1 billion (representing a positive capital balance even in the worst month of the stress period), then the amount of starting capital necessary to maintain positive capital throughout the stress period is $9.0 billion. If the lowest discounted monthly balance is −$1 billion (representing a negative capital balance in the worst month), the necessary starting capital is $11.0 billion.

In the final step, necessary starting capital is multiplied by 1.3 to complete the calculation of the risk-based capital requirement required by the 1992 Act.

B. Sensitivity of Capital Requirement to Risk

An Enterprise's risk-based capital requirement under this proposed regulation is sensitive to a wide variety of factors that affect Enterprise risk. The existing minimum capital requirement depends almost entirely on the size of an Enterprise's two principal businesses: MBS guarantees and leveraged investments in mortgages and in MBS. In contrast, the risk-based capital requirement depends not only on the outstanding volumes of an Enterprise's guarantees and assets, but also on the degree of risk taken on by the Enterprise in connection with these businesses. Thus, the risk-based requirement is sensitive to the characteristics of mortgages and mortgage guarantees that affect risk, credit enhancements for those mortgages, the asset/liability risk management strategies of the Enterprise, the value of properties collateralizing the mortgages, and recent interest rate levels.

In designing the stress test on which the risk-based capital requirement is based, OFHEO sought to incorporate all significant sources of credit and interest rate risk. OFHEO further sought to design the stress test so that differences in specific risk factors affect the risk-based capital requirement in amounts commensurate with the difference in risk. To quantify the marginal effects of changes in risk on the capital required for each scenario (required capital), OFHEO conducted a number of sensitivity tests. OFHEO first computed the risk-based capital requirement for each Enterprise in each interest rate

[42] Yields are calculated based on the outstanding principal balances for securities and notional amounts for derivative contracts.

scenario for June 30, 1997.[43] These results serve as a base case. OFHEO then made a series of small adjustments to each Enterprise's risk positions and compared the results for all four Enterprise-scenario combinations with the relevant base case results. The differences in results provide a measure of the incremental changes in required capital (which may be positive or negative) caused by the risk adjustment.

Section II. B.1., MBS Guarantees (Sold Loans), below presents the results of sensitivity tests related to an Enterprise's guarantee business. In each test, OFHEO simulated the effects on required capital of a hypothetical addition to each Enterprise's outstanding MBS guarantees (sold loans). The simulation results show, in both an absolute and relative sense, how different characteristics of sold loans affect required capital. Section II. B. 2., Commitments, illustrates how required capital would be affected if each Enterprise had had a larger volume of outstanding commitments. Section II. B. 3., Assets and Liabilities, discusses the effects of hypothetical additions of retained loans accompanied by additions of debt. Section II. B. 4., Administrative Costs, discusses how risk-based capital would be affected by higher administrative (operating) expenses. Finally, Section II. B. 5., External Economic Conditions, discusses how risk-based capital would be affected had house prices or interest rates behaved differently than they actually did in the period just preceding the starting date of the stress test.

Sensitivity test results differ between the two Enterprises for two reasons. First, the risk adjustments made to the two Enterprises' positions were not precisely the same. For example, in sensitivity tests involving changes in outstanding sold loan volumes, each Enterprise's additional sold loans reflect that Enterprise's typical security remittance cycles, and remittance cycles affect the risk characteristics of sold loans. Second, the incremental effects on required capital of any change in an Enterprises's risk positions are affected by the Enterprise's individual circumstances and policies. Two examples are the Enterprise's projected Federal income tax situation during the stress period and its dividend policies. During portions of the stress period in which an Enterprise is paying taxes or receiving refunds, financial gains and losses are shared with the government because changes in income cause changes in taxes. Conversely, during portions of the stress period in which an Enterprise has exhausted tax carrybacks, the full benefit or cost of a change in income is experienced by the Enterprise. In the base case, both Enterprises exhaust their tax carrybacks mid-way through the stress period in the down-rate scenario. In the up-rate scenarios, Fannie Mae does the same, but Freddie Mac either pays taxes or receives refunds throughout the stress period. An Enterprise's tax situation during the stress period depends primarily on the Enterprise's risk exposures. The longer an Enterprise continues to be profitable in the stress environment, the longer it is affected by taxes.

Differences in recent dividend policies can cause small differences in the incremental capital associated with specific changes in risk because common stock dividends during the first year of the stress period depend on recent dividend payouts. Differences in dividend policies, therefore, can lead to differences in the amount of earnings changes that are shared with stockholders.

Results are shown for both interest rate scenarios, even though only one (the one that results in the highest required capital) can be binding at any specific time. For June 1997, the up-rate scenario resulted in higher required capital for Fannie Mae, while the down-rate scenario was more adverse for Freddie Mac. However, the relative adversity of the two scenarios may change over time for either Enterprise depending on business strategies and market conditions.

In the tables of this section, the phrase ''incremental capital'' is used to mean the change in the amount of required capital in a particular scenario accompanying a small change in the overall risk profile of an Enterprise. Several considerations affect appropriate interpretation of these numbers. First, the incremental capital percentages shown in the tables are not fixed. As discussed below in section II. B. 5. c., Sensitivity to Risk Characteristics in Different Economic Environments, future business strategies and economic conditions may alter the required capital sensitivities from those of June 1997, which are presented here. Furthermore, bigger or smaller changes in risk may not have a proportional effect on capital. A $20 billion increase in a particular group of loan guarantees may not have exactly twice the effect on required capital as a $10 billion increase in the same group of guarantees.

Second, in anticipating the effect on required capital of a change in any risk factor, an Enterprise likely will be concerned not only with the immediate effect, but also with the longer term effect. For example, in considering the capital implications of making additional mortgage guarantees, the incremental effects on required capital of the guarantees at all future dates that the loans continue to be outstanding are relevant. In this case, an important consideration is that the incremental effects of mortgage guarantees generally diminish over time.

Third, the incremental capital percentages do not determine an amount of capital that must be added in order to accept a specific increase in risk. As discussed below in Section II. C. 2., Enterprise Adjustments to Meet the Proposed Standard, it may often be less costly to increase hedges of other risks than to raise equity funds in response to an increase in risks.

1. MBS Guarantees (Sold Loans)

The Enterprises have two principal lines of business. They function both as guarantors of mortgage-backed securities and as leveraged investors in mortgages and mortgage-backed securities. As guarantors, the Enterprises receive principal and interest payments on home mortgages, which they pass through to security investors, minus a share of the interest payments, which they retain as a guarantee fee. Because of differences in the timing of their receipt of funds and payments to investors, they also earn float income (which may be positive or negative). In return, they bear the risk of loss if a borrower defaults, and they incur additional administrative expenses.

The stress test projects the flows of income and expenses associated with loan guarantees based on the characteristics of the mortgages and the economic circumstances of the stress period. The resulting net cash inflows or outflows are directly reflected in the Enterprise's borrowing or investing volumes during the stress period. The interest paid or received on the new debt issues or investments that are attributable to the guarantees have further effects on income, borrowing, and investing volumes. Income, in turn, affects taxes, dividends, capital, and (ultimately) required capital.

OFHEO examined the implications for required capital of risk factors associated with sold loans as follows. After computing the capital required under this proposed rule for data reflecting the Enterprises' books of business and the accompanying economic circumstances as of June 30, 1997, OFHEO added a quantity ($10 billion) of sold loans that embodied the specific risk characteristics under

[43] The results are discussed in section II. C., Implications of the Proposed Rule.

examination. The capital required for each scenario was then recomputed and compared with the capital required for the same scenario before loans were added. The difference is the incremental capital required for the additional sold loans in that scenario. The results are expressed as a percent of the volume of sold loans added.

Additional sold loans would normally be accompanied by additional administrative expenses. In computing required capital for books-of-business that included additional sold loans, OFHEO estimated the additional costs by increasing administrative expense for each Enterprise in proportion to the increase in that Enterprise's overall (retained plus sold loan) portfolio. Those costs amounted to about six basis points (0.06 percent) per year on the new sold loans for each Enterprise. Different assumptions about administrative costs would affect the results; Section II. B. 4., Administrative Costs, discusses the effects on required capital of differences in administrative costs.

Section II. B. 1. a., Loans with Mixed Characteristics Reflecting Enterprise Portfolios, discusses a simulation incorporating a general increase in sold loans embodying the same mix of characteristics as that found in each Enterprise's sold loan portfolio in June 1997 and describes how the increase affects various types of income and expense over the course of the stress period. Section II. B. 1. b., Loans with Specific Identical Characteristics, discusses a series of simulations, each incorporating an increase in sold loans with specific characteristics.

a. Loans with Mixed Characteristics Reflecting Enterprise Portfolios

The first simulation (Simulation 1) was designed to examine the incremental effects of a general increase in each Enterprise's sold loan portfolio (MBS guarantees). The volume of each loan group (comprising loans with a common set of risk factors) in each Enterprise's sold loan portfolio as of June 1997 was increased proportionally by a factor that resulted in a total of $10 billion of additional sold loans. The results indicate the effects on risk-based capital of a general expansion of an Enterprise's MBS guarantee business. Alternatively, they can be viewed as the average effect on required capital of sold loans, weighted by each Enterprise's mix of outstanding sold loan business in June 1997. The results, expressed as a percent of the increase in sold loans, are summarized in Table 5.

Table 5. Incremental Capital for a General Increase in Sold Loans (as a percent of additional sold loans)

	Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
1	.12%	−.09%	.83%	.89%

In the up-rate scenario, a general increase in sold loans has only a small effect on required capital for either Enterprise. For Freddie Mac, sold loans are, on balance, a small source of strength. That is, income generated over the course of the stress period by sold loans (principally guarantee fees and float) exceeds related expenses (principally loan losses and administrative expense). The reverse is true for Fannie Mae. In the down-rate scenario, the incremental capital required for these sold loan mixes is near 0.85 percent of the increase in guarantees for both Enterprises. On average, the results for the two scenarios are similar to the existing minimum capital ratios for sold loans of 0.45 percent.

Table 6 illustrates the effects on specific income and expense categories of the additional sold loans in Simulation 1, and how these effects translate into changes in capital requirements.

Table 6. Sources and Computation of Incremental Capital for a General Increase in Sold Loans[1] (ten-year cumulative changes as a percent of additional sold loans)

	Up-Rate Scenario		Down-Rate Scenario	
	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
Credit Losses	1.87	1.63	1.39	1.25
Administrative Expense	.40	.40	.15	.15
Tax Paid	−.13	.07	−.08	−.16
Dividends Paid	.00	.01	.00	.00
Less: Guarantee Fees	1.77	1.76	.67	.68
Float Income	.22	.35	.06	−.22
Net Interest Income (excluding float)	−.11	.16	−.11	−.13
Total Change in Capital	.26	−.16	.84	.91
Cumulative Discount Factor	2.71	2.27	1.31	1.33
Discounted Total	.10	−.07	.64	.68
Discounted Total x 1.3	.12	−.09	.83	.89

[1] Computations based on unrounded data.

Guarantee fees and *administrative expense* depend on the volume of loans outstanding. Thus, they are sensitive to the projected liquidation rates (the sum of prepayment, default, and amortization rates) of the additional sold loans. In the down-rate scenario (with a ten-year constant maturity treasury yield of 3.2 percent during the last nine years of the stress period), loans prepay rapidly, while in the up-rate scenario (with all treasury yields at 11.4 percent), loans prepay slowly. As a result, in the up-rate scenario, guarantee fee income and administrative expense are roughly 2⅔ times as great as they are in the down-rate scenario.

Credit losses (charge-offs) depend on the credit risk characteristics of the additional sold loans. They are also larger in the up-rate scenario than in the down-rate scenario because loans remain outstanding longer, and therefore, at risk of default. Loss severity rates also are higher in the up-rate scenario because the interest carrying cost on foreclosed real estate is higher. These differences between the two scenarios are moderated by somewhat more favorable house price behavior and by better average loan quality when interest rates are high. Loan quality is poorer when interest rates are low because the better quality loans are projected to prepay much faster. Because of these offsetting influences, credit losses in the up-rate scenario are only 1⅓ times as great as they are in the down-rate scenario. Freddie Mac's credit losses are about ten percent lower than Fannie Mae's, reflecting a slightly less risky mix of loan characteristics.

Float income depends on security remittance cycles, interest rates, and loan liquidation rates. This source of income on the additional sold loans is higher, for both Enterprises, in the scenario with higher interest rates because of lower liquidation rates and higher earnings ratios on positive float balances. The difference is much more pronounced for Freddie Mac because of differences in security remittance cycles. Freddie Mac holds prepayment funds for a longer period than Fannie Mae, earning a market rate of interest during the extra time, while accruing liabilities to investors at the security coupon rate. When interest rates rise, that provides extra income, but when rates fall, net losses accrue.

Net interest income is affected because net cash inflows and outflows associated with the other income and expense categories lead to changes in borrowing or investing. The effects are small in the up-rate scenario because the net flows caused by other factors are small. The effects also are small in the down-rate scenario, even though the net cash flows are much larger, because the interest rates associated with new borrowing or investing are low.

Taxes reduce the effects of all income changes by 30 percent as long as an Enterprise is paying taxes or receiving tax refunds. Because both Enterprises, in the decreasing interest rate environment, and Fannie Mae, in the increasing rate environment, exhaust their tax carrybacks mid-way through the stress period, the tax effects vary depending on the timing of income flows during the stress period. Freddie Mac, however, performs well in the up-rate scenario, given its June 1997 risk positions, and pays taxes or receives refunds throughout the stress period.

Dividends on common stock can be affected by additional sold loans only through changes in income during the first year of the stress period because the stress test specifies that common stock dividends are paid only during that year. Common stock dividends are little affected in this simulation because income changes during the first year are small and because dividends in the base case simulations for Fannie Mae in both scenarios, and Freddie Mac in the down-rate scenario, are insensitive to income. In those cases, dividends are set at their absolute level in the quarter preceding the stress test because of income declines during the first year. Preferred stock dividends are unaffected in this simulation because the changes in capital are insufficient to affect whether either Enterprise meets its minimum capital requirement during the stress period.

The *total change in capital* is the sum (using the appropriate signs) of the effects measured through all of the above income and expense categories. The sum equals the net decline in capital at the end of the stress period (as a percent of the increase in sold loans). The capital position in the final month of the stress period is the lowest during the stress period for both Enterprises in both scenarios for the June 1997 base case, so it is the basis for the required capital calculations in all of the simulations discussed in this section.

The *cumulative discount factor* is based on after-tax borrowing or investing interest rates. Thus, discount factors are relatively high in the up-rate scenario. Freddie Mac's discount factor is lower than Fannie Mae's in that scenario because taxes reduce Freddie Mac's after-tax interest rates in the second half of the stress period, but do not reduce Fannie Mae's. The *discounted total* shows the effects of the additional sold loans on the amount of capital needed to survive the stress test. This amount, when multiplied by 1.3 to include the additional amount for management and operations risks, shows the effects on required capital of the additional sold loans.

b. Loans with Specific Identical Characteristics

Unlike the first simulation, which showed the combined effects of each Enterprise's existing mix of risk factors, the following simulations focus on the effects of changes in specific risk factors. In each of the following cases, the sold portfolio is increased as before, but all of the additional loans are identical. The results show how much required capital would be affected by additional sold loans with specific risk characteristics and guarantee fees or, alternatively, how much loans with such characteristics and fees contribute to required capital. The assumptions about guarantee fees have a significant effect on the results. Guarantee fees are generally the same in most of these simulations in order to focus the results on the incremental capital effects of specific risk factors. In practice, though, the Enterprises typically vary the guarantee fees charged to a loan seller depending on the mix of loans they receive from that seller. Thus, the Enterprises implicitly charge higher fees for riskier loans. It would be misleading to characterize these simulation results, which are based on constant guarantee fees, as indicating the relative capital implications of loans in different risk groups as typically acquired by the Enterprises, without making an appropriate adjustment for typical differences in effective guarantee fees. Making such an adjustment in the model would be difficult, however, because the Enterprises do not generally make explicit differences in guarantee fees for individual loans with differences in risk. The same guarantee fee typically applies to all loans in a pool of loans and may be affected by the mix of loans in the pool.

Also, Enterprise guarantee fees remain constant over the life of the loan, but the risk of the loan generally declines as the loan seasons. A majority of the simulations in this subsection involve new loans. The comparative results of such simulations provide a measure of the relative effects on required capital of different risk factors, but these results do not, by themselves, indicate the expected effects on required capital of the loans over their lifetimes. Additional simulations show the effects of loan seasoning on required capital.

In these simulations, securities were assumed to have been sold at par with coupons equal to the contract interest rates, less the servicing and guarantee margins. Servicing margins are 30 basis points. For Fannie Mae, the loans were assumed to be securitized under their standard programs with seven days of float on passthrough payments. For Freddie Mac, their ''45-day'' security rules were assumed in float calculations. These securities have negative three days of float on scheduled principal and interest (payments are made to investors before payments are received from servicers) and an average of 38 days of float on prepayments. (In Simulation 1, both 45-day and 75-day rules were used for Freddie Mac, based on the mix of securities outstanding in June 1997.)

(i) Differences in Guarantee Fees

To illustrate the effect on required capital of guarantee fees, two simulations were performed that were identical except for guarantee fees. In Simulations 2 and 3, shown in Table 7, the additional sold loans were all newly originated, fixed-rate mortgages (FRMs) in the West South Central Census Division (Texas, Oklahoma, Louisiana, and Arkansas); with 30-year terms, 7.5 percent contract interest rates, and 80 percent loan-to-value ratios (LTVs). In Simulation 2, guarantee fees were set at 23 basis points, which is roughly the overall average rate for the two Enterprises, but not necessarily for loans with these characteristics. This simulation is used as a reference for comparison in Tables 8, 11, 12, 16, 17, 19, and 20. The average rate was used in most of the simulations involving additional single family loans for convenience and to isolate the differential effects of other risk factors. In Simulation 3, however, the guarantee fee was reduced to 18 basis points to isolate the effects of different guarantee fees. The differences in the results for Simulations 2 and 3 can be used to roughly estimate how the results of other simulations might have been affected by other guarantee fee assumptions.

Table 7. Incremental Capital for New Sold Loans with Differing Guarantee Fees (as a percent of additional sold loans)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	Guarantee Fee	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
2	23 b.p.	1.05%	.95%	1.54%	1.91%
3	18 b.p.	1.35%	1.19%	1.72%	2.05%

The incremental capital needed for loans in both of these simulations is substantially higher than that needed for loans with the mix of characteristics in Simulation 1. This result occurs mainly because new 30-year FRMs have nearly double the credit losses in the up-rate scenario and 50 percent more in the down-rate scenario. For Freddie Mac, an additional reason is that securities with the 45-day remittance cycle assumed in Simulations 2 and 3 produce substantially less float income in the up-rate scenario and more negative float income in the down-rate scenario than the average guarantee mix in Simulation 1 did. Freddie Mac's capital need in the up-rate scenario is reduced relative to Fannie Mae's because of tax effects in the second half of the stress period.

The effect of lower guarantee fees is to increase required capital in both scenarios. A five basis-point reduction in guarantee fees raises required capital by 14 to 18 basis points in the down-rate scenario. The difference in incremental capital is twice that amount in the up-rate scenario because the loans survive longer, owing to significantly fewer prepayments, and so the change in the fee rate applies to a larger volume of outstanding loans during the stress period.

(ii) Differences in Loan Age, With Slow and Steady House Price Inflation

Seasoned loans (those not recently originated) have different risk characteristics than new loans because loans have different propensities to default and prepay at different ages and because the houses collateralizing seasoned loans have experienced changes in value. Changes in house value alter the probability of negative borrower equity, a key factor influencing default behavior.

In Table 8, the results of Simulations 4–7, along with Simulation 2, which is repeated here, show the effects of age on risk for loans originated in the West South Central Census Division. Houses in that area of the country generally have experienced price appreciation near the national average in recent years. Average annual appreciation over the eight years ending in the second quarter of 1997 was 3.0 percent. Table 9 shows the cumulative average appreciation for houses collateralizing loans of different ages.

Table 8. Incremental Capital for Loans of Differing Age with Slow and Steady House Price Inflation (as a percent of additional sold loans)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	Age	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
2	0 years	1.05%	.95%	1.54%	1.91%
4	2 years	.76%	.74%	1.38%	1.53%
5	4 years	.26%	.34%	.83%	1.09%
6	6 years	−.29%	−.07%	.56%	.79%
7	8 years	−.64%	−.37%	.21%	.43%

All of the simulations reported in Table 8 are identical, except for the age of the sold loans underlying the additional guarantees. Given the steady increase in house prices preceding the starting point of the simulations, loans are less likely to default over the course of the stress period the older they are at the beginning of the period. Cumulative credit losses for loans made eight years before the start of the stress period are only about ⅕ as great as for new loans in the up-rate scenario, and about ⅖ as great in the down-rate scenario. In addition, loans made more than four years earlier have lower liquidation rates than new loans, providing a larger stream of guarantee fees. Consequently, guarantees of older loans cause much smaller increases in capital requirements in the down-rate scenario and actually reduce capital required in the up-rate scenario.

Table 9. Cumulative Average House Price Appreciation Since Origination for Loans in the West South Central Division, 1997 Q2

Loan Age	Change in HPI
2 years	6.4%
4 years	13.7%
6 years	21.4%
8 years	26.8%

(iii) Differences in Past House Price Appreciation

The benefits of loan age in reducing risk can be substantially increased or reversed by differences in house price appreciation. Table 10 shows results for simulations on four-and eight-year-old loans from different geographic areas. Simulations 8 and 9 are the same as Simulation 5, except the loans in Simulation 8 were made on properties in the Mountain Census Division, where house values rose sharply after the loans were originated, and loans in Simulation 9 were made in the Pacific Census Division, where house values were stagnant. Similarly, Simulations 10 and 11 are the same as Simulation 7, except for the Census division.

Table 10. Incremental Capital for Seasoned Loans in Differently Performing Housing Markets (as a percent of additional sold loans)

			Up-Rate Scenario		Down-Rate Scenario	
Simulation	Census Division	Cumulative House Price Appreciation Since Origination	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
4-Yr. old loans						
5	W.S.Central	13.7%	.26%	.34%	.83%	1.09%
8	Mountain	34.5%	−.38%	−.21%	.28%	.56%
9	Pacific	4.3%	.85%	.88%	1.65%	1.73%
8-Yr.old loans						
7	W.S. Central	26.8%	−.64%	−.37%	.21%	.43%
10	Mountain	60.6%	−.72%	−.44%	.05%	.30%
11	Pacific	16.0%	−.56%	−.30%	.32%	.53%

For four-year-old loans, differences in credit losses are substantial and account for almost all differences in results. In both scenarios, credit losses are more than 2½ times as great in the Pacific Census Division as they are in the Mountain Census Division. However, the effects of different previous changes in house prices ultimately diminish. For eight-year old loans, charge-offs are only about ⅓ higher in the Pacific Census Division, despite increasing disparity in house price appreciation. Furthermore, that smaller proportional increase in charge-offs is applied to a smaller base because charge-offs are much lower for eight-year old loans than for four-year old loans in all three Census divisions.

(iv) Differences in Loan Age and Loan-to-Value Ratio

The higher the original loan-to-value ratio of a loan, the lower the borrower equity. Thus, the more likely it is to default and less likely it is to prepay. The effects of differences in original LTV, however, generally diminish with age. Table 11 shows the results for different LTV-age combinations for 30-year FRMs in the West South Central Division.

Table 11. Incremental Capital for Loans with Differing Ages and LTVs (as a percent of additional sold loans)

			Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Age**	**LTV**	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
12	0 Years	50%	−1.13%	−.85%	−.64%	−.05%
2	0 Years	80%	1.05%	.95%	1.54%	1.91%
13	0 Years	95%	3.17%	2.84%	6.04%	6.02%
14	4 Years	50%	−1.08%	−.78%	−.52%	.02%
5	4 Years	80%	.26%	.34%	.83%	1.09%
15	4 Years	95%	1.33%	1.32%	2.19%	2.20%

In these simulations, the 95 percent LTV loans are assumed to be covered by private mortgage insurance with 30 percent coverage, the current Enterprise standard, provided by a double-A rated firm. Even with the insurance coverage, however, high LTV loans are much riskier than low LTV loans. Not only are high LTV loans more likely to default at any time during the stress period, but they are also less likely to prepay, especially in the down-rate scenario. Thus, they are exposed to default risk over a longer amount of time.

For newly originated loans, the results are particularly striking. In the up-rate scenario, credit losses on 95 percent LTV loans are very much higher than they are for 50 percent LTV loans. In the down-rate scenario, the difference is even greater. These differences in performance between high and low LTV loans are much bigger than would be expected in normal times. But the very poor credit conditions in the stress test environment have a disproportionate effect on the more vulnerable high LTV loans.

For seasoned loans, the effects of LTV are muted. Seasoned loans with 50 percent LTVs reduce required capital less than comparable new loans. Though credit losses are lower than those of newly originated loans, the difference is minor, as credit losses are very low in both cases. More importantly, the older loans amortize faster, reducing guarantee fees significantly. For loans with 95 percent LTVs, the difference in credit losses between seasoned and new loans is substantial. With a 13.7 percent average house price appreciation since origination, these seasoned 95 percent LTV loans perform only a little bit worse than newly originated 80 percent LTV loans.

(v) Differences in Product Type and LTV Ratio

The simulations shown in Table 12 show the relative effects of three different product types (30-year FRMs, 15-year FRMs, and adjustable-rate mortgages) with low, medium, and high LTVs). All are newly originated loans. To isolate the effects of loan type, the 7.5 percent contract loan rate was retained for the 15-year FRMs and is the initial rate on the adjustable-rate mortgages (ARMs). The ARMs adjust annually to 2.75 percentage points above the one-year constant maturity Treasury yield, with a two percentage point annual adjustment cap and a five percentage point lifetime cap.

Table 12. Incremental Capital for Differing Product Types and LTV Ratios (as a percent of additional sold loans)

			Up-Rate Scenario		Down-Rate Scenario	
Simulation	Product Type	LTV	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
12	30 YR. FRM	50%	−1.13%	−.85%	−.64%	−.05%
2	30 YR. FRM	80%	1.05%	.95%	1.54%	1.91%
13	30 YR. FRM	95%	3.17%	2.84%	6.04%	6.02%
16	15 YR. FRM	50%	−1.08%	−.76%	−.68%	−.12%
17	15 YR. FRM	80%	−.84%	−.58%	−.37%	.05%
18	15 YR. FRM	95%	−.57%	−.32%	.00%	.38%
19	ARM	50%	−1.10%	−.69%	−.67%	−.16%
20	ARM	80%	1.96%	1.89%	1.19%	1.44%
21	ARM	95%	8.94%	7.95%	8.23%	7.09%

The intermediate-term (15-year) FRMs have consistently lower credit losses than long-term (30-year) FRMs because the shorter-term loans amortize more quickly, and borrowers choosing those loans tend to have greater financial resources. For 50 percent LTV loans, the difference in credit losses is small, as credit losses are very low for loans of both terms. In the up-rate scenario, the 30-year loans benefit from slower amortization, which results in more guarantee fees. In both the 80 percent and 95 percent LTV categories, the more favorable incremental capital effects of 15-year loans reflect their greater safety. For 95 percent LTV loans, the 15-year loans have sharply lower credit losses, nearly 90 percent below those of 30-year FRMs.

ARM loans are riskier than 30-year FRMs at all LTV levels in the up-rate scenario, with the differences becoming more pronounced as LTV ratios rise. ARM credit losses in the up-rate scenario are only modestly higher than 30-year FRM credit losses for low LTV loans, but rise to more than double those for 30-year FRMs for high LTV loans. Credit losses for high LTV ARMs cumulate over the course of the stress period to 13.5 percent of the initial loan balances. As the loan interest rates adjust to their lifetime caps, some borrowers have difficulty meeting the elevated payments.

When interest rates decline, ARMs perform much better. They prepay much more slowly than FRMs in this environment and, therefore, produce substantially more guarantee fee income. At low and moderate LTVs, ARMs have more favorable capital effects than FRMs. However, the greater sensitivity of defaults on ARMs with high initial LTVs outweighs the benefits of higher fee income generated by such loans. While credit losses for high LTV ARMs are still much lower in the down-rate scenario than in the up-rate scenario, the discounted values of those losses are larger in the down-rate scenario because the discount rates are so much lower in that scenario. The capital effects depend on the discounted values, so they are nearly as large in the down-rate scenario for high LTV ARMs as they are in the up-rate scenario. Because of the high risk associated with high LTV ARMs, the Enterprises generally have not purchased ARMs with LTV ratios above 90 percent under their regular underwriting guidelines.

(vi) Differences in Multifamily Loans

The Enterprises deal in a large variety of multifamily loan products, and the products differ significantly between the Enterprises. The simulations reported in Table 13 show the incremental effects on required capital of multifamily loans with some relatively common characteristics. The additional sold loans in Simulation 22 are newly originated 15-year balloons with 70 percent LTVs, debt coverage ratios (DCR) of 1.3.[44] The Fannie Mae loans are assumed to provide partial recourse to the seller for losses, while the Freddie Mac loans do not. Accordingly, a higher guarantee fee is assumed for Freddie Mac loans, 75 basis points, than for Fannie Mae loans, 50 basis points. Simulations 23, 24, and 25 differ, respectively, by changing the balloon to five years, changing the LTV to 80 percent and the DCR to 1.2, and changing the loan age to five years.

[44] All of the multifamily loans were originated in the West Census Region with 8.5 percent coupons and servicing margins of 50 basis points.

Table 13. Incremental Capital for Multifamily Loans with Differing Characteristics (as a percent of Additional Sold Loans)

				Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Product Type**	**LTV**	**DCR**	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
New Loans							
22	15 YR Balloon	70%	1.3	.23	−.10	−1.49	−1.31
23	15 YR Balloon	80%	1.2	1.91	1.95	−1.38	−1.17
24	5 YR Balloon	70%	1.3	.24	.05	−1.02	−.65
5-YR Old Loans							
25	15 YR Balloon	70%	1.3	2.49	3.15	−.61	.12

Unlike single family loans, multifamily loans with a few years of seasoning have substantially higher credit losses during the stress period. Both types of loans generally have low credit losses in the first years after origination, then rise to a peak before declining. However, the peak loss years for multifamily loans come several years after those for single family loans. Thus, the five-year old loans in Simulation 25 experience more bad loss years than comparable new loans (Simulation 22). Credit losses for high LTV, low DCR loans (Simulation 23) are also higher than comparable lower LTV, higher DCR loans because there is a higher probability that the borrower would have an economic incentive to default during the stress period (no equity and negative cash flow). Five-year balloons have higher losses in the up-rate scenario because some properties would be unable to manage the higher interest rates that would accompany a new loan. In the down-rate scenario, five-year balloons terminate sooner and, thus, provide less guarantee fee income.

Multifamily loan losses are generally less than guarantee fee income in the down-rate scenario. This is especially true for newly originated loans because most of the loans prepay before reaching their peak loss years. Multifamily loans also benefit in the down-rate scenario from lower capitalization rates, which improve their estimated LTVs.

(vii) Differences in Mortgage Insurance on High LTV Loans

By law, conventional loans purchased by the Enterprises with LTVs greater than 80 percent require credit enhancement. Of the three types permitted, private mortgage insurance is by far the most commonly used. As described above, simulations involving additional guarantees for loans with 95 percent LTV ratios assume that the loans carry 30 percent coverage by a AA rated firm. The simulations reported in Table 14 show effects of varying insurance characteristics on single family loans. The guarantee additions in each case are for newly originated, long-term FRMs.

Table 14. Incremental Capital for 95 Percent LTV Loans with Differing Insurance Characteristics (as a percent of additional sold loans)

			Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Coverage**	**Credit Rating**	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
13	30%	AA	3.17%	2.84%	6.04%	6.02%
26	25%	AA	3.72%	3.30%	7.07%	7.00%
27	30%	AAA	2.99%	2.69%	5.73%	5.70%
28	30%	A	3.53%	3.12%	6.66%	6.61%

In 1995, both Enterprises raised their coverage requirements on 95 percent LTV loans from 25 percent to 30 percent. Credit losses in Simulation 26, with lower coverage than in Simulation 13 (but with all other characteristics are the same), are 15 percent higher in the down-rate scenario and 12 percent higher in the up-rate scenario than they are in Simulation 13. Because the discounted value of those changes is higher in the down-rate scenario, the

required capital is affected more significantly in that scenario. Reducing the credit quality of the coverage (Simulation 28) has much the same effect as reducing the amount of coverage, while improving the credit quality (Simulation 27) has the opposite effect.

(viii) Differences in Mortgage Interest Rates

Loans with low interest rates amortize more quickly and prepay more slowly. The reverse is true for high interest rate loans. Table 15 shows the results of simulations for newly originated, long-term FRMs with different interest rates. In practice, loans with different interest rates have been originated in different time periods. However, to isolate the effects of different mortgage interest rates, all loans are assumed to be made simultaneously.

Table 15. Incremental Capital for Sold Loans with Differing Mortgage Interest Rates (as a percent of additional sold loans)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	Mortgage Interest Rate	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
29	5.00%	.57%	.46%	−.12%	.11%
2	7.50%	1.05%	.95%	1.54%	1.91%
30	11.75%	1.58%	1.50%	2.31%	2.93%

Faster amortization improves loan quality, so credit losses are significantly lower for mortgages with low interest rates. Low interest rate loans also prepay significantly more slowly in the down-rate scenario, increasing guarantee fees. For Freddie Mac, these differences between high and low mortgage interest rates are accentuated by differences in float income. Freddie Mac holds prepayments for an extra month before passing them through to investors. During that month, Freddie Mac earns a market rate of return while paying investors at the mortgage security coupon rate. Float earnings are roughly the same for both high and low mortgage interest rates, but interest passthrough payments to investors are much lower on low rate mortgages, increasing net float income.

(ix) Differences Between Loans on Owner-Occupied and Investor-Owned Properties

Loans on owner-occupied properties present less credit risk than loans on investor-owned properties. Simulation 31, presented in Table 16, shows the effects on required capital of adding newly originated, long-term fixed-rate mortgages that are all investor-owned. Required capital for loans on investor-owned properties is substantially higher in all cases because of higher credit losses.

Table 16. Incremental Capital for Sold Loans with Differing Occupancy Status (as a percent of additional sold loans)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	Tenure	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
2	Owner-occupied[1]	1.05%	.95%	1.50%	1.91%
31	Investor-owned	2.06%	1.79%	2.26%	2.52%

[1] Assumes the average percentage of investor-owned loans in each Enterprise's existing portfolio, about three percent.

2. Commitments

While commitments to purchase mortgages may result in new mortgage guarantees or new retained mortgages, the risk accepted by the Enterprise at the time of commitment is comparable to the risk on new mortgage guarantees. The stress test treats mortgages delivered pursuant to commitments as guarantees of mortgages that are originated in the first few months of the stress test at market interest rates. Hence, no portfolio interest rate risk will be incurred. The mix of other characteristics of the loans reflects the mix of characteristics for existing guaranteed loans of the Enterprise that

were originated during the six months preceding the start of the stress period.

Simulation 32, shown in Table 17, shows the effects on required capital of increasing each Enterprise's commitments outstanding in June 1997 by $10 billion. The results are, essentially, an average of the effects on required capital of a mixture of new loans, in which the proportions of loans with particular characteristics (including guarantee fees) match those present in an Enterprise's recently originated and securitized loans. In the up-rate scenario, the effects are muted relative to those in the down-rate scenario because the model assumes that sellers deliver loans for only 75 percent of the commitment volumes.

Table 17. Incremental Capital for Additional Commitments (as a percent of additional commitments)

	Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
32	.65%	.65%	1.50%	1.86%

3. Assets and Liabilities

The Enterprises' other line of business is purchasing mortgages and mortgage securities for their asset portfolios and funding them with debt. As holders of mortgages, the Enterprises receive interest income, incur administrative expenses, and bear the risk of loss if a borrower defaults. As market interest rates change, the interest rate of a mortgage becomes more or less favorable, and the value of the mortgage will change. The Enterprises hedge this risk by issuing callable long-term debt, which changes in value in a corresponding way. They also enter into interest rate derivative contracts that further reduce the overall sensitivity of their income and net worth to interest rate changes. As a holder of mortgage securities, an Enterprise experiences cash flows, income, and risks similar to those experienced as a holder of whole mortgages except that the credit risk is borne by the security guarantor (usually the Enterprise itself, acting in its other principal role).

The stress test projects the flows of income and expenses associated with these assets in much the same way as it does for mortgage guarantees. However, principal and interest received by an Enterprise on retained mortgages and mortgage securities is not passed on to investors, and no credit losses are charged on asset holdings of mortgage securities guaranteed by either Enterprise or by the Government National Mortgage Association (Ginnie Mae). In addition, the stress test projects interest expenses associated with debt and cash flows associated with derivatives contracts.

a. Assets/Liabilities With Mixed Characteristics Reflecting Enterprise Portfolios

Table 18 shows the additional capital that would be required in both scenarios by a general increase in each Enterprise's assets and liabilities. It is not possible to isolate the average incremental capital effects of a general increase in an Enterprise's mortgage assets in the same way that Simulation 1 measured those effects for guaranteed mortgages. Critical factors in assessing the risk of asset positions are the characteristics of the debt and equity used to fund them. However, specific debt and equity issues cannot be matched with specific assets. It is possible, however, to obtain a measure of the incremental capital effects of a proportional $10 billion increase in all of an Enterprise's assets, including non-mortgage assets, and a simultaneous $10 billion increase in the Enterprise's liabilities and interest rate derivatives.[45]

Table 18. Incremental Capital for an Equal Proportional Increase in All Assets and Liabilities (as a percent of additional assets)

Up-Rate Scenario		Down-Rate Scenario	
Fannie Mae	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
4.38%	2.81%	2.06%	.55%

These results reflect some differences between the Enterprises in asset composition, but, mostly, differences in debt structure and derivatives use in June 1997. In three of the four cases, the incremental effects are close to or less

[45] The process is indirect, using the results of other simulations. The increase in required capital for an equal percentage increase in all of an Enterprise's positions, such that assets increase by $10 billion, is simply that percentage of the Enterprise's required capital for the base case simulations for June 1997. This increase includes increases in guarantees and commitments. The effect of these increases can be removed by subtracting the incremental effects of the guarantees and commitments as calculated in Simulations 1 and 32, after making adjustments for the differences between a $10 billion change in those factors and a change of the percentage amount used in the first step.

than the 2.50 percent minimum capital ratio for Enterprise assets. For both Enterprises, the incremental required capital effects of sold loans were higher in the down-rate scenario while the effects of asset holdings and liabilities are higher in the up-rate scenario. Thus, the combined risks of both types of activities are more balanced with respect to interest rates than the risks of either type separately.

b. Retained Loans With Specific Identical Risk Characteristics

The simulations discussed below show the effect on required capital of an increase in mortgage assets that is funded by debt. A first group of simulations shows how different characteristics of mortgages affect required capital in each scenario. Five-year, fixed-rate notes were used to fund mortgage assets in each of these simulations. Different funding would not have an appreciable effect on the relative results for mortgages of differing characteristics, as long as the funding was the same for each. In the second group of simulations, mortgage characteristics were held constant, while the funding varied among three alternatives.

The Enterprises have available, and utilize, a much wider range of funding alternatives than those used in these simulations. These alternatives include debt (both callable and non-callable) of different maturities, debt-derivative combinations that create synthetic debt with various maturity and call characteristics, and debt combined with swaptions (options on swaps) or with interest rate caps, floors, or corridors. Other hedging techniques, such as asset swaps, are also used. The proposed risk-based capital requirements are fully sensitive to all of these alternatives.

In the Simulations presented in Table 19, $10 billion of retained unsecuritized loans with specific risk characteristics were added to each Enterprise's asset portfolio. The assets were funded with $10 billion of five-year notes paying 6.5 percent interest, with no call options. The mortgages in Simulation 33 have the same characteristics as those in Simulation 2, except they have not been securitized. They are newly originated 30-year fixed-rate mortgages, with 80 percent LTV ratios and 7.5 percent contract interest rates from the West South Central Census Division. In Simulations 34 through 39, one risk characteristic (mortgage type, LTV, or age) has been changed from Simulation 29 to illustrate the relative effects on required capital of changes in various characteristics.[46]

Table 19. Incremental Capital for Retained Loans with Differing Characteristics, Funded with Five-Year Debt (as a percent of additional loan assets)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	Distinguishing Characteristic	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
33	[1]	7.95%	7.54%	8.53%	7.97%
34	15 Yr. FRM	1.35%	.40%	6.97%	6.47%
35	ARM	−16.54%	−14.29%	7.90%	6.83%
36	50% LTV	5.35%	4.41%	7.89%	7.55%
37	95% LTV	10.27%	10.36%	8.46%	7.54%
38	4 Yrs. Old	5.57%	4.69%	10.39%	9.39%
39	8 Yrs. Old	5.68%	5.02%	5.88%	4.81%

[1] Newly originated, 30-year FRMs with 80 percent LTV ratios.

As the results make clear, using solely five-year fixed-rate debt to fund mortgages would not be an appropriate funding strategy to guard against the risk of large, sustained changes in interest rates like those incorporated in the stress test. When market interest rates decline, fixed-rate mortgages prepay rapidly, and the five-year debt is outstanding far longer than most of the mortgages it originally funded. When market yields rise, fixed-rate mortgages prepay slowly, and the debt matures long before most of the mortgages are liquidated.

In the up-rate scenario, ARMs with fixed-rate funding reduce required capital because interest income rises with market yields (until lifetime caps are reached), while funding costs remain unchanged during the first five years. Differences in the impact on required capital of fixed-rate mortgages of different types in the up-rate scenario primarily reflect differences in credit losses. However, 15-year loans also benefit from faster amortization, making their loan lives correspond more closely to the maturity of the debt used to fund them.

[46] While these results are for additional retained whole loans, the effects on required capital of additional holdings of mortgage security assets, backed by loans with the same characteristics and funded with the same debt, can be closely approximated by subtracting the effects of additional guarantees of loans with those characteristics. (The comparable loan guarantee simulations are Simulations 2, 17, 20, 12, 13, 5, and 7 respectively.)

In the down-rate scenario, ARMs prepay more slowly than FRMs, but also provide lower interest income. Among fixed-rate types of loans, four-year-old loans prepay more rapidly than new or eight-year-old loans. High-LTV loans, on the other hand, prepay slowly because borrowers lack sufficient equity for refinancing. These differences in prepayment rates greatly affect the interest rate risk characteristics of the loans, so that if they are funded with the same liabilities, four-year old loans with 80 percent LTVs generate higher capital needs in down-rate scenario than new loans with 95 percent LTVs, despite much lower credit losses.

The proposed capital requirements are very sensitive to differences in funding strategies for mortgage assets because of the magnitude of the interest rate changes in the two scenarios. Table 20 shows the results of three alternative funding choices for newly originated long-term FRMs with 80 percent LTVs like those in Simulation 33.

Table 20. Incremental Capital for Fixed-Rate Mortgages with Differing Funding (as a percent of additional loan assets)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Funding**	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
40	Short-Term	26.86%	29.79%	−9.59%	−7.90%
41	Long-Term	−8.42%	−6.80%	30.27%	31.02%
42	Callable Long-Term	−3.86%	−2.99%	−.68%	−1.27%

Funding long-term FRMs with short-term debt (six-month discount notes) provides very substantial benefits when interest rates fall. The debt matures more rapidly than the mortgages, permitting an Enterprise to continue receiving the original yield on the mortgages, while paying much lower interest rates. Short-term funding, though, is extremely costly when interest rates rise because maturing debt must be replaced at much higher rates. A portfolio of long-term fixed-rate mortgages funded with short-term debt, such as those held by Fannie Mae and most thrifts in the late 1970s, would require a capital/asset ratio of well over 20 percent under the proposed rule.

Funding with long-term debt (ten-year notes with semi-annual interest payments at 6¾ percent) provides large benefits when interest rates rise, but is extremely costly when interest rates fall. Callable long-term debt (ten-year maturity, with a coupon of 7⅜ percent, not callable during the first two years) provides benefits in both scenarios.[47] The results for different funding mixes can be approximated by combining the results shown in Table 20 on a weighted average basis. Thus, for example, in June 1997, the incremental capital effects of new fixed-rate mortgages funded with 65 percent callable long-term debt, 19 percent short-term debt, and 16 percent long-term, non-callable debt would be in a range of 1.2 percent to 2.6 percent for both Enterprises in both interest rate scenarios. Less callable debt would be needed to achieve the same result for seasoned loans.

4. Administrative Costs

During the stress period, administrative costs depend not only on the volume of loans held or guaranteed, but also on the rate of spending in the quarter immediately preceding the start of the stress period. A higher rate of administrative expense before the stress period increases costs and depletes capital during the stress period. In Simulation 43, shown in Table 21, $10 million in annual administrative expense ($2.5 million at a quarterly rate) was added to each Enterprise's reported spending in the year preceding the date of the base case simulations (June 1997).

Table 21. Incremental Capital for Additional Administrative Expenses (per dollar of added annual expense)

	Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
43	$5.92	$4.72	$3.53	$2.76

The results in Table 21 show that if Fannie Mae's annual administrative expense rate had been $1 higher in the year preceding the stress period, its capital requirement would have been $5.92 higher in the up-rate scenario and $3.53 higher in the down-rate scenario. The stress test projects the higher expense rate to continue throughout the

[47] The interest rates of long-term debt used in the simulations roughly reflect what the average cost of such instruments would have been in June 1997.

ten years of the stress period, except that the dollar amount of additional expense declines in line with the outstanding loan volume. Thus, in the up-rate scenario, for example, the initial annual $1 increase in the expense rate leads to an additional $7.65 of administrative expenses during the stress period. Discounting, taxes, and dividends reduce the incremental required capital to $5.92, even after the 30 percent management and operations risk supplement. Required capital increases more in the up-rate scenario than the down-rate scenario because administrative expense is tied in the stress test to outstanding loan volumes, which are larger in the up-rate scenario.

The effect of increased administrative expenses on required capital is lower for Freddie Mac in both interest rate scenarios. This is true partly because Freddie Mac's mortgages have slightly shorter lives in both interest rate scenarios, but more importantly because Fannie Mae has disproportionately larger commitments outstanding at the start of the stress period. As commitments are transformed into loans during the early months of the stress period, Fannie Mae's overall loan balances rise relative to initial balances by more than Freddie Mac's. This effect is less significant in the up-rate scenario because only 75 percent of commitments become loans. However, Freddie Mac's costs in the up-rate scenario are reduced by taxes throughout the stress period, while Fannie Mae's are not. Therefore, Freddie Mac's administrative expense rate has a smaller effect on required capital in both interest rate scenarios.

5. External Economic Conditions

a. House Prices

Stress test results are also greatly affected by changes in external economic conditions. Seasoned mortgages in the base case simulations for June 1997 benefited from modest, but steady average house price appreciation of about three percent per year during the time between origination and the beginning of the stress period. In Simulations 46 and 47, shown in Table 22, the house price index was reduced by one percent and five percent, respectively, in the quarter immediately preceding the stress period (1997 Q2). That is, house price appreciation rates between the first and second quarters of 1997 were assumed to be one percentage point or five percentage points (4 or 20 percentage points at an annual rate) less than they actually were. Subsequent house price appreciation rates are the same as in previous simulations.

Table 22. Incremental Capital Caused By Lower House Prices (dollars in millions)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	Reduction in House Prices	Fannie Mae	Freddie Mac	Fannie Mae	Freddie Mac
44	1%	$620	$344	$890	$490
45	5%	$3270	$1920	$3303	$2579

When house prices are decreased by one percent, credit losses for each Enterprise increase by four to five percent in the up-rate scenario and by about seven percent in the down-rate scenario. The increases in credit losses when house prices are decreased by five percent are about five times as large as they are for a one percent house price decrease. The increases in incremental capital in both simulations are larger in the down-rate scenario because the decrease in house prices slows prepayment rates in that scenario, owing to higher probabilities of negative equity. Slower prepayment rates increase the volume of mortgages exposed to the risk of default. While loans also prepay more slowly in the up-rate scenario, prepayment rates in the base case simulation for that scenario are already so slow that a similar percentage change has little absolute effect.

The slowing of prepayment rates with lower house prices in the down-rate scenario also produces two benefits that offset much of the increase in loan losses: guarantee fee income and net interest income increase. The key factor causing the effects on required capital to be larger in the down-rate scenario is that discount rates are lower in that scenario, so the present value of similar additional credit losses is greater.

Differences in the changes in required capital between the Enterprises primarily reflect lower additional credit losses for Freddie Mac. Fannie Mae's losses are higher because its owned or guaranteed loan volume was about 45 percent larger than Freddie Mac's in June 1997 and its credit losses per dollar of loans are 11 to 14 percent higher in the simulations, owing to a somewhat riskier mix of loans.

b. Market Interest Rates

The behavior of interest rates in the months before the starting date of the stress test can also have a significant effect on required capital. In the simulations shown in Table 23, all market yields were assumed to be 200 basis points higher (Simulation 46), or lower (Simulation 47) in the month preceding the stress test period (June 1997) than they actually were.[48] The principal means by which this change in market yields affects required capital is through the change it causes in market interest rates during the last nine years of the stress test.[49]

[48] No changes were made to interest rates on asset, liability, or off-balance sheet positions that had been put in place during the month, but they constitute a small share of total positions, and the effects of adjusting interest rates for those positions would have been largely offsetting. Nor were any changes made to Enterprise hedge positions that they might have made had market yields actually changed.

[49] In the circumstances of June 1997 (or any other time since September 1991), the applicable statutory rule for determining the change in the ten-year constant maturity Treasury yield during the stress period is that it increases by 75 percent or decreases by 50 percent from the average over the preceding nine months. If interest rates were 200 basis points higher in June 1997, stress test rates would have risen to a level $200 \div 9 \times 1.75 = 39$ basis points higher for the last nine years in the up-rate scenario. And, in the down-rate scenario, rates

Continued

Table 23. Incremental Capital Caused by Differing Initial Interest Rate Levels (dollars in millions)

		Up-Rate Scenario		Down-Rate Scenario	
Simulation	**Change in June 1997 Yields**	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
46	+200 b.p.	$1598	$642	−$1132	−$220
47	−200 b.p.	−$2105	−$842	$694	$280

In Simulation 46, the hypothetical increases in June 1997 yields make the stress test more severe in the up-rate scenario and less severe in the down-rate scenario. Simulation 47 does the reverse. The size of the effects is much greater for Fannie Mae because its asset size was roughly double Freddie Mac's at the time, and because Fannie Mae's interest rate risk was less fully hedged then Freddie Mac's. Although changes in net interest income accounted for nearly all of the change in required capital, differences in prepayment rates in the down-rate scenarios of both simulations affected required capital through changes in other income and expense categories. Lower prepayment rates in Simulation 46 increased credit losses, but also increased guarantee fees. Higher prepayment rates in Simulation 47 decreased credit losses and guarantee fees.

c. Sensitivity to Risk Characteristics in Different Economic Environments

The results of the sensitivity analysis discussed above are dependent on the risk structure of the Enterprises and the economic conditions of June 1997. For example, as discussed above, credit losses on seasoned loans vary depending on house price behavior between the time of origination and the start of the stress test. At higher interest rate levels, the consequences of imperfectly matched assets and liabilities would be greater because stress test changes in interest rates would be larger. At lower interest rate levels, the effects would be smaller. Different Enterprise hedging strategies could affect reported sensitivities because they could result in a different pattern of profits and losses during the stress period, which could affect the role of taxes. Changes in common stock dividend payouts could affect the impact of dividends during the first year of the simulations.

C. Implications of the Proposed Rule

The Enterprises perform an important role in the nation's housing finance system. Although the current risk of an Enterprise failure is small, the continued financial health of the Enterprises cannot be taken for granted. Over the past two decades, failures of financial institutions have been commonplace, including more than 2900 banks and thrifts and a number of securities firms. The risks associated with Fannie Mae and Freddie Mac differ in some important ways from those associated with banks, thrifts, and securities firms. However, government sponsored enterprises are not immune to failure. Fannie Mae encountered serious financial difficulty in the early 1980s, recovering in large part because of a fortuitous decline in interest rates, and the Farm Credit System experienced serious problems later in the decade. Because of the Enterprises' key role and important public mission, Congress created OFHEO to ensure their safe and sound operation. The current combined obligations of the Enterprises amount to more than $1.7 trillion, and unlike banks, thrifts, and securities firms, no Enterprise obligations are backed by an insurance fund that could contribute toward meeting creditor claims.

The risk-based capital rule (in conjunction with OFHEO's other regulatory tools) is intended to reduce the risk of financial failure of an Enterprise. The rule can contribute to that goal by requiring the Enterprises to hold more capital or take less risk than they otherwise would in some or most potential circumstances, particularly those circumstances in which the danger of failure is greatest. In circumstances in which some capital or risk adjustment is necessary, the rule gives an Enterprise the flexibility to choose whether more capital, less risk, or a combination of the two best suits its business needs.

OFHEO believes that the proposed rule would effectively serve its intended role. By promoting the Enterprises' safety and soundness, the regulation promotes their ability to continue to carry out their public purposes.[50] These include providing stability in the secondary market for residential mortgages and providing access to mortgage credit in central cities, rural areas, and underserved areas.

Capital reduces the risk and costs of failure by absorbing losses. For most firms, debt markets provide strong capital discipline, penalizing a firm that is excessively leveraged with higher borrowing costs. That discipline is largely lacking for the Enterprises because of their government sponsored enterprise status. The lack of normal market discipline makes capital requirements particularly important for the Enterprises.

The minimum capital regulation, currently in place for the Enterprises, provides important protection against failure. It requires the Enterprises to have a minimally acceptable level of capital in relation to their overall size, regardless of their measurable risk. The establishment of the minimum capital standard was accompanied by considerable increases in capital at both Enterprises. Because, however, it is based on simple leverage ratios, it will not be sufficient if an Enterprise chooses to take risky financial positions or if market conditions move adversely and increase the risk of what had been less risky positions. By contrast, the proposed rule is quite sensitive to risk. It would require an Enterprise to increase capital when risk rises, well before the potential adverse

would have decreased to a level $200 \div 9 \times 0.50 = 11$ basis points higher. Similarly, if interest rates were 200 basis points lower in June 1997, stress test rates would have been 39 basis points lower in the last nine years of the up-rate scenario and would have fallen to a level 11 basis points lower in the last nine years of the down-rate scenario. These differences are incorporated in Simulations 46 and 47.

[50] 1992 Act, section 1302(2) (12 U.S.C. 4501(2)).

consequences of the rise would be reflected in the Enterprise's financial statements. Each of the two capital rules is an essential complement to the other.

1. Capital Requirements Under the Proposed Rule

Consistent with the purpose of reducing the risk of Enterprise failure, the proposed rule can be expected to influence how the Enterprises manage their risk and the amount of capital they hold. Table 24 shows actual total capital (amounts available to meet the risk-based capital requirement) and required total capital under the proposed rule for two dates: September 30, 1996 and June 30, 1997.[51] It also shows actual core capital (amounts available to meet the minimum capital requirement) and required core capital on the same dates. The difference between total capital and core capital is that total capital includes general loss reserves, while core capital does not.

Table 24. Actual Capital and Capital Required Under the Proposed Risk-Based Rule and the Existing Minimum Capital Rule (dollars in billions)

	Fannie Mae		Freddie Mac	
Risk-Based Capital Requirement (Proposed)				
Date	**Actual Total Capital**	**Required Total Capital**	**Actual Total Capital**	**Required Total Capital**
9/30/96	$13.05	$16.55	$7.23	$5.66
6/30/97	$14.05	$17.73	$8.11	$6.83
Minimum Capital Requirement				
Date	**Actual Core Capital**	**Required Core Capital**	**Actual Core Capital**	**Required Core Capital**
9/30/96	$12.27	$11.12	$6.54	$6.28
6/30/97	$13.26	$11.94	$7.43	$6.80

Table 25 shows the surplus or deficit of total capital for both interest rate scenarios. The risk-based capital requirement for an Enterprise is based on the scenario that would result in the greatest deficit or smallest surplus. To meet the requirement, an Enterprise must not have a capital deficit in either scenario. Freddie Mac would have had a risk-based capital surplus of 28 percent on the 1996 date and 19 percent in 1997, while Fannie Mae would have had a deficit on each date of 21 percent. In contrast, both firms met the existing minimum capital standard on both dates, with surpluses ranging from 4 percent to 11 percent. Thus, the risk-based capital requirement would have been much higher than the minimum capital requirement for Fannie Mae, even after taking account of the differences in the definition of capital under the two standards. For Freddie Mac, however, the minimum capital requirement would have been higher than the risk-based capital requirement. Thus, the risk-based standard would not have imposed any additional requirement on Freddie Mac on those dates. The primary reason Fannie Mae's risk-based capital requirement would have exceeded its minimum capital requirement, while Freddie Mac's would not, is that Freddie Mac's asset/liability structure was more fully hedged against interest rate risk than Fannie Mae's.

[51] These results include estimated effects on required total capital for three provisions of the proposed rule that require credit ratings: credit losses on non-mortgage investments; on derivative contracts; and on rated mortgage-related securities, such as mortgage revenue bonds. OFHEO assumed that 50 percent of non-mortgage investments are rated AAA, 35 percent are rated AA, and 15 percent are rated A. The percentages for derivative contracts are 85, 15, and 0, respectively; and those for rated mortgage-related securities are 70, 30, and 0, respectively. The results do not reflect the effects of master netting agreements, nor haircuts on foreign-denominated contracts. Multifamily credit enhancements, other than those for Fannie Mae's DUS product are not modeled explicitly, but are assumed to reduce loss severities by 15.9 percentage points.

Table 25. Surplus or Deficit Total Capital of the Enterprises Using the Proposed Rule for September 30, 1996 and June 30, 1997 (dollars in billions)

	Up-Rate Scenario		Down-Rate Scenario	
Dates	**Fannie Mae**	**Freddie Mac**	**Fannie Mae**	**Freddie Mac**
9/30/96	−$3.50	$1.61	−$3.25	$1.57
6/30/97	−$3.68	$3.18	−$.95	$1.28

Risk-based capital requirements in the future may vary significantly, depending not only on the Enterprises' assets and obligations, but also on contemporary economic conditions. Declines in house prices in the years preceding the starting date of the stress test can greatly raise capital requirements under the proposed rule, and rapid house price appreciation during these years can greatly reduce them. Unhedged interest rate exposures would require greater capital when interest rates are higher at the start of the stress period because changes in interest rates during the stress period will be greater. The reverse is true when interest rates are lower. Economic environments entailing greater than usual uncertainty about future interest rates or mortgage defaults will be accompanied by higher costs for hedges, such as callable debt or credit enhancements. In the absence of a risk-based capital standard, an Enterprise might choose to maintain capital and hedges that would be sufficient to meet the proposed standard in low risk environments, but might not do so in high risk environments owing to the higher cost of capital and hedges in such environments.

2. Enterprise Adjustments To Meet the Proposed Standard

An Enterprise with capital and risk preferences that are not consistent with the proposed standard could adjust to the standard by either increasing capital or decreasing risk or both. Capital can be increased by reducing share repurchases, adjusting dividends, or issuing new equity shares. Enterprise risk can be reduced by increasing the use of interest rate and credit risk hedges, after risk is taken on, or by reducing the amount of risk taken on.

Financial markets currently provide a wide range of hedges against interest rate risk. These include, among others: callable long-term debt, caps and floors, and swaps and swaptions. Adding interest rate risk hedges may frequently be cheaper than increasing equity. For example, based on the differences in results of Simulations 40, 41, and 42 shown in Table 20, Fannie Mae could have met the proposed standard in June 1997 by issuing $22 billion of callable ten-year notes and using the proceeds to pay off $14 billion of short-term debt and repurchase $8 billion of ten-year notes.[52] Given the market yields at that time, such a change in debt structure would have cost less than $200 million on an annual basis, after taxes. However, because this debt restructuring would have provided substantial benefits in terms of reduced risk, the net cost would have been much lower.

Changes in an Enterprise's asset/liability structure to reduce interest rate risk, such as the one described in the above example, may be much cheaper than raising new equity. If the annual cost of equity capital is assumed to be 15 percent, the net cost of raising sufficient equity would have been roughly $385 million.[53] Other forms of liability restructuring, or changes in the interest rate risk characteristics of the assets, might have resulted in lower costs than those estimated here for hypothetical changes in debt structure. Fannie Mae anticipated the likelihood of such opportunities in its comment on OFHEO's ANPR: ''* * * if the [mortgage] portfolio is in a position where its risk-based capital requirement exceeds its actual capital, the practical remedy would be to change the portfolio's asset/liability structure so that this is no longer the case.'' An alternative way for an Enterprise to reduce its interest rate risk is simply to reduce the size of its asset portfolio. Given the high profitability of those portfolios in recent years, that currently would not be a likely choice.

Increasingly, credit risk can also be hedged in financial markets. Freddie Mac's 1998 MODERNS transaction effectively transferred a portion of the credit risk on its 1996 mortgage purchases to investors in the new securities.[54] Further development of the credit derivatives market may provide additional opportunities for transferring credit risk in the future. An Enterprise can also reduce its credit risk by requiring or acquiring more credit enhancements. As an example, the Enterprises increased requirements for mortgage insurance on 95 percent LTV loans starting in 1995.

Finally, an Enterprise could adjust to a capital shortage by curtailing the size of its mortgage guarantee business. Such a measure is likely to be taken only as a last resort, as that business is the primary means by which an Enterprise fulfills its fundamental public purposes. As long as that business is profitable, an Enterprise is likely to prefer to restructure its asset/liability positions, obtain more credit risk hedges, or, if necessary, raise additional capital. If the Enterprise is financially safe and sound, raising additional equity capital should not be difficult. Because the proposed rule should help ensure the Enterprise's continued healthy financial condition, the rule would make it less, rather than more, likely that the Enterprise will need to restrict its activities.

3. Guarantee Fees

It is unlikely that the proposed rule will have any material effects on the general level of guarantee fees charged by the Enterprises. The stress test results make it particularly unlikely that the rule would have any effects on guarantee fees in economic environments like those of the recent

[52] The interest rates of long-term debt used in the simulations roughly reflect what the average cost of such instruments would have been in June 1997.

[53] In its analysis supporting its affordable housing goal rule, HUD used an estimate for the cost of equity capital of 17 percent, but subsequent increases in price-earnings ratios suggest a smaller number for more recent dates. The cost calculation assumes that the additional equity would have replaced an equal amount of debt.

[54] Investor returns on the securities are dependent on the rate of defaults in a pool of mortgages representing 17.4 percent of Freddie Mac's single family, 30-year FRMs purchased in 1996.

past. Freddie Mac would have met the risk-based standard in 1996 and 1997 by substantial margins, without any changes to its balance sheet or business operations. Thus, the risk-based capital standard would not have given Freddie Mac any cause to raise guarantee fee levels. Fannie Mae would not have been able to, if it wished to maintain its competitive position. In the future, there may be circumstances in which the capital or risk positions of both Enterprises are affected simultaneously by the risk-based standard. The analysis of such cases is more complicated. However, the duopolistic structure of the secondary mortgage market and the generally small impact of the guarantee business on required capital make it unlikely that the standard would affect guarantee fees in those circumstances, either.

Guarantee fees compensate the Enterprises for assuming credit risk on the mortgages they purchase in the secondary market. They may be explicit, as they are for securitized loans, or implicit, as they are for loans purchased for Enterprise portfolios. These fees primarily cover expected credit losses and operating expenses, but include a return to the capital needed to protect against more severe credit losses in adverse environments. The need to provide such a return effectively makes capital a component of cost in the Enterprises' secondary market activities.

In a fully competitive market, a regulation (such as a capital regulation) that raises the marginal costs of all firms in that market would result in higher prices (guarantee fees in this case). However, the secondary mortgage market is not fully competitive.[55] Fannie Mae and Freddie Mac constitute virtually the entire buy side of the secondary market for fixed-rate conforming, conventional mortgages, making that market a duopoly.[56] In a duopoly, the two firms generally exercise market power by charging prices (the guarantee fee) in excess of marginal cost, and thereby recognizing economic profits.

In theory, the guarantee fee charged by Fannie Mae and Freddie Mac may range between the perfectly competitive rate (where the fee equals the firms' marginal cost) and the monopoly rate (where the fee maximizes the two firms' joint profits as if they were operating as a cartel). If the fee at which other firms may enter the market is less than the monopoly fee, then the maximum fee would be that at which entry would take place.

The Enterprises' current guarantee fees reflect the profit-maximizing decisions of both Enterprises. These decisions are affected by the degree of competition between the two firms, the threat of entry by other firms, and activities necessary to maintain or enhance the value of their public charters. The current level of guarantee fees already reflects the maximum guarantee fees that each Enterprise feels it can charge without reducing long-run profits. If this were not the case, Enterprise shareholders likely would object. In such circumstances, a small increase in capital (or any other) cost is unlikely to affect guarantee fees. Only if the cost increase was sufficiently large to raise marginal cost (including an adequate return to attract capital) above the current fee level, would a fee increase reasonably be expected.

The Treasury Department and the Congressional Budget Office estimated in 1996 that the Enterprises collected roughly five basis points (0.05 percent) in fees for their mortgage-backed security guarantees above what they would need to recover costs plus a normal profit margin.[57] After taxes (at an effective rate of 30 percent), that amounts to 3.5 basis points. A risk-based capital standard that raised the capital costs associated with the Enterprises' guarantee business by less than that amount would still allow the Enterprises to earn returns above a normal profit margin.

If a new capital standard required an Enterprise to increase its equity when it increased its guarantee business, its capital cost per dollar of new guarantee business would be the amount of additional capital required times the cost of new equity capital, perhaps 15 percent. The proposed rule, however, provides an alternative to raising equity, which is to reduce some other risk. As shown in the previous section, Fannie Mae could meet an overall higher capital requirement of $3.68 billion at an after-tax cost of less than $200 million in June 1997. The cost per dollar of additional capital requirements was only about 5.4 cents (0.20 ÷ 3.68). An additional dollar of capital requirements associated with new guarantee business could be met in the same way. Based on that cost of capital, if an additional dollar of guarantee business caused required capital under the new standard to be 65 basis points greater than under the existing standard, the additional capital cost would be only as great as the duopoly surplus margin of 3.5 basis points ($65 \times .054 = 3.5$).

In the absence of a risk-based capital standard, regulatory capital costs are based on the existing minimum capital leverage ratio for mortgage-backed security guarantees, which is 0.45 percent (45 basis points). A comparison with the incremental capital required for sold loans under the risk-based capital requirement must take into account that the leverage requirement can be met only with equity (core) capital, while the risk-based requirement can be met with both equity and reserves (total capital). Reserves for losses on mortgage-backed security guarantees average about seven basis points per dollar of guarantees at both Enterprises, so the comparable minimum capital requirement in terms of total capital is 52 basis points. Thus, a risk-based capital standard could potentially raise the incremental amount of total capital required for sold loans to as much as 117 basis points (52 + 65) and still allow the Enterprises to earn sufficient profits to continue to attract capital.

Even greater increases would be unlikely to affect guarantee fees in circumstances when the capital and risk decisions of one or both Enterprises are unaffected by the risk-based standard, as was presumably the case for Freddie Mac on the two recent dates for which risk-based capital calculations have been performed. If the risk-based standard were binding (affected capital or risk decisions) for only one of the Enterprises, then, even if its incremental risk-based requirements for sold loans were very much higher than the minimum capital ratio, it would be difficult for that Enterprise to raise guarantee fees independently. Doing so likely would cause it to lose market share and profits to the other Enterprise.

Even if the risk-based standard were binding on both Enterprises, it appears unlikely that the proposed standard would raise the capital required for the Enterprises' mortgage guarantee business to as much as 117 basis points. The results of a simulated increase in

[55] For a fuller discussion of secondary mortgage market structure and behavior, see Benjamin E. Hermalin and Dwight M. Jaffe, ''The Privatization of Fannie Mae and Freddie Mac: Implications for Mortgage Industry Structure,'' in *Studies on Privatizing Fannie Mae and Freddie Mac,* U.S. Department of Housing and Urban Development, May 1996. This paper was jointly commissioned by HUD, the Department of the Treasury, the General Accounting Office, and the Congressional Budget Office.

[56] The ''buy side'' terminology here is traditional but confusing. The Enterprises are either buying mortgages or selling guarantees. Either way, they are charging implicit or explicit fees for assuming credit risk.

[57] U.S. Department of the Treasury, *The Government Sponsorship of the Federal National Mortgage Association and the Federal Home Loan Mortgage Corporation,* July 11, 1996; The Congressional Budget Office, *Assessing the Public Costs and Benefits of Fannie Mae and Freddie Mac,* May, 1996.

overall MBS guarantee volumes, shown in Table 6, indicate that the incremental capital required in 1997 for the up-rate scenario of the risk-based standard was well below the 52 basis points needed to meet the minimum capital standard. In the down-rate scenario, incremental capital of as much as 89 basis points would have been needed, but that is still substantially below the 117 basis points level that potentially would trigger a rise in guarantee fees.

While the results referred to in Table 5 are informative, an Enterprise evaluating the capital costs associated with its mortgage guarantee business would properly focus on its prospective costs at future dates. To do so, it would want to estimate the likelihood of its being bound by the risk-based standard in the future, and if it thought it would be bound, the relative likelihood of being bound by the up-rate and down-rate scenarios. It would also want to make informed guesses about the other Enterprise's estimations on its own behalf. Finally, it would want to estimate the likelihood of significantly higher incremental capital requirements for sold loans under the risk-based standard.

These incremental requirements will be affected by the pace of house price appreciation in the years preceding the date of capital calculation. The figures in Table 5 reflect annual appreciation of about three percent, lower than long-run historical averages. If an Enterprise anticipated stagnant or declining house prices over an extended period of time, and if it believed both itself and the other Enterprise likely would be bound by the risk-based standard, particularly the down-rate scenario, it might have an incentive to raise guarantee fees. In such a circumstance, its expected losses would also rise, and likely by far more than its capital costs. The higher expected losses would, in that case, be the principal cause of higher fees.

A riskier interest rate environment could also affect projected capital costs. If the cost of interest rate risk hedges rose dramatically, so that it became cheaper to meet shortfalls in required capital by raising new equity than by increasing interest rate hedges, any increase in capital required by an Enterprise's sold loans would be more costly and more likely to lead to a small increase in guarantee fees. However, providing adequate protection in unusually risky economic environments, such as those with much higher interest rate hedging costs or persistent weakness of house prices is a fundamental purpose of the risk-based capital standard.

OFHEO has also considered the possibility that the proposed standard, while not affecting the general level of guarantee fees, could affect the fees charged directly or indirectly on loans made to low income borrowers. Such effects are unlikely and would, in any event, be minimal. Consequently, the risk-based capital standard will not significantly affect the Enterprises' ability to purchase affordable housing loans. These conclusions are based on several considerations. First, the capital surpluses that Freddie Mac would have held in 1996 and 1997 under the rule show that no changes in any Enterprise fees or loan-purchase practices would have been justified in recent economic environments.

Second, with respect to potentially more adverse environments, the capital cost of single family loans meeting the Enterprises' affordable housing goals should not be materially different, on average, from the cost of other loans. The stress test makes no specific distinctions among loans to different income groups. However, the stress test does distinguish single family loans according to LTV class and some Enterprise affordable products are high LTV loans. The simulation results in Section II. B., Sensitivity of Capital Requirements to Risk, show that high LTV single family loans are generally riskier and affect risk-based capital requirements more than other loans. However, the overall LTV distribution of single family loans purchased by Fannie Mae and Freddie Mac for low- and moderate-income borrowers (borrowers with less than area median income) is practically the same as the LTV distribution of all their purchased loans. In fact, only a small percentage of the loans to low- and moderate-income borrowers purchased by the Enterprises are high LTV loans (those with LTV ratios above 90 percent).

Third, while high LTV loans have much higher than average risk, the simulation results overstate the capital implications of those loans. The results of Simulations 13 and 15, in Table 12, show incremental capital required under the risk-based standard for new and four-year-old loans, as of June 1997. For a weighted average of Enterprise loans guaranteed at that time, these incremental requirements were about 170 basis points above the comparable minimum capital ratio in the up-rate scenario, and about 325 basis points above in the down-rate scenario. Those differences in capital required, however, overstate the impact of high LTV loans because they assume only an average level of guarantee fees. As discussed earlier, the Enterprises generally charge higher fees implicitly on such loans by adjusting the average fees charged to lenders according to the average risk of the loans they deliver. And as shown by the comparison of Simulations 2 and 3, in Table 8, differences in guarantee fees affect incremental capital requirements. The overstatement may be increased by the assumption that the Enterprises have priced these loans based on the incremental capital needed to meet the minimum standard. Both Enterprises use internal capital models that reflect the higher risk of high LTV loans and already may incorporate higher capital costs into the implicit fees charged for these loans.

Fourth, the capital implications of multifamily loans, which predominately benefit low- and moderate-income households, are mixed and serve, in some circumstances, as hedges for other high-risk loans. Simulations 22 to 25 show a wide variety of incremental capital requirements under the risk-based standard for June 1997. On a weighted average basis, accepting credit risk on multifamily loans lowered risk-based requirements in the down-rate scenario and raised them somewhat more than minimum capital requirements in the up-rate scenario. The results in the down-rate scenario are the reverse of the pattern for high LTV single family loans, so that higher costs on high LTV single family loans are substantially offset by lower costs on multifamily loans. In the up-rate scenario, the potential effects of high LTV loans and multifamily loans are similar, but not large.

Finally, even if the proposed rule did require some additional capital against a portion of the Enterprises affordable housing activities, such a requirement would be consistent with the Enterprises' charters and public mission. The Enterprises' charters specifically state that the return on required lending to low-and moderate-income borrowers may be less than the return earned on other activities.

4. Mortgage Interest Rates

The primary effects of the Enterprises' activities on mortgage interest rates occur through their roles as mortgage security guarantors. Mortgage security yields are determined in capital markets, and the interest rates borrowers pay reflect those yields plus the margins retained by the Enterprises, as guarantee fees, and those retained by lenders and servicers. Because of the dominant role of the Enterprises in the market for conforming, single family mortgages, increases in their guarantee fees would raise lenders' costs and translate fairly directly to changes in borrowers' costs.

However, because the proposed rule likely will have no material effect on guarantee fees, it would not have a significant effect on mortgage rates through the Enterprises' roles as mortgage guarantors.

As investors in mortgages and mortgage securities, the Enterprises may also affect mortgage rates indirectly. They now hold roughly an eighth of all conforming, single family mortgages, and massive changes in their purchase volumes could have some effect, at least temporarily, on prices in that market. However, the Enterprises do not dominate the mortgage investment asset market in the same way that they dominate the market for guarantees on conforming loans. Consequently, the effects on mortgage security yields of even substantial changes in their investment in mortgage securities would be small. Furthermore, the proposed rule is unlikely to have a substantial effect on Enterprises' purchases of mortgage assets. Freddie Mac added roughly $100 billion to its portfolio in the four years preceding the June 1997 simulations and still easily met the requirements of the proposed rule. Thus, it is unlikely that the proposed rule would affect the mortgage interest rates paid by borrowers through the Enterprises' roles as mortgage investors, either.

III. Issues, Alternatives Considered

A. Mortgage Performance

The 1992 Act requires the risk-based capital test to subject the Enterprises to specified adverse credit and interest rate risk conditions to determine the level of capital needed to survive a hypothetical ten-year stress period. The 1992 Act does not specifically refer to mortgage performance, but rather discusses the credit-risk portion of the stress test as including rates of mortgage default and loss severity. As a convenience, OFHEO used the term ''mortgage performance'' in the ANPR to facilitate discussion of the essential elements of credit risk, mortgage default and loss severity, as well as mortgage prepayment, a key element of interest rate risk. The 1992 Act's requirement to determine a prepayment experience consistent with the stress period is also relevant to credit risk, because loans that are paid off prior to maturity affect default rates by reducing the number of loans that have the potential to default and by increasing the proportion of loans likely to default. Together, default, prepayment, and loss severity define how a portfolio of mortgages will perform in the proposed stress test. That performance is a key element in determining the ability of an Enterprise to withstand the economic shocks imposed by the stress test.

To determine the level of capital needed to survive the stress test, the proposed regulation uses a monthly cash flow model to project the performance of each Enterprise during the stress period. Underlying the simulation of mortgage and mortgage security cash flows are models that project mortgage performance during the stress period.

This section discusses the issues, alternative approaches and related ANPR comments that were considered by OFHEO in developing models to project mortgage performance under economic conditions specified in the l992 Act. Section III. A. 1., Statutory Requirements describes relevant statutory requirements. Section III. A. 2., Overview of Mortgage Performance, explains how mortgage performance is measured and projected in the stress test. Next, in section III. A. 3., Statistical Models of Mortgage Performance, through section III. A. 7., Relating Losses to the Benchmark Loss Experience, the issues encountered by OFHEO in developing models of mortgage performance, along with relevant comments received in response to the ANPR, are discussed. Section III. A. 3., Statistical Models of Mortgage Performance, discusses OFHEO's decision to employ statistical models to predict default, prepayment, and severity rates. Section III. A. 4., General Methodological Issues, reviews general methodological issues encountered in making product distinctions and developing loan and property value data for use in estimating the statistical models and in applying those models in the stress test. Section III. A. 5., Default/Prepayment Issues, details the construction of the default and prepayment models, including use of conditional rates of default and prepayment, use of joint models of default and prepayment, and choice of the explanatory variables used in the models. Section III. A. 6., Loss Severity, moves from default and prepayment to issues encountered in modeling loss severity rates. Section III. A. 7., Relating Losses to the Benchmark Loss Experience, discusses issues arising from the statutory direction to reasonably relate stress test losses to the benchmark loss experience.

1. Statutory Requirements

The 1992 Act mandates a stress test based on a regional recession involving the highest rates of default and loss severity experienced during a period of at least two years in an area containing at least five percent of the total U.S. population.[58] This mandate required identifying a benchmark loss experience, which is the default and severity behavior of mortgage loans, in a place and time meeting statutory requirements, that resulted in the highest loss rate for any such place and time.[59] In this context, default and severity behavior means the frequency, timing, and magnitude of losses on mortgage loans, given the specific characteristics of those loans and the economic circumstances affecting those losses. The 1992 Act requires that default and severity rates in the stress test be reasonably related to this benchmark loss experience. In contrast, the 1992 Act does not prescribe any particular experience for the third key component of mortgage performance, prepayment. Rather, the Act requires that the Director determine prepayment levels, ''on the basis of available information, to be most consistent with the stress period.'' [60]

The 1992 Act requires the Director to take into account appropriate distinctions among mortgage product types and differences in loan seasoning. It also authorizes the Director to also take into account any other factors that the Director deems appropriate.[61] The statute defines the term ''seasoning'' as ''the change over time in the ratio of the unpaid principal balance of a mortgage to the value of the property by which such mortgage loan is secured.'' [62] The importance of seasoning is that a decline in a property's value can result in negative equity, the factor most predictive of rates of default.

The 1992 Act defines mortgage product type as a classification of one or more mortgage products having similar characteristics with respect to the property securing the loan, the interest rate, the priority of the lien, the term of the mortgage, the owner of the property (owner-occupant vs. investor), the nature of the amortization schedule, and any other characteristics as the Director may determine. Specifically, the 1992 Act requires OFHEO to take into account distinctions between different mortgage types, such as: (1) properties consisting of 1–4 residential units and those containing more than four units;

[58] 1992 Act, section 1361(a)(1) (12 U.S.C. 4611(a)(1)).

[59] *See* 61 FR 29592, June 11, 1996, in which OFHEO proposed procedures for establishing the benchmark loss experience.

[60] 1992 Act, section 1361(b)(2) (12 U.S.C. 4611(b)(2)).

[61] 1992 Act, section 1361(b)(1) (12 U.S.C. 4611(b)(1)).

[62] 1992 Act, section 1361(d)(1) (12 U.S.C. 4611(d)(1)).

(2) fixed and adjustable interest rates; (3) first and second liens; (4) terms of 1–15 years, terms of 16–30 years and terms of more than 30 years; (5) owner occupants and investors; and (6) fully amortizing loans and loans that are not fully amortizing.

The 1992 Act prescribes two interest rate scenarios, one with rates falling and the other with rates rising.[63] In each scenario, the ten-year constant maturity Treasury yield (CMT) experiences a significant change during the first year of the stress test, and then remains at the new level during the remaining nine years of the stress test. The capital requirement for each Enterprise is based on the scenario with the more adverse impact.[64] The 1992 Act recognizes that interest rates are related to credit risk as well as interest rate risk, specifically requiring that credit losses be adjusted for a correspondingly higher rate of general price inflation if applying the stress test results in an increase of more than 50 percent in the ten-year CMT.[65]

2. Overview of Mortgage Performance

The amount of capital needed to survive the stress conditions prescribed by statute is determined by the overall financial performance of the Enterprises' starting books of business, including all assets, liabilities, and off-balance sheet obligations, under the stress conditions. Mortgage performance contributes to the overall financial performance of an Enterprise during the stress period, because various sources of income and expense reflected on an Enterprise's income statement depend directly on mortgage performance. For example, guarantee fee income on securitized loans, net interest income on retained loans and securities, and losses on defaulting loans (offset by the receipt of private mortgage insurance payments and other third-party credit enhancements) all depend on the projected default and prepayment behavior of the underlying mortgage assets.

For purposes of the proposed regulation, mortgage performance is a function of the survival or termination of loans and, ultimately, the associated cash flows. Loan terminations can occur either through default (borrower failure to pay) or through prepayment (early payment in full). Prepayments have a significant impact on credit risk, because they affect the timing and rates of default. Prepayments also affect Enterprise income, because they cut off the income stream from interest payments or guarantee fees. Defaults likewise cut off the income stream, and, in addition, result directly in credit losses.

To understand how the stress test generates and uses mortgage performance information, the test may be viewed as comprised of three elements—models, stress test specifications, and data inputs. In the context of mortgage performance, the models are sets of equations designed to predict the performance of any group of Enterprise mortgages under any given set of economic circumstances. The model equations themselves are ''estimated'' based upon OFHEO's historical database of mortgage information to predict the most likely default and severity rates for any given group of mortgages under any given pattern of interest rates and house prices. These models are generic tools that could be used in many different stress tests with different specifications. The specifications actually define the ''stress'' in the stress test. They include adjustments to reflect statutory requirements, such as the requirement that default and severity rates be ''reasonably related'' to the benchmark experience or that interest rate increases greater than 50 percent reflect a correspondingly higher rate of inflation. The specifications also include the house price and residential rent paths and the interest rates that will apply during the stress period. The data inputs to the models can change each time the stress test is run. The data inputs include data on the characteristics of loans owned or guaranteed by the Enterprises, starting interest rates, and updated house and residential rent price indexes, which are used to calculate current equity in the loan collateral properties.

The general approach of the stress test to mortgage performance involves three main steps: (1) estimation of statistical models of mortgage performance (default, prepayment, and loan loss severity) using Enterprise data covering a wide range of historical experience; (2) adjustments to the statistical models to assure a reasonable relationship to the benchmark loss experience; and (3) application of the adjusted models to starting Enterprise mortgage portfolios in the stress test. To assist the reader in understanding the more detailed discussion of mortgage performance issues that follows, this section provides a brief summary of some key issues concerning of the statutory requirement to ''reasonably'' relate the performance of mortgages in the stress test to the benchmark experience.

Because the benchmark sample contained only newly-originated, fixed-rate, 30-year, owner-occupied, single family loans, the stress test could not simply apply the rates of default and losses in the benchmark loss experience and still take into account differences in mortgage product types, seasoning of mortgages, and other factors the Director considers appropriate, as required by the 1992 Act.[66] Thus, the first issue considered by OFHEO was how to link mortgage performance in the stress test to the benchmark loss experience. The primary question was whether to use a model-based approach to help link the performance of an Enterprise's current loan portfolio to the benchmark loss experience, or to rely upon a less sophisticated, but less risk-sensitive approach. For reasons discussed under section III. A. 3., Statistical Models of Mortgage Performance, OFHEO concluded that the benefits of using a model-based approach exceed any potential shortcomings.

The next key issue was the choice of variables to include in any statistical equations that would be part of a (statistical) model of mortgage performance. OFHEO's choices in this regard were again governed by the need to meet the multiple statutory objectives described above, while also implementing a credit stress test based on the historical benchmark loss experience. The stress test does not project all differences in loan performance that may have been identified in previous research. Rather, the factors used to project mortgage performance are limited to those necessary to: (1) reflect differences in characteristics of loans in implementing the credit risk stress component of the stress test as required by the 1992 Act; and (2) reflect differences in the interest rate environments experienced by the loans in the stress test.

Other factors that relate to or explain differences in mortgage performance are not, in OFHEO's view, appropriate to the proposed regulation. Specifically, the stress test does not attempt to adjust losses by incorporating factors to reflect changes in Enterprise business practices subsequent to the benchmark loan origination and loss experience.[67]

[63] 1992 Act, section 1361(a)(2) (12 U.S.C. 4611(a)(2)).

[64] 1992 Act, section 1361(a)(2) (12 U.S.C. 4611(a)(2)).

[65] 1992 Act, section 1361(a)(2)(E) (12 U.S.C. 4611(a)(2)(E)).

[66] 1992 Act, section 1361 (b)(1) (12 U.S.C. 4611 (b)(1)).

[67] For example, both Enterprises have made changes to their single family underwriting standards and practices since the time the benchmark loans were originated in 1983–84, but no underwriting variable is included. This particular issue is discussed in greater detail below, in the context of comments received in response to OFHEO's ANPR.

OFHEO believes that such adjustments would undermine the purpose and intent of the statutory requirements to implement a credit stress test based on the benchmark loss experience. In addition, although some business practices that contributed to the losses of the past may have been improved over time, a new severe economic environment may expose other unobservable weaknesses. Furthermore, in reasonably relating starting position loan portfolios to the ''experience'' of the benchmark loans, it is not possible to separate the effects of business practice from other aspects of the benchmark economic environment.

The proposed regulation also does not incorporate economic or demographic variables that are not specifically prescribed for the stress test, such as unemployment or divorce rates. Nor are such variables included in the estimation of the statistical model used in the stress test. If they were to be included, it would be necessary to assume values for these factors in the stress period—values that are consistent with the benchmark experience. Such an approach would substantially increase the number of variables for which assumptions would be required during the stress period, without gaining significant value in predicting credit losses for Enterprise loan portfolios.

3. Statistical Models of Mortgage Performance

A threshold issue for OFHEO was whether to develop statistical models of mortgage performance or to use a simpler approach, such as applying a table of historical default, prepayment, and loss severity rates.

a. ANPR Comments

Most of the comments related to this issue suggested that the direct application of benchmark rates of default, prepayment and loss severity would be problematic. A number of respondents to the ANPR cautioned that direct application of benchmark default rates, which were experienced during a period of declining interest rates, would not be appropriate for the up-rate scenario of the stress test. Freddie Mac suggested that OFHEO adjust benchmark default rates to the interest rate environment or use a proportional downward adjustment to credit losses. Mortgage Risk Assessment Corporation (MRAC) stated that it is important to model the interaction between expected losses and expected prepayments. America's Community Bankers (ACB) recommended joint modeling of prepayments and defaults as the best way to capture adjustments to housing values.

Fannie Mae, on the other hand, favored applying benchmark rates of default and loss severity directly. More specifically, Fannie Mae recommended that OFHEO model total loan terminations (defaults plus prepayments) using a commonly applied method of relating total terminations to interest rate movements (sometimes referred to as a ''total terminations model''). Fannie Mae recommended that the default portion of total terminations should be based on observed default rates for mortgages from the benchmark experience, with appropriate distinctions based on different LTV ratios, mortgage product, and risk categories. The level of prepayments would be calculated by subtracting those defaults from total terminations. Fannie Mae stated that a statistical model designed to predict defaults and prepayments simultaneously would be difficult to replicate because it would employ computer simulation methods based upon random numbers, known as Monte Carlo simulations. Fannie Mae also expressed concern that the Enterprises would have difficulty managing capital requirements based on econometrically derived relationships, rather than on the certainty of defined historical loss rates.

b. OFHEO Response

Based on its analysis of available information, including the ANPR comments and relevant academic literature, OFHEO found that statistical modeling has numerous advantages over alternative approaches, such as applying tables of default, prepayment, and loss severity rates from the benchmark experience.

First, statistical models are able to provide valid outcomes when data inputs occur in different combinations from those observed in the available historical data. This capability is important, because the benchmark loss experience does not include large enough sample sizes for all relevant loan products and risk classes to allow direct application of benchmark loss rates to the Enterprises' starting loan portfolios. Statistical models based on large samples of loans can capture differential mortgage performance across a wide variety of products and still allow the performance of each product to be related to the benchmark experience. OFHEO has access to a rich database, consisting of millions of detailed loan records from the Enterprises, which allows for a statistical model of defaults and prepayments that can capture the nuances of product distinctions.

Second, statistical models allow the stress test to extrapolate reasonably to out-of-sample events, such as the sustained adverse interest rate scenarios of the stress test.

Third, applying statistical models of mortgage performance provides the ability to impose multiple statutory requirements in a logically consistent manner. For example, the 1992 Act specifies rates of default and losses in the stress test that are reasonably related to the benchmark loss experience. The 1992 Act also provides that the Director take into account the impact of ''mortgage seasoning'' and a variety of other factors that delineate various mortgage product types (property type, amortization type, amortization terms, ownership type, etc.). Statistical models allow the stress test to address all these statutory provisions when applying the two adverse stress test interest rate scenarios.

OFHEO also found that using statistically derived models of default, prepayment, and loss severity together with a cash flow approach is the most accurate method to describe the financial performance of the Enterprises on a monthly basis over the ten-year stress period. Moreover, use of statistical models in the stress test is consistent with the 1992 Act[68] and the Congressional expectation expressed in the House Report that the risk-based capital standard ''will be an economic model that will test the enterprises' financial position under stressful economic situations.''[69] The House Report also noted that:

> [t]he Department of the Treasury, the Congressional Budget Office, the General Accounting Office, the Office of Management and Budget and HUD have all stated that the proper way to ensure that Fannie Mae and Freddie Mac have adequate capital is to use traditional capital ratios in combination with sophisticated financial models, or risk-based capital stress tests.[70]

Fannie Mae's recommendation to estimate a statistical model of total terminations with default rates fixed at benchmark levels would make it more difficult for the stress test to satisfy the

[68] The 1992 Act directs OFHEO to include in the regulation ''specific requirements, definitions, methods, variables, and parameters used under the risk-based capital test.'' This direction suggests that a statistical model was contemplated. The 1992 Act, section 1361(e)(2) (12 U.S.C. 4611(e)(2)). Further, the Director is required to ''provide copies of the statistical model or models'' to other government agencies. 1992 Act, section 1361(f) (12 U.S.C. 4611(f)).

[69] H.R. Rep. No. 102–206, at 62 (1991). *See also,* S. Rep. No. 102–282, at 24 (1992).

[70] H.R. Rep. No. 102–206, at 62 (1991).

provisions of the 1992 Act that require OFHEO to consider seasoning and the various loan characteristics described above. OFHEO is also concerned that a model that derives prepayment rates as suggested by Fannie Mae would not be consistent with section 1361(b)(2) of the 1992 Act, which directs that ''[c]haracteristics of the stress period other than those specifically set forth in subsection (a), such as prepayment experience . . ., will be those determined by the Director, on the basis of available information, to be most consistent with the stress period.'' The consistency of prepayment experience with the stress period is best achieved by modeling both prepayment and default rates, rather than using a statistical model of terminations with embedded default rates that are not statistically determined.

OFHEO also found that the total terminations models to which Fannie Mae refers are applied widely and usefully only in circumstances where credit losses are not an issue (for example, in pricing mortgage-backed securities for investors, where credit risk can be ignored because of agency guarantees), or when the available data do not allow the analyst to distinguish default terminations from voluntary prepayments (for example, in the pool level data available from commercial sources). This is not the case for the stress test.

OFHEO is sensitive to Fannie Mae's concern that a statistical model of defaults and prepayments would be difficult to replicate. OFHEO does not propose to base any component of the stress test on random number (Monte Carlo) simulations. The model is straightforward and transparent, so that it will be possible for the Enterprises to project default and prepayment patterns in the stress period using their own information about the composition of their business, and recent economic trends.

As for complexity, OFHEO believes that there is no fundamental difference in complexity between computing total termination rates from the models mentioned by Fannie Mae, and computing them from the separate default and prepayment rates generated by the model OFHEO has proposed. Once the statistical model OFHEO proposes has been estimated and calibrated, its application is no more difficult than the application of a table of historical default rates. That is, the model provides a means to ''look up'' the default or prepayment probabilities for loans with a particular set of characteristics. Further, under the approach proposed by Fannie Mae, the actual level of default rates applied in the stress period would not actually be fixed, but would vary with changes in the composition of an Enterprise's loan portfolio and trends in property values that update borrower equity values. Under either approach, determining the potential impact of market conditions or changes in an Enterprise's portfolio on its capital requirement is straightforward.

4. General Methodological Issues

A number of general issues arose in the context of using statistical models to project mortgage performance in the stress test. These issues required decisions about how to account for product differences, what sources of historical data to use in estimating the statistical models, and what level of data aggregation to use to estimate and project mortgage performance. In addition, OFHEO received a number of comments in response to ANPR questions on property valuation issues. These were also considered in developing and applying statistical models of mortgage performance. Each of these areas is considered in the following sections.

a. Product Differences

The 1992 Act requires the stress test to capture both the unique risk characteristics of various loan product and property types and adjust for changing economics (house prices and interest rates) over time. In deciding its approach to modeling default and prepayment rates, OFHEO found it necessary to treat single family and multifamily products separately because of the significant differences in collateral property types and loan terms explained below.

The nature of the collateral property differs substantially between single family and multifamily loans. Nearly all single family property mortgages held by the Enterprises are owner-occupied.[71] In contrast, multifamily collateral produces income from rentals. Multifamily mortgages are commercial loans on housing projects that compete for market share among a very mobile population with short-term rental contracts and relatively low moving costs. The household demographics of apartment renters vary greatly from those of single family homeowners and renters. The dynamics of construction cycles that accentuate market booms and busts are also different for single family and multifamily residences.

[71] Even those that are rentals rely upon the performance of one, or at most four, households.

Single family and multifamily mortgages generally have different loan terms. In particular, to balance the desire of borrowers for flexibility with the needs of investors for stability, multifamily mortgages typically have ten- to fifteen-year balloon terms and initial yield-maintenance periods of seven to ten years. During the yield-maintenance period, borrowers may prepay, but they are subject to a prepayment penalty until the maintenance period expires. Such prepayment disincentives are not used in single family lending. Also, in contrast to single family mortgages, multifamily mortgages tend to be non-recourse, which means that multifamily lenders and guarantors, have recourse only to the collateral, and not to the borrower's other assets and income.

Because of these differences, OFHEO developed separate mortgage termination models for single family and multifamily mortgages, with all other property and product type differences handled as subsets of these two primary classifications. This approach is consistent with comments from HUD, Freddie Mac, ACB, and Mortgage Bankers Association of America (MBA). However, there are many issues common to both the multifamily and single family models, and the general modeling approach to both models is similar in many respects.

In the ANPR, OFHEO solicited public comment on modeling approaches generally and, more specifically, on how to relate the credit risk of other loan product types to the 30-year fixed-rate mortgages used to identify the benchmark experience. These comments are addressed below in section III. A. 7., Relating Losses to the Benchmark Loss Experience.

b. Historical Analysis Data

Another modeling issue faced by OFHEO was whether to use only Enterprise data to estimate statistical models, or to use data from a wider array of sources. A similar issue arose in the context of identifying the benchmark loss experience. After considering ANPR comments, OFHEO found that Enterprise data sets were the most relevant sources currently available for determining a benchmark loss experience, because Enterprise data is the most representative of the experience of loans owned or guaranteed by the Enterprises. Further, using Enterprise data is consistent with the general practice of banking and thrift industry regulators and credit rating agencies, which is to use data on the loss experience of comparable assets

for the relevant industry to determine credit quality and/or capital adequacy.

For the same reasons, OFHEO also used Enterprise data to estimate the statistical models for default and prepayment in the proposed stress test. Using Enterprise data for this purpose provides consistency between the estimates of the benchmark loss experience, the estimation of the statistical models for default and prepayment, and the aggregation of loan level data to create starting position data for the stress test. It will also permit OFHEO to update the statistical models over time, as needed, to capture new performance dynamics and/or new products.

c. Aggregation

Another threshold issue for OFHEO was how to aggregate loan level data to reduce the number of data records that must be stored and processed, while preserving sufficient detail to capture differences in loan performance among important risk classes in the stress test.

(i) ANPR Comments

MRAC stated that a loan level model would be most appropriate if data were available, but a model that aggregates on the basis of the origination year, loan term, coupon rate and current loan-to-value ratio (CLTV) would be acceptable. Freddie Mac recommended that, if OFHEO were to use a joint default/prepayment model, OFHEO should construct a pool for each origination year, aggregated by mortgage product, property type, occupancy status, and CLTV. Both MRAC and Freddie Mac recommended that OFHEO not only aggregate data according to CLTV, but also use CLTV as an explanatory variable in statistical models of default and prepayment rates.

(ii) OFHEO Response

OFHEO proposes to aggregate single family loan level data into loan groups based on the following characteristics: Enterprise, portfolio type (securitized vs. retained), product type, origination year, original LTV, original coupon, and region (Census division). Multifamily loans are aggregated using the same categorical variables as for single family loans, with an additional aggregation class for original debt-coverage-ratio values. Single family loans purchased during the stress period under existing contractual commitments are grouped using all of the characteristics of existing loans plus month of origination (representing the timing of delivery during the stress period). All loan group records include additional fields for measured characteristics, such as the total unpaid balance (UPB) for loans held in portfolio, UPB-weighted average values for guarantee fees for securitized loans, and original term-to-maturity.

OFHEO chose not to propose CLTV as a criterion for data aggregation. Attempting to aggregate data by CLTV would be problematic because CLTV value changes throughout the stress period. However, CLTV is used to compute important explanatory variables used to predict default, prepayment, and severity rates. These variables rely upon CLTV to incorporate a loan seasoning process that updates property values at the start of the stress test and then throughout the stress period.

d. Property Valuation

The 1992 Act requires that OFHEO take into account the impact of the ''seasoning'' of mortgages on mortgage performance. As that term is used in the statute, it requires accounting for changes in LTV due to changes in housing values and the repayment of loan principal. Accounting for changes in LTVs requires some method of updating property values, in addition to computing scheduled amortization. The first NPR proposed using the House Price Index (HPI), developed by OFHEO, as the basis for updating single family housing values to meet the statutory requirement for loan seasoning, in lieu of the Constant Quality House Price Index published by the Secretary of Commerce.[72] The HPI, which is published quarterly, provides average house price appreciation rates for the nation, the 50 States and the District of Columbia, and the nine Census divisions. It uses repeated observations of housing values on individual single family residential properties. These repeat observations arise where at least two primary mortgages on the same property were purchased by either Freddie Mac or Fannie Mae since January 1975.[73] Index values are published starting with 1980.

In this NPR, OFHEO proposes the method by which loan seasoning will be used to predict credit losses in the stress test, both for single family and multifamily mortgages. For single family mortgages, the OFHEO HPI is supplemented with various measures of the distribution of individual house price growth paths around the average values measured by the index. Three terms—dispersion, volatility, and diffusion—are important concepts for understanding these measures and how the stress test fulfills the statutory requirement that mortgage loans be seasoned. ''Dispersion,'' refers to the distribution, at any point in time, of the (cumulative) growth rates for values of each house in a group, around the average growth rate for that group. Dispersion results from ''volatility'' or variability of growth rate paths on individual properties from the average growth rate path for all properties. Volatility, like dispersion, can be measured through statistical relationships. The underlying process by which a model generates individual house price growth paths to yield various levels of volatility and dispersion over time is called ''diffusion.''

Similar procedures are used to season multifamily loans, except that there is no underlying property value index. Rather, property value is estimated using indexes that first update property cash flows. Still, the concepts of dispersion, volatility, and diffusion apply to multifamily property values, and to the principal measures of borrower equity in models of multifamily mortgage performance.

The ANPR posed several questions related to measurement of house price dispersion and to the statistical validity of the HPI as a price index. Issues raised by these questions will be discussed below.[74] They are: the appropriate level of geographic aggregation for the HPI in the stress test, how to account for the dispersion of house prices around the mean in the loan seasoning process, and whether and how to adjust for statistical biases and revision volatility inherent in the HPI data and estimation methodology.[75]

(i) Geographic Aggregation

OFHEO's HPI is estimated at the level of individual States and the nine Census divisions. A national index is also produced as a population-weighted average of the nine Census division indexes. Decisions regarding the level of geographic aggregation at which to estimate and apply house price indexes

[72] 61 FR 29616, June 11, l996.

[73] The procedures underlying the estimation of the HPI assume that individual house price growth rates will be distributed around the average growth rate through a log normal diffusion process.

[74] The first NPR proposed the HPI as the index OFHEO would use to season loans in the stress test, but did not address how OFHEO would use that index in the stress test. Comments regarding the first NPR will be addressed, together with comments on this NPR, when OFHEO publishes a final Risk-Based Capital regulation.

[75] ''Revision volatility'' refers to changes in previously estimated index values that occur as a result of the addition to the data of new repeat transaction pairs associated with current transactions. Current transactions can change index values for prior quarters, because every repeat sale of a property provides additional information about house price changes during the time since the prior transaction on that property.

typically involve a tradeoff between the need to identify relatively homogeneous market areas and the need for large enough samples of repeat transactions to assure the accuracy of the indexes. This is, simply put, a trade-off between the advantages and disadvantages of creating indexes for smaller versus larger geographic areas.

At lower levels of geographic aggregation, both property types and the local factors influencing house prices are more likely to be similar, and therefore the average appreciation rate is likely to be more representative of the trend in individual property values. However, lower levels of geographic aggregation result in relatively fewer observations for estimation, resulting in increased sampling error in the estimated house price index.[76] At larger levels of geographic aggregation, the greater number of observations may yield estimates of average price growth with smaller sampling errors, but at the risk of not projecting accurately the appreciation rates of the various submarkets.[77]

(a) ANPR Comments

A number of comments were received on the issue of geographic aggregation of house price indexes. All commenters implicitly recognized the tradeoff involved in choosing the level of geographic aggregation. The National Association of Realtors (NAR) recommended using the lowest level of market aggregation possible, while at the same time minimizing the variance of individual house prices in a market area, and urged that the optimum level of aggregation be determined by computational considerations. MRAC recommended that the choice of aggregation level be driven by objective, external criteria, such as minimizing estimation errors, and described its practice of using the lowest level of geographic aggregation in constructing its indexes, while using higher levels of aggregation for computing the variances. Freddie Mac recommended that OFHEO use house price indexes computed at the Census division level to avoid the need to rely on what it called ''highly uncertain individual house-price volatility processes'' that would be associated with the use of a national index together with corresponding volatility measures. In addition, when compared to State or local level house price indexes, Census division level indexes would have lower standard errors and thus more reliable predictions.

(b) OFHEO's Response

The choice of aggregation level of the HPI for the stress test is, ultimately, a selection of the level that is most appropriate for the seasoning of mortgages when estimating and projecting mortgage performance. Because the stress test cannot determine the value of each house securing every loan, some type of aggregation is needed. The proposed stress test, therefore, combines estimates of average trends in house prices with estimates of the dispersion of individual appreciation rates around the average growth rate within a given geographic area. This approach provides the maximum relevant information about the equity position of borrowers.

After considering the alternatives and the comments, OFHEO believes that using HPI indexes computed at the Census division level combined with estimates of dispersion of individual appreciation rates around the divisional indexes would be appropriate. OFHEO found that available data is not sufficient to generate statistically valid State-level indexes for some of the less populous States. OFHEO has not proposed to use indexes below the State level (at the metropolitan statistical area (MSA) level, for example), because there are too few areas in which statistically valid indexes can be estimated.

OFHEO agrees with Freddie Mac's comment that Census division indexes without volatility measures reflect regional dispersion better than using a national index with such measures. While OFHEO does publish State-level HPI series, these series are not statistically valid for some of the less populated States. Using Census division indexes, in combination with estimates of individual house price volatility and the resulting dispersion in each division, provides a more complete characterization of housing value dynamics both within and across regions.

MRAC's practice of using a larger level of geographic aggregation for volatility estimates than is used for the price index itself is appropriate when price indexes are based on very small aggregation levels, for example, at the MSA level. Using a larger area to measure volatility helps to diminish the small sample problems of generating price indexes for very localized markets. However, the same is not true when estimating price indexes at the Census division level, because there are no small-sample problems at that level of aggregation. Furthermore, applying national level volatility to division-level price indexes would defeat the purpose of using the division-level indexes. National volatility measures of individual house price growth could be so large that divisional variations in average house price growth become meaningless.

(ii) Volatility and Diffusion

Choosing to use Census division level price indexes with dispersion measures opens additional issues. In particular, capturing the dispersion of house price growth rates around an index value requires both a measure of volatility and a particular diffusion process to translate volatility into actual dispersion. Several ANPR commenters addressed these issues in the context of their discussions of geographic aggregation.

(a) ANPR Comments

Comments received in response to the ANPR differed on whether and how to estimate the dispersion of individual house-price-appreciation rates around the average rates implied by a house price index. Both MRAC and the Department of Veterans Affairs (VA) recommended that OFHEO use a stochastic (random) diffusion process to allow volatility measures to generate a normal (bell-shaped) distribution of individual house prices around the mean prices implied by index values. MRAC noted that failure to do so would underestimate dispersion, even if a highly disaggregated index were used. MRAC observed that underestimation of dispersion could cause underestimation of default and severity rates. MRAC also stated that the tradeoff between the accuracy of the larger sample size and the greater geographic specificity of a smaller sample is even more important in estimating the variance (volatility) than in constructing the index.

Both Fannie Mae and Freddie Mac, on the other hand, recommended against using a stochastic process to estimate dispersion of house values. Freddie Mac argued that one cannot directly observe the volatility of house-price growth rates, and that attempts to estimate it have thus far failed to achieve adequate consistency. Nor is it necessary to estimate volatility, Freddie Mac argued, because the variation in house price indexes across Census divisions

[76] That is, if only a small number of repeat transactions are available to calculate a price index, there is a greater chance that the resulting index is not representative of price changes in the particular housing market as a whole.

[77] This situation could occur, for example, if two adjacent smaller areas with different rates of appreciation are combined and assigned the same average rate of appreciation through a common price index. Whether this type of aggregation is ultimately a problem depends on how the house price index is to be applied, and whether it is to be applied to individual properties or to loan aggregates.

captures a significant amount of the house price dispersion around a national house price index, as well as the basic shape of the house price distribution for Enterprise loans.

Freddie Mac also questioned OFHEO's assertion in the ANPR that dispersion increases over time. It suggested that models that impose increasing dispersion on house price changes, such as ''random walk'' models, are inappropriate because long-run market forces keep the appreciation of individual houses moving roughly with the national average, and because the data do not support such models. Freddie Mac asserted that such models systematically overstate dispersion for longer holding periods and could significantly and artificially inflate the capital requirement.

(b) OFHEO's Response

OFHEO understands the reason for Freddie Mac's concerns about volatility, but notes that Freddie Mac's comments preceded OFHEO's first publication of the HPI. Based on its experience in estimating the HPI, OFHEO now finds it possible to estimate house-price volatility with adequate reliability, particularly for indexes estimated at the Census division level. Volatility measures are produced as part of the statistical process used to generate the OFHEO HPI. These measures are used to summarize the underlying diffusion process and characteristic dispersion of house price growth paths as a function of time. The volatility measures (parameters) are published in the OFHEO HPI Report. They model dispersion as a function of mortgage age. OFHEO preferred such a stable process to one that relies on stochastic processes that yield different results every time they are used. Because the OFHEO HPI volatility parameters are produced with the HPI itself, they provide results consistent with the HPI, and they are, therefore, OFHEO's choice for capturing house price dispersion in the proposed stress test. However, OFHEO agrees with Freddie Mac's concern that estimates of dispersion for longer holding periods may be unreliable, and has adopted an approach in which estimated dispersion is held at fixed levels after mortgages reach a certain age.[78]

[78] This age varies by Census division, but is approximately 15 years from mortgage origination. The formula for computing the maximum allowable age for each Census division can be found in section 3.5.2.3.2.3., Probability of Negative Equity ($PNEQ_q$), of the Regulation Appendix.

(iii) Revision Volatility

Revision volatility primarily affects growth rate estimates for the most recent quarters included in the index. This is due to the fact that relatively more additional data is added affecting these quarters than earlier quarters.

(a) ANPR Comments

OFHEO received a number of comments in response to the ANPR on whether changes in the index resulting from revision volatility should be reflected in the stress test and, if so, with what frequency. NAR suggested that revisions should be made at the same time OFHEO is required to re-estimate the capital standards. In contrast, MRAC suggested using a ''chaining method'' [79] that precludes the need for revision to index values for historical periods. The chaining method eliminates revision volatility because it does not revise data of earlier periods as new data become available. Freddie Mac suggested that OFHEO calculate the revisions so as to exploit the greatest possible set of information, but moderate the resulting volatility of the capital requirement by placing limits on the size of the quarterly or annual revisions to the indexes. ACB argued for a reasonable advance notice to the Enterprises prior to any changes in the capital requirement resulting from changes in the indexes to enable them to engage in reasonable business planning.

(b) OFHEO's Response

The proposed stress test does not include an adjustment for revision volatility. Since the time the issue of revision volatility was raised in the ANPR, OFHEO has determined that revision volatility is not likely to have a significant impact on risk-based capital. Revision volatility primarily affects growth rate estimates of the most recent quarters, which will be those immediately preceding the start of the stress test. For loans that have been outstanding for several years at the start of the stress test, changes in appreciation rates in the most recent quarters will represent a small proportion of the total change in housing values since origination. For loans that have been outstanding only a short time at the start of the stress test, projected changes in house prices and in LTV will be minimal in any case, due to the fact that little time has elapsed since origination, and quarter-by-quarter appreciation rates are generally small. Consequently, OFHEO does not expect revision volatility to affect risk-based capital requirements. OFHEO also proposes not to revise the house price index used to determine the appreciation rates applied in the stress period. Rather, HPI values, as published in the 1996, third quarter, HPI Report, will be the basis for relating stress test economic conditions to the benchmark experience.

OFHEO chose not to propose the chaining method suggested by MRAC because it fails to use all of the available data in estimation. In particular, the chaining method uses information on recent property and mortgage transactions only for calculating appreciation rates in the most recent period, ignoring the information provided by these transactions on appreciation rates in earlier periods.

(iv) Statistical Biases

In the ANPR, OFHEO requested comment on whether the HPI should include adjustments for identifiable sources of statistical bias, on how sample selection bias should be addressed,[80] on whether a statistical adjustment should be made to address appraisal bias,[81] and on what additional sources of statistical bias exist and how they might be addressed. In NPR1, OFHEO stated that it would make no

[79] The chaining method involves the following steps: (1) estimation of a historical reference index using all repeat transactions data available as of a specified date, after which no revisions in previously estimated index numbers will occur; (2) acquisition of new data providing information on the most recent time period, and including additional repeat transactions that pair with transactions in previous periods; (3) application of the most recently updated index series to inflate the first property value for a repeat transaction pair to update this value to the penultimate (next-to-last) time period; and (4) estimation of the index number for the last time period using the pseudo-repeat transactions data created in steps (1)–(3).

[80] Sample selection bias refers to the possibility that using repeat transactions as the selection criteria, rather than random selection, could result in an index that is biased. Selection bias results when the probability that a property does or does not repeat is correlated with the change in value. For example, bias can result when the period between transactions is correlated with the change in house prices. Because more rapidly appreciating properties turn over within shorter time intervals, they are more likely to appear in the sample used for estimation. In addition, properties that are sold or refinanced are likely to be the ones that have had higher than average appreciation.

[81] Appraisal bias can result from the perceived tendency of appraisers, as agents of primary mortgage lenders, to impart an upward bias to a home value to insure that a home sale is made. Appraisal bias also occurs when the use of appraisals to value property at refinancing may smooth the fluctuations in housing values because appraisals are derived from comparisons with properties that have either been sold or listed for sale within the past several months and may fail to indicate more recent changes in housing value. In fact, listings are only used in case circumstances where actual sales are few and far between, most often in rural areas.

adjustments to the HPI itself, but would discuss in the second NPR whether such adjustments were to be made in the stress test.

(a) ANPR Comments

As a general comment, Freddie Mac cautioned that research on potential sources of bias is relatively new and that attempting to ''un-bias'' future price index values estimates introduces a high degree of complexity. Consequently, Freddie Mac recommended keeping the house price index simple until research on potential bias is more conclusive. Freddie Mac also suggested that the reliance of the weighted repeat sales technique on the ordinary least squares (OLS) method [82] may result in bias because that methodology does not generally provide robust estimates of central tendencies in the presence of outlier observations, where appreciation is especially large or small. Freddie Mac suggested eliminating outliers or ''down-weighting'' them, for example, by using a median regression.

(b) OFHEO's Response

OFHEO agrees with Freddie Mac that attempts to adjust the HPI would be premature and should await more conclusive research. OFHEO also agrees with Freddie Mac's general observation on the sensitivity of OLS estimates to outliers, but has concluded that adopting another estimation methodology is unwarranted. It should be noted that the weighted-repeat sales (WRS) methodology [83] applied to estimate the OFHEO HPI uses information obtained from a first-stage OLS estimation to develop weights that have the effect of discounting the impact of transactions that occur far apart in time. Because these are the transactions that are presumed under the WRS method to have the largest sampling variability, and therefore those most likely to contribute outliers, the WRS method automatically accounts for the potential impact of outliers. In addition, OFHEO reports median rather than mean appreciation rates, which diminishes any potential impact of outlier data.[84]

[82] Ordinary least squares is the most commonly used statistical technique for simultaneously analyzing the relationship of many explanatory variables to one special variable of interest (called the ''dependent'' variable).

[83] This methodology, which is explained in the first NPR, uses pairs of transactions (i.e., repeat sales) involving the same homes to estimate home price appreciation.

[84] The WRS methodology used to generate the OFHEO HPI actually computes median growth rates, directly. These rates need to be adjusted to compute mean growth rates. In NPR1, these were referred to as geometric and arithmetic means, respectively.

(v) Sample Selection Bias

Repeat-sales and repeat-transaction price indexes do not include property value information from all mortgage transactions. Issues of potential bias in the measured house price appreciation rates arise because the sample of properties on which repeated transactions are available may not be fully representative of all properties in a given market area.

(a) ANPR Comments

A number of comments were received on sample selection bias in generating a house price index. Freddie Mac noted that sample selection bias results from using only properties that have been sold or refinanced. The selection of these properties is not random and is correlated positively with price appreciation. That is, properties with lower rates of appreciation will have fewer sales and refinancings, and thus provide relatively fewer observations for calculation of the HPI. Although Freddie Mac recommended that this issue be addressed by using a WRS index, which provides retrospective information by pairing two transactions on the same property at different time periods, it noted that some sample selection bias is present in the near term.

NAR suggested that sample selection bias results from the movement of an individual property from government mortgage insurance programs (Federal Housing Administration (FHA) VA) into the conforming conventional market, and vice versa, because the lower property values captured in the government insurance and guaranty programs might not be matched in the WRS series. If price appreciation in a market area is distributed unevenly with respect to selling price (i.e., lower priced homes appreciate slower or faster than do higher priced homes), the absence of a match at the lower end may introduce a bias in the level of price appreciation for the market under evaluation. NAR suggested that using FHA data, to the extent it is available, to construct the weighted repeat sales transactions, would adjust for the low-end sample selection bias. NAR also suggested that OFHEO investigate using different criteria with respect to time between repeat transactions entering the Enterprise loan history file to determine if the end of sample bias is significant, and to possibly suggest ways of correcting for it. NAR suggested that one way of correcting for any such bias would be to restrict the repeat sales in the sample to three-, five-, and seven-year matches and to evaluate the level of bias that results.

ACB suggested that the effect of sample selection bias resulting from the tendency to have greater turnover in that part of the housing stock in which price appreciation has been stronger could be determined by a separate analysis of the relationship between a foreclosure property index and the overall price index. MRAC suggested that some bias might result from properties leaving the sample because they have appreciated enough that the size of subsequent mortgages on those properties is above the conforming loan limit. MRAC then suggested that indexes built on Enterprise data be compared to other more broadly constructed indexes, such as those estimated by MRAC, that include all properties that initially meet the conforming limit. MRAC also suggested that the incidence of default and expected losses would be underestimated if the impact of junior liens were not taken into account.

(b) OFHEO's Response

OFHEO believes that no adjustments are necessary to correct for potential sample selection bias. Low-end sample selection bias due to the exclusion of FHA loans should not have a significant impact on the HPI. FHA loans do not represent the entire lower end of housing markets. There is ample representation of lower valued loans and properties in the data used to estimate the HPI, in part because the Enterprises promote affordable lending and are subject to HUD affordable lending regulations. Furthermore, although FHA eligibility requirements have historically been less restrictive than conventional lending requirements, current trends in conventional lending are toward more flexible standards, including lower down-payment requirements.

Although OFHEO agrees with MRAC that the conforming loan limit may itself produce some bias in repeat transactions index values, this bias is not significant in the HPI. Bias resulting from the conforming loan limit would occur in high-cost housing markets where there are significant numbers of homes with values near the conforming loan limit, and where appreciation rates are greater than the national average. As home values and loan amounts increase in these areas, new loans may no longer be eligible for purchase by the Enterprises, and the property appreciation cannot be captured in the HPI. However, such bias would occur only in very isolated instances. First, the conforming loan limit is substantially

above the average home price in nearly all areas of the country. The loan limit would only create a significant issue for the stress test if OFHEO were to use State, rather than Census division, indexes. The potential in particular States with high-cost metropolitan areas for sample selection bias resulting from the conforming loan limit becomes less relevant when the HPI is estimated at the Census division level. Second, the loan limit is updated annually by a factor representing national house price appreciation.[85] Third, borrowers may obtain two mortgages on a property in order to take advantage of the interest rate advantages of having a first mortgage under the conforming limit. In that situation, repeat transactions are captured by the HPI even if the total amount of mortgages on a property exceeds the conforming loan limit. All of these factors suggest that the conforming loan limit is not a significant source of bias in the OFHEO HPI.

(vi) Appraisal Bias

Because interest rates have generally fallen since the early 1980's, most of the mortgage transactions used in estimating the HPI are refinancings, rather than loans for home purchase. This fact raises the question of the consistency between actual prices recorded on purchase-money mortgages and appraisals used for refinance mortgages.

(a) ANPR Comments

Several comments on appraisal bias were received. Freddie Mac recommended against using a statistical adjustment to the HPI to address the impact of appraisal bias, asserting that it is far from clear whether indexes based solely on purchase prices, versus those based on a combination of purchase prices and appraisal values, better represent true house-price appreciation rates. Freddie Mac asserted that the common notion that purchase price is the ''true'' price is a misconception, since the purchase price is but one of a distribution of potential prices for any given house at any time. In light of the current uncertainty over the extent of the bias, Freddie Mac believes that it would be premature for OFHEO to attempt to develop a model to correct for it.

MRAC suggested that eliminating transactions in which an appraised value is used for either ''sale amount'' in the matched pairs would be desirable, but may not be practical. MRAC cited its own research to suggest that appraisal bias causes the yearly price appreciation measured by transaction-based indexes to be one percentage point too high. ACB suggested that construction of house price indexes with and without refinance transactions would permit an assessment of about whether appraisal bias is a significant phenomenon.

(b) OFHEO's Response

OFHEO agrees with Freddie Mac's recommendation that adjustments in the HPI for potential appraisal bias not be made. Issues of statistical bias merit further research and analysis, but at the present time OFHEO is aware of no better alternative index to use in the stress test. Also, measuring HPI only on actual purchase prices would compromise the statistical reliability of the indexes over time, because the majority of property values used in generating the various HPI indexes come from refinancing transactions, using appraisal values.

In response to MRAC's comment on appraisal bias in appreciation rates, it should be noted that the mere existence of identifiable differences due to use of appraisals does not outweigh the overall benefit of using the HPI in the stress test. Further, it is unlikely that any appraisal bias that may exist in the HPI would have a meaningful effect on risk-based capital because of the way in which the HPI is used in the stress test. The mortgage performance models in the stress test rely upon statistical equations that relate explanatory variables developed using the historical HPI to actual, historical mortgage performance. The same historical HPI series is used to season (update LTVs of) existing loans to the start of the stress period. Using the same HPI series to estimate the statistical model and to run the stress test eliminates the effect of any appraisal bias in the HPI on default and prepayment rates in the stress test.[86]

(vii) Multifamily Loans

For multifamily loans, OFHEO does not propose to use the HPI or any other repeat-sales or repeat-transaction index to update property values. There is not enough data available for OFHEO to develop its own price index, and the only known price indexes blend many commercial property types, have small numbers of observations, and are national in scope. To overcome these data problems, OFHEO proposes to use an earnings-based method for updating property values.

Multifamily loans are commercial loans for which property value depends upon the stream of earnings generated by the property. For these loans, OFHEO proposes to base the property value on earnings multiplied by a price-to-earnings capitalization factor. The capitalization factor summarizes the present value of a stream of expected future earnings for a given property, using current interest rates at each month of the stress test to discount the expected earnings stream. Earnings are a function of net operating income at loan origination, rental inflation, and the change in vacancy rates since loan origination. The proposed stress test updates the price-to-earnings capitalization factors as a function of changes in interest rates, holding property-specific characteristics constant. In this way, the stress test updates property values and seasons multifamily loans in the proposed stress test.

In choosing the actual rent growth and vacancy indexes used to update property earnings over time, OFHEO used government data where available. Government data were available for all statistical analysis, and for seasoning loans to the start of the stress test. In particular, the model performs the statistical analysis and the seasoning of existing loans to the start of the stress test using the rental cost component of the Bureau of Labor Statistics Consumer Price Index (CPI) to create a geographic specific rent index. Vacancy rates are not needed for pre-stress period seasoning, but are used in estimating the statistical model. The series used is the rental property vacancy series published by the Bureau of the Census (Census Vacancy Series).[87] Because Enterprise purchases of multifamily loans are heavily concentrated in MSAs, MSA indexes are used, where available, to update property values.

Government data are not available for the entire stress period itself. As explained later in the discussion under section III. A.7., Relating Losses to the Benchmark Loss Experience, the stress

[85] The conforming loan limit is administered by the Federal Housing Finance Board.

[86] Appraisal bias could, theoretically, affect the rates generated by the stress test if the method of computing the HPI were changed in some way to account for appraisal bias or if appraisal bias were found to be significantly different in more recent data than in the historical data used to estimate the models. OFHEO does not believe the change in the amount of appraisal bias in the HPI, if any, is significant.

[87] The CPI and Census Vacancy Series are both based on single and multifamily rental properties. OFHEO believes that the inclusion of single family rental properties in the samples used to calculate vacancy rate and rent growth rate series is not a serious concern for the stress test. These series capture the cyclical dynamics of multifamily rental markets, and are useful for updating property values before and during the stress period.

test links stress period losses to the benchmark experience in part by specifying benchmark rates of property value appreciation. However, CPI rental cost data is not available for the benchmark time and place, and Census Vacancy Series rates are only available for the benchmark experience starting in 1986. To deal with this absence of government data, OFHEO created a rent index consistent with the CPI data, but based upon apartment data available from the Institute for Real Estate Management (IREM). To fill in benchmark experience vacancy rates for 1984–1985, OFHEO also used IREM vacancy data to estimate the Census Vacancy Series. The estimated government series are consistent with the data used to estimate the mortgage performance models and season the loans prior to and during the stress period itself.

Volatility estimates for rental rate inflation and vacancy rates are used to calculate the dispersion of multifamily property values, in much the same way volatility measures for the HPI series are used to measure dispersion of property values for single family loans.

5. Default/Prepayment Issues

a. Use of Conditional Default and Prepayment Rates

A threshold issue for OFHEO was whether to construct statistical models of conditional rates of loan defaults and prepayments or to adopt a less detailed approach, such as calculating only cumulative rates and distributing them in fixed percentages across the ten years of the stress test. A conditional rate of default or prepayment refers to the volume of loans that default or prepay during any period, expressed as a percentage of the total volume of loans surviving at the start of that period. The term ''surviving loans'' means those from the group that have not previously prepaid or defaulted. A cumulative rate of default or prepayment is the total percentage of a group of loans that default or prepay during the entire period being studied (such as the ten-year stress period). A group of loans studied over a ten-year period would have a single cumulative default rate, but would have ten annual conditional default rates.

(i) ANPR Comments

The ANPR asked whether default rates should be expressed in terms of conditional failure rates, cumulative default rates, or in some other manner. In response, MRAC stated that ''[d]efault rates are best measured by cumulative life-of-loan rates with conditional rates for each time period determined by estimating 'seasoning curves' similar to the Standard Default Assumption of the Public Securities Association (PSA)[88].'' ACB's comments, which emphasized the importance of modeling the shrinking population of loans exposed to the credit risk in the declining rate scenario, assumed that a conditional rate approach should be used. Similarly, a preference for conditional rates of default and prepayment is also implicit in NAR's assertion that the principal merit of using a joint default/prepayment model is that it is capable of using all available information to determine whether a mortgage survives from one year to the next.

Freddie Mac and Fannie Mae, however, recommended using cumulative default rates to simplify the analysis. Freddie Mac was concerned that conditional prepayment rates would lead to absurdly high default rates in an up-rate stress test. In the up-rate scenario, prepayment rates would be low, more loans would be outstanding, and default rates conditioned on the number of loans outstanding would result in more defaults. Freddie Mac recommended using actual cumulative default rates from the worst region, which, implicitly, would include the same prepayment effect as that which occurred during the benchmark period.

(ii) OFHEO Response

OFHEO proposes to apply statistical models of conditional rates of default and prepayment for both single family and multifamily mortgages in the stress test. The advantages of this approach are numerous. The proposed approach automatically accounts for the impact of defaults on the number of loans remaining active and subject to the risk of prepayment, and vice versa. This feature is essential to develop a reasonable representation of Enterprise mortgage cash flows across the different economic scenarios envisioned by the stress test. It also avoids potential numerical anomalies that might arise when total or annual defaults during the stress test are fixed, such as years in which total defaults would exceed total surviving loans due to high prepayment levels in the declining-rate scenario of the stress test. Also, the periodic nature of mortgage payments, scheduled amortization, and the coupon adjustments on adjustable rate loans, all of which affect mortgage performance, require a model that reflects a discrete time period for each default or prepayment event.

OFHEO believes that a statistical model of conditional defaults and prepayments is more accurate and more sensitive to stress test economic factors, and to the Enterprises' starting books of business, than are simpler methods that might be developed. Each quarter the test is applied, a statistical model can account for changes in economic conditions (such as the level and shape of the Treasury yield curve or recent trends in house prices) and the composition of an Enterprise's business since the last time the test was performed. That is, the rates of default and prepayment applied when the stress test is run are adjusted to reflect current circumstances. Such adjustments are particularly important because mortgage prepayment and default rates are highly time-dependent, characteristically increasing during the first years following origination, peaking sometime between the fourth and seventh years, and declining over the remaining years. However, this time-characteristic pattern is itself affected by economic conditions.

Another advantage of modeling conditional default and prepayment rates is the support this approach provides for the proper treatment of loss severity. Loss severity is affected significantly by factors that affect the timing and amount of defaults in the stress test. Loss of loan principal balance, the single largest cost element in determining loss severity, is dependent upon house price declines, which are dependent upon economic conditions leading up to the date of default. Funding costs are also affected by the changing interest rates in the stress test, as explained in later discussions under section III. A. 6., Loss Severity. For all of these reasons, using conditional default and prepayment rates during each month of the stress period greatly improves the sensitivity of the stress test to risk factors.

The proposed approach is, overall, responsive to concerns raised in the ANPR comments, although OFHEO has proposed models of conditional rates of default and prepayment, rather than accept the recommendation of several commenters to use cumulative rates. NAR and ACB recommended use of

[88] PSA has subsequently changed its name to the Bond Market Association. The PSA Standard Default Assumption is to allow monthly conditional rates to increase from zero to some peak rate over the first 30 months of mortgage life, to hold that peak rate constant for another 30 months, and then to allow monthly rates to decline for an additional 60 months. The final rate reached at the end of 120 months is held constant throughout the remaining life of the loans (Public Securities Association, *Standard Formulas for the Analysis of Mortgage-Backed Securities and Other Related Securities.* New York: Public Securities Association, update No.7, June 29, 1993, at SF–14.).

conditional rates. As ACB recognized, the stress test must account for the shrinking population of loans exposed to credit risk in the declining rate scenario. Only through the application of conditional default and prepayment rates is it possible to account for this shrinking population under the alternative interest rate scenarios of the stress test.

MRAC recommended measuring cumulative life-of-loan rates with conditional rates for each time period determined by estimating ''seasoning curves'' similar to the Standard Default Assumption of the Public Securities Association to determine conditional rates. OFHEO proposes a model with much the same features suggested by MRAC. This model uses mortgage age in the statistical default equations to provide a baseline default rate time-series analogous to the PSA assumption. (*See* note 41, infra.) That baseline is scaled, or multiplied upward, in the same way that PSA recommends using its baseline curve, when the stress test adjusts or ''calibrates'' its statistical default equations to relate them to the benchmark experience. (*See* section III. A. 7., Relating Losses to the Benchmark Loss Experience.)

OFHEO's approach is also responsive to the recommendations of Fannie Mae and Freddie Mac to keep the models simple. OFHEO proposes to minimize the number of explanatory variables and to create as much consistency as possible across different mortgage types while still capturing differential credit risk by mortgage type. The models are also ''simple'' in that the mortgage performance equations used in the stress test can be used by the Enterprises—without any modifications-to replicate the stress test. Further, OFHEO believes that using cumulative default rates would not achieve significant simplification. Freddie Mac's comments recognized that default and prepayment rates are not uniform among loans with different characteristics. To deal with these important differences, Freddie Mac suggested developing a system of multiples and LTV categories that would be applied to historical cumulative default rates. However, this approach requires a matrix of rates that becomes, in practice, more complicated to estimate than a statistical model of conditional default rates. Therefore, developing a statistical model, based upon well-recognized techniques that are widely used in the mortgage industry, was, in OFHEO's view, a preferable approach.

b. Identifying Events for Default and Prepayment

A practical issue for modeling default and prepayment rates is how to identify a default or prepayment event in the historical Enterprise data.

(i) ANPR Comments

A number of ANPR commenters, including MBA and Freddie Mac, suggested defining default events only in terms of foreclosures, because many delinquencies are cured and do not generate significant losses. In contrast, the VA suggested modeling the timing of cash flows associated with all delinquencies, including loans that are reinstated and do not terminate.

Only Freddie Mac addressed the subject of curtailments as a form of prepayment. Curtailments are partial prepayments, made in addition to regularly scheduled mortgage payments. Freddie Mac did not suggest that they be tracked as mortgage events, but only that some consideration of them be given in the calculation of current LTV ratios to account for the resulting improvements in borrower equity positions. Freddie Mac cited a study on Ginnie Mae curtailment speeds,[89] and suggested that Enterprise loan pools might have higher rates of curtailment than found in the study, because of better borrower equity and liquidity positions.

(ii) OFHEO Response

OFHEO agrees with MBA and Freddie Mac that the stress test should not consider all delinquencies to be defaults. Only delinquencies that result in termination of the loan are treated as defaults in the stress test. Historically, these events predominantly have been foreclosures, although today these events also include pre-foreclosure sales, where delinquent borrowers sell their properties before foreclosure and share the losses with the Enterprise and/or mortgage insurer.[90] OFHEO found that the more detailed modeling of delinquencies suggested by the VA would make the model more complex and would not have a significant impact on risk-based capital. The impact would be minimal, because in the time and place of the benchmark loss experience, few, if any, alternatives to foreclosure were utilized by the Enterprises and the benchmark rates would, therefore, not change. Also, even if modest improvements to the stress test were possible by modeling delinquency events, at this time there are insufficient data to support an analysis of delinquency resolutions and costs.

Mortgage default and prepayment events result from a borrower's decision to terminate the mortgage, either by prepaying or defaulting, resulting in an observed last-paid installment, after which no further payments are forthcoming. In the case of (full) mortgage prepayment, the borrower terminates the loan by repaying the remaining principal and any outstanding interest. The models identify prepayment events in the Enterprise data by the existence of a last-paid installment date and a change in the loan status from active to prepay. Loan defaults are identified as any loan that has terminated without an indication that it has been prepaid or paid off at maturity.

In the proposed stress test, curtailments made prior to the beginning of the stress period are accounted for in the starting loan balances reported to OFHEO from the Enterprises. OFHEO does not, however, propose giving further consideration for potential curtailments in the stress period itself. OFHEO has found no evidence that curtailments have a significant impact on current LTVs of Enterprise loans on a portfolio-wide basis.[91]

c. Use of Joint Default/Prepayment Models

A key issue raised in the ANPR was whether to use a joint prepayment and

[89] Peter Chinloy, ''Elective Mortgage Prepayment: Termination and Curtailment,'' *Journal of the American Real Estate and Urban Economics Association* 21 (3, Fall 1993), 313–332.

[90] A less important default termination event is the transfer of the property deed, in lieu of foreclosure. This is a foreclosure-like event in that it results in the Enterprise taking title to the property and having to manage and sell it, just as is the case with foreclosed properties.

[91] The Chinloy study cited by Freddie Mac, which used a limited data set, found that curtailments in the study period (January 1988–May 1989) amounted to a very small rate (0.42 percent per year) on the outstanding loan balances of the Ginnie Mae security pools. Ibid., p. 326. More recent work by Fu, Lacour-Little, and Vandell, on conventional mortgage curtailment rates, also shows that curtailments amount to a small percentage of portfolio balances. Qiang Fu, Michael Lacour-Little, and Kerry Vandell, ''Retiring Early: an Empirical Analysis of the Mortgage Curtailment Decision,'' unpublished manuscript, University of Wisconsin—Madison, December 1997. These authors observed 25,566 mortgages for a 21-month period. These included a mixture of conforming and jumbo loans, and included loans originated from 1967 to 1995. During a 21-month observation period, these authors found that over 86 percent of the loans surveyed made no curtailments, and only 0.64 percent of the loans made curtailments in excess of one percent of the original loan balance. Ibid, Table 3, p. 22. The largest curtailments were made on older loans (close to 20 years old), where loan balances and default rates will be small to begin with. Thus, any effect of these curtailments on credit losses would be insignificant for risk-based capital determination.

default model or some simpler assumptions about default and prepayment rates in the stress test. In the ANPR, OFHEO also asked whether prepayments during the stress test should affect the volume or timing of defaults.

(i) ANPR Comments

Several commenters supported the use of a joint model of defaults and prepayments. MRAC stated that the ''absolute merits'' of the approach are ''obvious.'' NAR asserted that the principal merit of using a joint model of conditional default and prepayment probabilities is its ability to use all the available information to determine whether a mortgage survives from one year to the next or is lost from the portfolio through prepayment or default. HUD cited the need to model defaults and prepayments together as simultaneous decisions based on the underlying property equity.

The Enterprises opposed a joint default and prepayment model. However, Fannie Mae, although not recommending joint modeling, noted the interrelationship between defaults and prepayments. Fannie Mae favored the use of a statistical model that would determine only total terminations (prepayments plus defaults) in each of the two stress test interest rate scenarios. Fannie Mae suggested that total defaults in both scenarios be set at the levels that occurred in the benchmark loss experience. Prepayments would be calculated by subtracting total defaults from total terminations. Fannie Mae made no specific recommendation about how conditional default rates might be determined or how total defaults and prepayments should be distributed through the stress period. Fannie Mae opined that the methodology it recommended would be consistent with the 1992 Act and would provide a workable framework for capturing the relationship between defaults and prepayments. Fannie Mae also viewed this approach as consistent with industry practice and asserted that it would be easier for the company to manage to a capital standard based upon such an approach than it would be to manage to one based upon a joint statistical model.

By contrast, Freddie Mac, while preferring a simpler approach to default modeling, asserted that a joint statistical model of default and prepayment rates would be preferable to total termination models in the stress test context because: (1) unlike the total terminations models, the joint model ensures that defaults and prepayments ''add up'' to the total mortgage terminations; (2) total termination models focus on interest rate movements under the assumption that default is a small part of terminations under normal conditions, (an assumption Freddie Mac found unwarranted in a stress test environment); and, (3) standard termination models capture small effects such as seasonal variation, which would unnecessarily complicate the stress test.

Freddie Mac also favored an empirically based statistical model of mortgage performance over a stochastic simulation model like those used in mortgage-backed security pricing. Freddie Mac stated that stochastic models are not typically used by the industry for default and prepayment modeling because borrower housing objectives are too complex and heterogeneous to be described adequately with a single set of rules simple enough to solve analytically.

Although Freddie Mac favored the use of a joint statistical model over these other approaches, Freddie Mac did not recommend that OFHEO use one in the stress test, asserting that OFHEO would have difficulty using the data from the benchmark experience to estimate the model. Freddie Mac also cited the need to model prepayments during the stress period as a function of current coupons and interest rates. Freddie Mac instead recommended estimating a statistical equation for prepayments based on historical data from a distressed region to factor prepayments into the stress test. Freddie Mac asserted that this approach would allow implementation of the two interest-rate scenarios while tying prepayment rates to the benchmark experience. Freddie Mac also recommended using cumulative default rates from the benchmark experience as the stress test default rates.

Freddie Mac raised other issues about joint models, claiming that they are not ideal because: (1) they are complex; (2) they require assumptions about both house price drift (average appreciation) and volatility (variation in individual appreciation rates around the average rate); (3) they require assumptions as to what constitutes negative equity; and (4) they require other factors, such as loss of employment to be modeled.

(ii) OFHEO's Response

OFHEO proposes to use joint statistical models in the stress test for both single family and multifamily loans, agreeing with recommendations of many commenters. Also, OFHEO found that total termination models, such as those recommended by Fannie Mae, were not adequate for the purposes of the proposed regulation. (*See* earlier discussion under section III.A.5.a., Use of Conditional Default and Prepayment Rates.) As explained in the ANPR, prepayments have a major impact on cumulative and conditional rates of default, because every loan that prepays is one less loan that could later default. However, high levels of prepayment, which occur when interest rates decline, can also result in increased conditional default rates in periods that follow. This phenomenon, referred to as ''adverse selection'' or ''burnout,'' occurs because loans that do not prepay when interest rates decline are often lower quality loans that do not qualify for refinancing. Using a joint default/prepayment model allows the stress test to reflect the impact of prepayments (and, therefore, of interest rate changes) upon defaults.

The joint modeling approach is based on well-known and accepted statistical methods that are widely applied in the mortgage performance research. Researchers have found multivariate statistical models to be necessary for this research, because the borrower's options to default or prepay are interrelated. OFHEO believes that simpler approaches (models or tabulations) that fail to account for this complexity would not provide reasonable and appropriate projections of mortgage performance during the stress period.

OFHEO addressed Freddie Mac's concern about the difficulty of retaining a reasonable relationship to the benchmark loss experience in a joint model by: (1) replicating certain benchmark economic factors—specifically, house prices, rent growth rates and rental vacancy rates—in the stress test; and (2) adjusting the underlying default and severity equations used in the stress test to allow them to replicate exactly the benchmark experience. Modeling the effects of differences in starting coupons and interest rates from the benchmark loss experience was possible, because OFHEO's database allowed the models to be estimated based upon a broad and representative sample of historical mortgage performance data. The statistical equations therefore yield reasonable estimates that can be used to project mortgage prepayment under many different circumstances, including stress test interest rate scenarios.

Regarding the issue of model complexity, in OFHEO's view, the proposed models strike the appropriate balance between accuracy and simplicity. The stress test uses an approach based on well-known and

accepted statistical methods that are applied and accepted widely in academic research and in industry practice. Further, OFHEO has developed specifications for the default and prepayment models that avoid unnecessary complexity. The prepayment model suggested by Freddie Mac—using Freddie Mac projections from a statistical equation with ad hoc adjustments based on mortgage coupon rates—is at least as complex, but far less accurate.

As to house price appreciation and volatility, any model of mortgage performance includes, explicitly or implicitly, assumptions about these factors. OFHEO believes that the proposed stress test includes a reasonable and appropriate methodology for updating house prices throughout the stress period. (*See* section III.A.4.d., Property Valuation.)

OFHEO does not agree with Freddie Mac that the need to use assumptions about negative equity to estimate a joint model is a reason not to use a joint model. Any statistical model of mortgage default requires certain assumptions about how to measure negative equity in order to predict defaults. Although expected equity values cannot be assigned to individual borrowers to determine a precise LTV for each loan, using probabilities of negative equity provides substantial information about the negative equity position of individual borrowers. The probability of negative equity is a function of the current loan balance and the probability that individual house prices are below that balance. It is especially valuable when modeling the default potential from groups of loans, as is the case in the proposed stress test. By applying estimates of house price drift and volatility obtained from independent estimates based on the OFHEO House Price Index, the distributions of individual housing values relative to the value at mortgage origination are determined. This approach eliminates the measurement difficulties associated with calculating individual borrower equity at the loan level.

The concern that developing a statistical model for the stress test would require modeling the effects of unemployment on prepayment rates does not raise an issue, because OFHEO does not propose to use unemployment as an explanatory variable in the stress test. In general, OFHEO has limited the explanatory variables in the stress test to those that define different loan characteristics or product types are required to meet statutory requirements. As explained above in section III.A.2., Overview of Mortgage Performance, OFHEO has avoided variables, such as unemployment, that require assumptions about stress period economic conditions that are not specified in the 1992 Act. (*See* section III.A.5.e., Choice of Explanatory Variables for Default and Prepayment).

d. Choice of a Statistical Method for a Joint Model of Default and Prepayment

(i) ANPR Comments

The ANPR sought comment on the appropriate statistical method to use for a joint model of default and prepayment. None of the ANPR comments provided an express recommendation of a model, but NAR supported a multivariate model and suggested that the proportional hazard model developed by John Quigley and Robert Van Order in 1992 would provide a good starting point. Other commenters, such as Freddie Mac and ACB, emphasized that any joint model must be robust and able to yield reasonable results under many different scenarios.

(ii) OFHEO Response

OFHEO agrees with the NAR comment that proportional hazard models provide a good starting point. These models measure conditional rates of default and prepayment. The stress test utilizes a similar approach, the logit model, which is more appropriate for large data sets. OFHEO also agrees with Freddie Mac and ACB that a joint model should be robust and able to yield reasonable results under many different scenarios. As explained more fully in the Technical Supplement, OFHEO has evaluated its proposed models to ensure that they yield reasonable results under many different scenarios, use widely accepted techniques, and are otherwise appropriate for OFHEO's purposes.

OFHEO is proposing statistical models for single family mortgages that were estimated using multinomial logit specifications for quarterly conditional probabilities of default and prepayment. The multifamily model was estimated similarly, although it is based upon annual, rather than quarterly, conditional probabilities of default and prepayment, as described more fully in the discussion of the multifamily default/prepayment issues, below. There are several advantages to using the multinomial logit specification. First, it guarantees that the estimated and projected probabilities of default and prepayment always lie between 0 and 100 percent. Second, one can estimate weights for the impact of specific explanatory variables on the probabilities of default and prepayment separately. Third, it is possible to specify different lists of explanatory variables for each type of event. Fourth, the model automatically accounts for the impact of differences in the estimated probability of default on prepayment and vice versa. Finally, estimation routines for multinomial logit models are readily available in a large number of commercially available statistical software packages.

e. Choice of Explanatory Variables for Default and Prepayment

In the ANPR, OFHEO requested comment on the appropriate explanatory variables to use in statistical models of default and prepayment. OFHEO asked specifically about how to account for the effects of house prices, interest rates, and other economic factors, and whether to include measures of mortgage age and mortgage value as explanatory variables. OFHEO also asked about empirical and theoretical approaches to estimation of multifamily credit risk, and several respondents addressed the issue of explanatory variables in responding to that question.[92] Because there are some differences between the explanatory variables for single family and multifamily models, the comments on explanatory variables are discussed separately for the two models. Some comments related to specific explanatory variables are discussed below in connection with the discussion of the particular variable.

(i) Comments on Explanatory Variables for Single Family Modeling

Freddie Mac suggested that using mortgage product, property type, occupancy status and current LTV as explanatory variables would explain a significant portion of the differences in default rates without venturing into more complex relationships that might prove unreliable for purposes of the stress test. Freddie Mac recommended caution in the consideration of mortgage age as an explanatory variable, noting that while age may be a valuable proxy for unmeasurable determinants of default, it should not take on such importance that mortgage age patterns dominate the capital requirements. In contrast, Freddie Mac did recommend that OFHEO include a measure of the mortgage premium value (reflected by the difference between the interest rate on a given mortgage and the current market interest rate for a similar loan) in

[92] No commenters provided suggestions on how to actually model multifamily mortgage defaults and prepayments.

its modeling efforts, as an adjunct to borrower equity. Freddie Mac cited its own research showing that borrower default choices do respond to differences between the mortgage coupon rates and current market rates of interest.

World Savings stated that OFHEO should be cautious about including unemployment rates as an explanatory variable in any statistical model of mortgage performance, because the statutory stress test takes a regional experience and uses it to imply a national recession. World Savings reasoned that, in a regional recession, homeowners who lose their jobs might find employment elsewhere but retain their homes. They may rent their homes until such time as house prices again rise enough to permit them to sell their properties without incurring a loss. However, in a national recession, such opportunities would not be available and the dynamics of default could be much different.

MRAC recommended using the following variables: current LTV, length of residence, mortgage term and type, loan purpose, occupancy status, primary home status, relocation loan status, consumer credit information, and mortgage premium value. Recognizing that length of residence is not always available to researchers, MRAC suggested that mortgage age could be used instead. The MBA recommended including measures of borrower equity, mortgage premium value, and product type differences in a statistical model. Standard and Poor's asserted that mortgage age is a very important explanatory factor, noting that 80 percent of all defaults occur by the seventh year of a mortgage pool.

The VA asserted that borrower equity is the most important determinant of default and prepayment rates and recommended that OFHEO think of explanatory variables in two categories: those that indicate the borrower's ability to pay, and those that indicate the borrower's ability to sell the property. The former category could include such things as job loss, divorce, necessary relocation, and hazard loss (e.g., uninsured fire or water damage to the home). The latter category could include the borrower's equity position and ability to complete a property sale quickly. The VA also mentioned that its own statistical model of default and prepayment rates includes regional unemployment, house sale activity measures, and a house-purchase-affordability index.

NAR recommended that OFHEO include a factor for mortgage age, but not for the mortgage premium value. While NAR accepted the theoretical justification for including mortgage value in a statistical model, it did not find its influence on defaults to be statistically significant in its own modeling efforts. NAR also mentioned a factor not discussed by other commenters—the relative size of each loan. NAR commented that the influence of house price appreciation on default depends on whether the loan has a high or low balance, and that OFHEO should carefully analyze this issue in the context of Enterprise experience. In addition to these comments, NAR also provided, without further explanation, a list of all the variables it believes should be included in a statistical model of default and prepayments. Listed were: origination LTV, ratio of the mortgage coupon rate to the current market rate for home mortgages, current LTV, loan size, presence of credit enhancement (e.g., private mortgage insurance), house price dispersion, transaction costs, the burden on household cash flow of servicing the mortgage, origination year of the mortgage, policy year (age) of the mortgage, mortgage premium value (for prepayment only), region of the country, unemployment rate, inflation, regional household mobility rate, mortgage product characteristics, and net borrower equity in the home.

(ii) Comments on Explanatory Variables for Multifamily Modeling

OFHEO received fewer responses to its ANPR questions on approaches to multifamily modeling than it did to questions related to single family mortgage performance modeling. The import of these comments was to direct OFHEO to look at property cash flows as the primary influence on defaults. Freddie Mac emphasized that cash flow after mortgage debt service, as measured by the debt coverage ratio (DCR) is important, as are property equity and balloon terms. It also mentioned the need to measure multifamily market conditions directly, rather than relying upon single family house price appreciation to update explanatory variables over time. Freddie Mac further indicated that OFHEO needs to take into account significant factors that affected multifamily default rates during the 1980s, such as tax law changes, but should not include in the stress test the effect of any speculative political factors, such as potential legislative actions.

Standard and Poor's also suggested that DCR should be the focal point for multifamily mortgage default risk, but added that the quality of the real estate securing mortgages is also considered in the S&P credit analysis. ACB recommended accounting for the changing cash flow position of the mortgaged property (i.e., using the DCR), rather than relying solely on net income, and including factors for tax laws and depreciation allowances. It also commented that, while data is not available to consider these additional variables, the underlying determinants of multifamily defaults are factors that lead to problems in tenant rental payments: unemployment, reduced hours of work, and reduced income. HUD suggested considering the corporate bankruptcy literature when deciding how to model multifamily defaults. This literature emphasizes changes in the cash flow position of multifamily properties. HUD also commented that OFHEO should treat balloon payoffs differently than normal, early prepayments.

(iii) General Approach

Models of mortgage performance are models of borrower behavior—of individual borrowers' decisions whether to continue making monthly mortgage payments, to prepay, or to default. Each month, every borrower must choose among these three options. Because mortgage performance models are an attempt to predict how borrowers will choose to exercise these options, financial options theory provides the most widely accepted conceptual framework to link these borrower choices to differences in the underlying loan characteristics and economic conditions.[93]

In the options theory framework, the most important variables are borrower equity and interest rates. When equity is

[93] This conceptual framework is the basis for nearly all mortgage performance research. It applies to all of the mortgage performance models referenced in the ANPR (*See* 60 FR 7470–7471, Feb. 8, 1995, footnotes 11 and 13). Other references can be found in the Technical Supplement to this regulation. Financial options theory treats a mortgage like a bond issued by the borrower with embedded financial options to default or prepay, which borrowers will exercise when it is in their financial interest to do. From the lender or mortgage investor's perspective, this conceptual framework is sometimes referred to as ''contingent claim analysis.'' The mortgage investor, as bondholder, has a claim to a cash flow (mortgage payments), the value of which is contingent upon the value of the options to the borrower and the actions of the borrower with respect to the mortgage property (e.g., property maintenance). The choice to pay off (prepay) a mortgage is likened to a ''call'' option, where the borrower effectively buys back the mortgage from the lender at the book (face) value. The choice to default is seen as a ''put'' option, where the borrower sells the mortgage back to the lender at the current market value of the collateral property. The choice of an options-based model is consistent with the apparent underlying assumption of the preponderance of ANPR comments, which generally relate to how to account for factors that affect the exercise of these options.

negative, that is, the property value is less than the outstanding mortgage balance, the default (put) option is said to be ''in the money.'' That term is used to mean that, theoretically, the borrower might find it financially advantageous to default in order to eliminate the negative equity position in the mortgage.[94] When equity is negative, maintaining the mortgage through regular monthly payments leaves the borrower paying more for the property than it is worth. Under such conditions, default becomes an economically rational option for many borrowers, particularly those who may be undergoing other financial stresses, such as unemployment, divorce, health problems, etc.

In an options-based model, interest rate changes create positive or negative value in the mortgage itself. This value is referred to in the ANPR as ''mortgage value.'' It is also sometimes referred to as the mortgage premium value. That is, the current mortgage has a ''premium'' or positive value to the borrower—it is worth holding on to—if the coupon interest rate is below current market rates. That mortgage value is reduced if current market rates are below the coupon rate. If a borrower is in a position of negative property equity due to declines in local house prices, but has a below market rate mortgage, the mortgage premium value reduces incentives to default. On the other hand, an above market rate mortgage could, in theory, increase the incentive to default for the same borrower.

The mortgage premium value is inversely related to the value of the prepayment (call) option. When current market rates are below mortgage coupon, the call option is ''in the money,'' and its value is high. When the mortgage rate is below market, the call option is ''out of the money,'' and its value is low. Borrower equity also plays a part in prepayment determination; generally, it must be a certain positive amount before lenders will offer refinance opportunities. It must also meet a positive threshold before a property can be sold without the borrower incurring out-of-pocket expenses. However, as long as minimum equity thresholds are met, the higher the mortgage coupon rate is above the market rate, the greater is the incentive for a borrower to exercise the prepayment option by paying off the existing mortgage from the lender with the proceeds of a new loan.[95]

Although property equity and interest rates are the predominant variables of relevance in an options approach to mortgage termination modeling, many other factors affect borrower decisions to exercise a default or prepayment option.[96] For single family mortgages, some of these factors are: (1) the potential for lender deficiency judgments, which reduce borrowers' ability to force lenders to absorb the negative property equity through defaulting; (2) borrowers' desire to maintain access to credit at preferential rates, which will also make them more hesitant to default; (3) moving costs, which reduce the value of the default option; (4) forced mobility due to job loss (or relocation) or family disruption, causing default or prepayment when it would not otherwise be financially advantageous to terminate the mortgage; (5) expected future mobility, which reduces tendencies to prepay in the present when that option is otherwise ''in the money''; and (6) the up-front expenses involved in prepayment, which require that interest rates fall by a certain amount before it is really advantageous to prepay. For multifamily mortgages, the additional factors that affect the borrower's decision to exercise an option to default or prepay are: (1) property cash flow and the ability to service the mortgage; (2) the value of depreciation write-offs in reducing tax burdens; (3) prepayment penalties, which reduce the value of refinancing in the early years of a loan; and (4) balloon terms, which generally require a loan to be refinanced at maturity. Balloon term considerations are more important for multifamily than for single family mortgages because balloons are the predominant instrument type in the conventional, multifamily mortgage market.

In choosing which variables to include in estimating the statistical models used in the stress test, OFHEO considered financial options theory, ANPR comments, data availability, the need for simplicity in model design, and the need to meet multiple statutory objectives while implementing a credit stress test based on the benchmark loss experience. In selecting explanatory variables to use in running the stress test, OFHEO considered whether they were necessary to reflect the differences in loan characteristics and interest rate environments as required by the 1992 Act. Some variables were used to estimate the statistical models, but they did not meet the criteria for inclusion in the stress test itself.[97] They are represented by simplifying assumptions in the stress test so that their values do not vary across loans or time. All variables used to estimate the models and any other variables suggested by commenters are discussed below. The variables common to both single family and multifamily analysis are discussed first, followed by a discussion of variables unique to each.

(iv) Common Single and Multifamily Variables

(a) Measures of Borrower Equity

The actual variable used in the proposed stress test to capture borrower equity positions is the probability of negative equity—the probability that the value of a mortgage will be larger than the value of the property securing it, so that the default (put) option is ''in the money.'' Calculation of this explanatory variable uses the measures of property value described in section III. A. 4. d., Property Valuation, along with original loan amortization schedules.[98] Measuring the probability of negative equity is appropriate because the actual appreciation rates of individual properties are unknown and because such a measure gives the best representation of the percentage of loans in any given pool or portfolio that are at risk of default. The probability of negative equity is also included in prepayment equations, because negative equity may prevent prepayment by making it difficult to refinance. This variable, therefore, has opposite effects on default and prepayment rates. Increases in the probability of negative equity mean that fewer loans in the pool qualify for refinancing, which decreases prepayment rates. At the same time, borrowers who are forced to relocate or

[94] Negative equity is only one factor that influences the borrower's decision. Borrowers are usually personally liable on the note, which means that default could have numerous negative consequences beyond losing the property in foreclosure. For this reason, the model recognizes that negative equity does not cause a default, but simply makes it more likely.

[95] It is also possible that borrowers exercise the prepayment option with personal equity, liquidating other assets to pay off the mortgage even if property equity is negative. Borrowers may also turn to alternate lenders, who offer loans with LTVs higher than those usually purchased by the Enterprises, for refinancing opportunities when borrowers have little or no positive property equity.

[96] Empirical studies have shown that mortgage borrowers are not ''ruthless'' in their exercise of these options. First, just being ''in the money'' at a point in time does not mean that an optimal ''strike price'' has been reached, where the option value is maximized. Second, there are many other factors that affect both option value and whether borrowers will default or prepay their mortgages.

[97] Any variable that is included as an explanatory variable in the stress test is also used to estimate the model.

[98] In the estimation of single family default and prepayment equations, and in the stress test simulation of default and prepayment rates, balloon loans are amortized over their original rather than amortization terms. In the final rule OFHEO intends to substitute amortization term for original term in the calculations for balloon loans.

who experience a loss of income may have difficulty prepaying, making the default option a more likely borrower strategy.

For multifamily loans, the stress test uses a variable capturing the joint probability of negative equity and negative cash flow to predict default. As highlighted by the ANPR commenters, cash flow may be more important than equity for multifamily default. Although negative equity is a necessary condition for the default option to be ''in the money,'' it is not a sufficient condition for default. Default will maximize wealth only if cash flows are also negative. When the equity is negative, but cash flows are positive, default is not rational because the borrower would give up positive income. Because both negative equity and negative cash flow are required for default to occur, the primary variable proposed to explain multifamily default is the joint probability that a property has both negative equity and negative cash flow.

Additional consideration is given to the equity position of borrowers with balloon loans when those loans mature. At the balloon maturity point, when borrowers must pay off and find new financing, weak property financials can lead to even higher default rates than might occur earlier in the life of the loans. The multifamily model, therefore, gives additional weight to the joint probability variable in the balloon maturity year to reflect the increased risk that a borrower will not qualify for a new mortgage.[99]

Multifamily balloon loan payoff is also a function of the financial characteristics of the underlying property, because loans must meet equity and cash flow standards before new financing can be secured. To capture the impact of equity and cash flow on the ability of a borrower to refinance a multifamily loan at the balloon point, the stress test uses a variable that measures the joint probabilities that both property equity and cash flow are at sufficiently high levels to qualify for refinancing.

(b) Mortgage Premium Value

OFHEO posed a question in the ANPR about use of the mortgage value (mortgage premium value)—the financial value of an above or below market rate mortgage coupon—as an explanatory variable in default equations. The mortgage premium value is a measure of the value of the prepayment option to the borrower, that is, the value of prepayment before accounting the transaction costs of prepayment. It is, therefore, an important variable used by all the models to explain prepayment behavior. At issue is whether this factor should also be used to help explain default behavior.

ANPR commenters had differing views on this issue. Those suggesting that it should be used were Freddie Mac and VA. Two other commenters, NAR and ACB, were supportive in theory, but were not confident that a statistically valid relationship to default rates could be found, at least for single family mortgages. MRAC included the difference between the mortgage coupon rate and current market interest rates (a proxy for mortgage premium value) in its list of explanatory variables for a default/prepayment model. This is a proxy for the mortgage premium value.

As explained earlier, options theory suggests that increases in the value of the prepayment option (resulting from lower interest rates) should increase both prepayment and default rates because the current mortgage becomes expensive compared to alternatives. Prepayments increase because refinancing becomes attractive. Default rates increase for borrowers who already have negative property equity because some such borrowers relieve themselves of both the negative property equity and the expensive mortgage by defaulting and then renting, or by taking out a new mortgage to purchase another property. Conversely, increases in market interest rates increase the value of holding on to an existing mortgage, and thus may decrease default rates as well as prepayments.

While recognizing that there is a theoretical basis to include a mortgage premium value variable in the default equations, OFHEO proposes, nevertheless, to limit its use to prepayment equations. The influence of interest rate changes on mortgage defaults is captured adequately in single family default equations by a ''burnout'' variable, which measures the instances when borrowers have not taken advantage of previous refinancing opportunities. This variable is explained in a later discussion under section III.A.5.e., Choice of Explanatory Variables for Default and Prepayment. A burnout variable is not included in the multifamily equations, because prepayments are severely limited by prepayment restrictions.

For prepayment equations, the actual variable used to capture the prepayment option value is a relative spread variable: the difference between the current mortgage coupon rate and the current market interest rate, as a percentage of the current mortgage coupon rate. This variable has been shown to provide an approximation of the mortgage premium value.[100]

For multifamily mortgages, this relative spread variable is not included in the default equations, because the interest rate effect on default rates is reflected adequately in the joint probability variable. Declines in interest rates increase the present value of after-debt income stream generated by the property, and thus its market value, all else equal. Consequently, multifamily property values generally rise when interest rates fall.[101] Thus, a relative spread variable is not included for multifamily defaults.

(c) Mortgage Age

OFHEO proposes to include mortgage age as an explanatory variable in its single family and multifamily models, as recommended in the ANPR comments. OFHEO found that conditional probabilities of default and prepayment of Enterprise loans exhibit characteristic age profiles that increase during the first years following origination, peak sometime between the fourth and seventh years, and decline thereafter.

Because the benchmark loss experience was based entirely upon newly originated loans, an adjustment is necessary to account for the fact that at any point in time Enterprise single family portfolios consist of loans with varying ages. Adding mortgage age as an explanatory variable provides such an adjustment by allowing conditional default and prepayment probabilities to vary during the stress period in ways that historical profiles indicate are appropriate for loans of each age. Although Freddie Mac raised a concern that mortgage age might have too large an effect in the stress test, OFHEO research indicates that this is not the case. Although mortgage age is an important variable in the models, it does not diminish the impact of other, more

[99] OFHEO does not propose a similar treatment of single family balloon mortgages at this time, because they are not substantial portions of single family loan portfolios of the Enterprises, their balloon point refinance qualification standards are not as stringent as those for multifamily loans, and the Enterprises readily help single family borrowers to refinance balloon mortgages.

[100] This approximation of the mortgage premium value was introduced by Y. Deng, J. M. Quigley, and R. Van Order, (1996) ''Mortgage Default And Low Downpayment Loans: The Costs Of Public Subsidy,'' *Journal of Regional Science and Urban Economics* 26(3–4), 263–285.

[101] While market interest rates do have some effect on prices of single family homes, the effect is not as direct as it is for multifamily and other investment properties.

direct risk factors included in the stress test.[102]

(v) Additional Explanatory Variables Used in the Single Family Model

The following discussion addresses additional explanatory variables that are used only in the single family model. A list of additional explanatory variables for the multifamily model is provided after this discussion of single family variables. The variables discussed below help to complete or modify the basic option valuation for single family mortgages. The original LTV ratio helps to account for differences in default and prepayment rates due to borrower financial status. Occupancy status accounts for differences between single family owner-occupiers and investor-owners. Product-type factors adjust for differences that might be due to the unique risk characteristics of those products and the borrowers who use them. The yield curve slope accounts for different incentives to refinance between fixed-and adjustable-rate products. Some of the variables discussed below are used in statistical estimation of the models, but are represented by simplifying assumptions in the stress test.

(a) Original LTV Ratio

Original LTV ratio is used in the stress test as a proxy for a number of factors related to the financial status of single family borrowers that are recognized widely as influencing the propensity of borrowers to default. Among these factors, which were mentioned by ANPR comments, are borrower income, net worth, and debt burdens. Information about these factors is not available for most of the loans in OFHEO's database. A variable that is available as a proxy for relative financial status of borrowers is the original LTV ratio.[103] Both Freddie Mac and NAR recommended use of this variable. By making low down payments, high LTV borrowers signal that they are more likely to have few economic resources to finance the transaction costs of prepayment, or to endure spells of unemployment or other ''trigger'' events that might cause them to exercise their option to default. Also, high LTV borrowers demonstrate a willingness to ''leverage'' the financing of the home purchase, which may mean that they are more likely to exercise their default option when it is in the money. For these reasons, OFHEO found that original LTV is an important risk characteristic of mortgages, which OFHEO proposes to use both in estimating the single family model and in running the stress test.

(b) Occupancy Status

Historically, single family loans to owners who live in the collateral property have exhibited different performance than similar loans made to investors who rent the property. Difference in occupancy status is one of the loan characteristics that the 1992 Act specifically requires that OFHEO take into account in the stress test. It is also a distinction often made by the mortgage industry, because of a clear difference in the risks of borrower default or prepayment. Owner occupants are less likely than investors to exercise the default option because of the direct benefits occupants receive from the consumption of housing services. Also, owner occupants are more likely to prepay for non-financial reasons, such as residential mobility, than are investors.

The statistical equations used in the stress test were estimated with an investor loan indicator variable that captures the differential default and prepayment risk of these mortgages. However, to capture the differential risk of investor loans in the proposed stress test, OFHEO makes a simplifying assumption that investor loans are spread equally across all loan groups, according to their percentage in the overall Enterprise book of business, rather than creating separate loan groups for investor mortgages. For example, if investor loans are four percent of all loans for a particular Enterprise in a particular starting quarter for the stress test, then four percent of the loans in each aggregated loan group are presumed to be investor loans for purposes of running the stress test. The statistically derived investor-loan weighting factor (statistical coefficient) in each default and prepayment equation is then applied to the four percent figure to arrive at the differential investor loan risk for every loan group. Because investor loans are a small percentage of Enterprise single family portfolios and are heavily concentrated in the 70 to 80 percent LTV category, OFHEO's simplifying approach has no significant impact on loss rates.[104] The exact algorithms used in the proposed stress test to capture investor loan risk are detailed in section 3.5.2.3.2.5., Occupancy Status (OS), of the Regulation Appendix.

(c) Product Type

The 1992 Act expressly requires OFHEO to take differences in mortgage product type into account. In addition, because the benchmark loss experience was identified using the 30-year fixed-rate mortgage, it is necessary to reasonably relate the default experience of other types of mortgage products to the benchmark. Most commenters suggested some type of multiplier approach for other single family mortgage types that would measure the risk of these products in proportion to the risk of the benchmark loan type. OFHEO's proposed approach is broadly consistent with the thrust of these comments. Because comments received by OFHEO focused particularly on relating various mortgage product types to the benchmark experience, these comments are discussed later under section III.A.7.b., Relating Other Single Family Products to the Benchmark. This section discusses the way in which mortgage product type differences are handled in the single family mortgage performance model.

The stress test uses two primary sets of statistically estimated single family default/prepayment equations, one for fixed-rate and one for adjustable-rate mortgages. A third set of equations, which may be thought of as modified fixed-rate equations, is used to project the performance of less prevalent single family mortgage types relative to the performance of 30-year FRMs. This final set of equations includes as explanatory variables unique product-type indicators for 15-year fixed-rate mortgages, 20-year fixed-rate mortgages, balloon mortgages, FHA/VA-insured mortgages, and second liens. Description of these specific product-type variables and their derivations are included in section 3.5.2.3.2.8., Product Type Adjustment Factors of the Regulation Appendix and section IV.B.5.j., Product Type Indicators, of the Technical Supplement. Product type indicators allow estimation of multiplier-like effects using all available historical data, and they assure that measured differences in product-type

[102] Mortgage age combines with the constant term in the statistical default and prepayment equations to create what can be called ''baseline'' rates of default and prepayment: the time series of rates that would occur if all other influences were absent. Once variables representing those other influences are added to the equations, the actual patterns of default and prepayment rates can vary greatly from the baseline paths.

[103] Although credit scores could be a good indicator of the financial status of borrowers, as discussed below under section III. A. 5. e. vi. f., Credit Scores, their usefulness for developing and implementing a default/prepayment model in the stress test is limited because credit scoring is a fairly recent development in the mortgage industry.

[104] Loans on owner-occupied properties in the Enterprise portfolios also have a central LTV range of 70–80 percent. Thus, attributing some investor loans to higher LTV categories and some to lower categories, by assuming they have the same overall LTV distribution as do owner-occupied loans, has offsetting effects on predicted credit risk.

risk are consistent with the stress test environment. All products with variable payments over time are included as adjustable-rate mortgages. Other non-standard mortgage types, such as reverse mortgages and bi-weekly mortgages, are included with their fixed-rate counterparts with similar mortgage contract terms (length of mortgage in years).

As explained in section III.A.7.b., Relating Other Single Family Products to the Benchmark, some commenters were justifiably concerned that applying several product type multiples to a single loan would have an inappropriate compounding effect on default rates. OFHEO addressed these concerns in two ways. First, the multipliers were estimated in a multivariate statistical analysis within the default and prepayment probability equations, rather than applying fixed multipliers to estimated default rates for 30-year fixed-rate loans. This approach provides adjustment factors that are most consistent with broad historical experience and with the other risk factors in the model. By controlling for other explanatory variables, only the residual effects of the differences in product type are captured by these product-type adjustment-factor multipliers, which limits the size of their effects. Second, the models include all other explanatory variables as categorical variables (indicators of value-range categories), instead of as continuous measures of variable values. Using categorical variables helps control for unreasonable compounding risks, by preventing the combination of low house-price growth and sustained adverse interest-rate movements in the stress test to cause default rates to rise to unrealistic levels. For example, the stress test gives the same default weight to all probability of negative equity values above 35 percent, which effectively caps the influence of this variable in the stress test.[105]

(d) Yield Curve Slope

The slope of the Treasury yield curve is included as an explanatory variable in the prepayment equations. Both the choice between ARM and FRM loans and the timing of refinancing are influenced by expectations about future interest rates and differences in short-term and long-term borrowing rates associated with the slope of the Treasury yield curve. The slope of the Treasury yield curve is measured in the proposed stress test by the ratio of the ten-year CMT to the one-year CMT. A high value for the slope of the yield curve indicates that short-term rates are low relative to long-term rates. A high value, therefore, reduces the likelihood that ARM borrowers will refinance into fixed-rate mortgages, and increases the likelihood that fixed-rate borrowers will refinance into ARMs to take advantage of the more attractive interest rates.

(e) Burnout

For single family mortgages, the proposed stress test uses the variable burnout to capture the effect of the inability of borrowers to refinance their mortgages due to equity or other credit constraints. Burnout is the adverse selection that occurs when borrowers retain their mortgages during periods when there are clear financial benefits to refinancing. In this context, adverse selection is reflected in the lower average credit quality of mortgages remaining in a pool after a significant refinancing opportunity, compared to the overall quality of the mortgages in the original, larger pool. Adverse selection occurs because borrowers and properties with higher credit quality refinance in higher proportions than do those with lower credit quality. The remaining mortgages, therefore, will experience higher conditional default rates. Accounting for this change in the underlying quality of a mortgage pool is preferable to using only a prepayment-option-value variable in predicting defaults, principally because its effect continues unchanged over time. The burnout variable in the stress test indicates whether, over the previous eight quarters of mortgage life, there have been at least two quarters with significant refinance opportunities, as defined by a two percentage point difference between the mortgage coupon rate and the market interest rate on fixed-rate mortgages.

For similar reasons, burnout is also included as an explanatory variable in single family prepayment equations, although its effect is in the opposite direction to that in the default equations. As discussed in the ANPR, burnout suggests that prepayment rates will be less responsive to interest rate changes after a pool of mortgages has already undergone a significant period of refinance opportunities.

(vi) Single Family Variables Not Used in Running the Stress Test

Addressed below are several variables suggested by ANPR commenters that either are not used in the single family default/prepayment model, or were included in the statistical estimations but are represented by fixed or constant values when the stress test is run. In general, to estimate the model, OFHEO used variables that had significant independent effects on default and prepayment rates. However, OFHEO does not propose to use all of these variables in running the stress test. Some variables are not used in the stress test because they would diminish the role of the benchmark loss experience in determining stress test credit risk. Others were not needed to reflect statutory requirements to distinguish among loan types and characteristics, or between the effects of the up-rate and down-rate scenarios. Allowing such variables to vary in value in running the stress test would create credit-risk dimensions that are unnecessary and not contemplated by the statute.

(a) Relative Loan Size

Relative loan size[106] is the ratio of the original loan amount to the average-sized loan purchased by the Enterprises in the same State and in the same origination year. This variable was included when estimating the statistical model to isolate differences in the performance of loans of above and below average size, but is not used in the stress test.

As suggested by NAR, OFHEO explored the different default propensities of loans with high and low balances using Enterprise data. OFHEO's use of a relative loan size variable in the statistical estimations of the single family model demonstrated that relatively larger loans tend to have higher prepayment speeds, but differences in default rates by loan size were small and inconsistent. OFHEO interprets the faster prepayment speeds of relatively large loans as reflective of the higher dollar value of the prepayment option on these loans. Households with relatively large loans may also have higher overall debt burdens and be more responsive to opportunities to refinance debt so as to lower payment burdens.

The stress test does not use relative loan size as a variable, because it is not needed to reflect statutorily required distinctions, and including it as a variable would have necessitated a sevenfold increase in the number of loan group records in the stress test. OFHEO believed that the benefit

[105] The number of loans in the historic sample used to estimate the statistical model of default and prepayment rates gets very small as the value of the probability of negative equity rises much above 35 percent. OFHEO therefore does not believe that there is valid information on default risk that could be gained by allowing for categories of probability of negative equity above, for example, 50 percent.

[106] Relative loan size should be distinguished from the actual original and current dollar balances of the loans, which are included elsewhere in the stress test.

derived did not justify the additional complication of the stress test that would result. As a result, all loans are put into the ''average'' size category for this variable when running the stress test.[107]

(b) Season of the Year

The season (quarter) of the calendar year was included when estimating the statistical model to account for the potential impact of weather, school schedules, and seasonal employment patterns on residential mobility and default and prepayment. In order to avoid seasonal variation in the quarterly risk-based capital requirements when the model is applied in the proposed stress test, an average of the season of the year effects is used. Because of the actual statistical technique used to estimate the equations, this average effect is obtained by excluding the season-of-year variable from the stress test default and prepayment equation.[108]

Use of seasonal variation was mentioned by Freddie Mac as a weakness of the termination models used by investment banks to value mortgage backed security pools. OFHEO agrees with Freddie Mac that such seasonal variation would complicate the stress test, by creating quarterly volatility in loss rates, with no particular safety and soundness benefit.

(c) Origination Year

Freddie Mac and NAR recommended including origination year as a variable. This approach would capture differences in the performance of specific mortgage origination cohorts due to excluded factors such as regional income growth and unemployment, or changes in mortgage underwriting standards over time. OFHEO considered using this variable but found that origination year is not an inherent risk factor, is not needed to reflect the types of distinction required by the 1992 Act, and is incompatible with the requirement to relate stress test losses to the benchmark loss experience. The last point is most important. The benchmark loss experience captures loans with the worst origination year and the worst credit risk profile. Assigning to loans originated in a given year a unique underlying credit profile, which may be different from the benchmark credit profile, would remove an important element of the link between stress test losses and the benchmark loss experience. In addition, varying inherent credit risk by loan origination year would require speculative assumptions about loan quality for more recent origination years for which no credit-risk track record has yet been established.

By not including origination year as an explanatory variable, the statistical equations capture average origination-year profiles of default and prepayment. As discussed later under in section III.A.7., Relating Losses to the Benchmark Loss Experience, these profiles are adjusted further to reasonably relate starting loan portfolios to the benchmark loss experience. If the stress test were to allow for origination year differences when estimating the statistical equations, it would be necessary to assign the benchmark origination year effect to all loans in the stress test to preserve a reasonable relation to the benchmark loss experience. This approach would complicate the stress test without changing the results that are obtained using the proposed approach.

(d) Unemployment

Unemployment rates were listed by some commenters as a possible explanatory variable. For numerous reasons, OFHEO does not propose to include unemployment as a variable either in running the stress test or in estimating the statistical model. OFHEO does not propose to include unemployment rates as an explanatory variable in the stress test, primarily because it is not a loan characteristic, but a macro-economic variable, and it is not one of the economic variables specified in the 1992 Act. In any event, the effect of economic-condition variables not specified in the statute, such as unemployment, are captured in the stress test by relating the stress test to the actual benchmark loss experience, because the appropriate values are inherent in that experience. Thus, reasonably relating the stress test to the benchmark loss experience, as described in the next section, captures the strenuous economic conditions required by the 1992 Act without adding more economic variables. Minimizing the number of variables used to define economic conditions is responsive to the comments of both Fannie Mae and Freddie Mac, who argued against unnecessary complexity.

(e) Purchase vs. Refinance Loans

MRAC suggested that OFHEO take loan purpose into account. OFHEO considered whether this distinction should be included as a variable, but has proposed a stress test that does not distinguish between loans made for the purpose of purchasing and loans made for the purpose of refinancing property. OFHEO has found insufficient basis to distinguish between the risks of loans for purchases and loans for refinancing. Furthermore, OFHEO prefers not to create capital incentives based on loan purpose, except as required by statute (e.g., the occupancy status distinction).

(f) Credit Scores

OFHEO does not propose to follow the recommendation of MRAC to use mortgage borrower credit quality considerations as explanatory variables. OFHEO is aware that the mortgage industry is moving toward risk-based loan pricing based, in part, on mortgage credit scores that rely heavily on borrower credit ratings.[109] OFHEO is studying the use of credit scores by the Enterprises, and the potential for impact on stress test credit losses, but does not believe that it is appropriate to consider these in the stress test or to use them to estimate the models. First, it would be difficult, if not impossible, to reasonably relate credit risk differences based upon credit scores to the benchmark loss experience, because credit-scoring data are not available for benchmark era loans.[110] Second, the proposed stress test is designed to reasonably relate starting the performance of mortgage portfolios to the benchmark loss experience based upon loan characteristic differences referenced in the 1992 Act, which do not include measures of borrower creditworthiness.[111]

[107] This value is part of the fixed-factor terms reported in section 3.5.2.3.3., Combining Explanatory Variables and Weights of the Regulation Appendix for each default and prepayment equation. Relative loan size is discussed in section B.5.i., Relative Loan Size of the Technical Supplement.

[108] Seasonal variation is discussed in section B.5.g., Season of the Year, of the Technical Supplement.

[109] The most widely used measure of borrower creditworthiness is a composite score developed by Fair Isaac Corporation, commonly referred to as a ''FICO score.''

[110] Archives at the credit repositories only go back to the late 1980s, and, even there, records are not complete.

[111] The fact that OFHEO does not consider differences of credit risk by credit scores in the proposed stress test does not limit the ability of the Enterprises to to make use of credit scores. The Enterprises may further stratify the risk classifications used by OFHEO in the proposed stress test, for purposes of internal capital allocation and guarantee pricing. For example, after determining the required regulatory capital for a particular product class the Enterprises may, if they choose, allocate the required capital among purchases of that product according to borrower credit scores, for internal purposes. Thus, the dimensions on which the Enterprises choose to develop risk-based guarantee pricing are not limited by stress test risk classifications.

(vii) Additional Multifamily Explanatory Variables

Understanding the choice of explanatory variables for the multifamily default/prepayment model requires understanding the way in which default and prepayment equations are organized. The stress test uses two default equations, to distinguish between different multifamily lending programs, and five prepayment equations, to distinguish between different product types. The multifamily model allows these various default and prepayment equations to interact with each other to provide appropriate default and prepayment rate projections for all multifamily loans, throughout the stress period.

One of the two default equations is for purchases of newly originated loans (cash purchases),[112] and the other is for negotiated swaps of seasoned loan pools for mortgaged-backed securities (negotiated purchases). This separation allows the stress test to account for differences in loan quality across the two programs. The Enterprises may take lower quality loans and properties in their negotiated purchase programs than in the cash purchase programs, but require significant credit enhancements from the seller/servicers to compensate.

The five prepayment equations used to accommodate product-type and product life-cycle differences allow the proposed stress test to account for the effects of loan characteristics, such as yield-maintenance provisions,[113] adjustable interest rates, and balloon terms. It is more important to capture the unique features of balloon mortgages in the multifamily business than it is in the single family business because balloons make up the majority of multifamily portfolios. The five prepayment equations are for: (1) All fixed-rate loans in the yield-maintenance period; (2) fully-amortizing fixed-rate loans after yield maintenance requirements; (3) fixed-rate balloon loans after the expiration of yield-maintenance requirements (but prior to maturity); (4) all ARM loans (prior to maturity for balloon ARMs); and (5) all balloon loans (with fixed or adjustable interest rates) at and after the maturity year.

To see how these prepayment equations work together, note, for example, that fixed-rate balloon loans have three relevant time periods: first is ''in-yield maintenance,'' the time when the yield maintenance terms apply; second is ''post yield maintenance,'' the period after the yield maintenance term expires and prior to loan maturity; and third is ''post-balloon,'' the period starting when the loan is due in full.[114] For loans that extend to and beyond the balloon point,[115] OFHEO proposes a separate prepayment equation, which is referred to as a ''payoff'' equation because it is no longer possible to ''prepay'' loans on or after the balloon date.

(a) Explanatory Variables in the Two Multifamily Default Equations

The two multifamily default equations are similar except in two respects. First, the equation for cash purchases makes adjustments for loans purchased in original multifamily programs to distinguish them from more recent programs. Second, the negotiated purchase loan equation has an adjustment factor for loan programs that obligate the seller to repurchase loans when they are delinquent for 90 days. These distinctions will be discussed in the context of each explanatory variable.

(1) Joint Probability of Negative Equity and Negative Cash Flow

As with single family loans, one of the most important factors affecting multifamily loan default is borrower equity. When the value of the property is less than the value of the mortgage, the borrower, by defaulting, can effectively ''sell'' or ''put'' a mortgage back to a lender at the value of the underlying property. However, as recognized by the ANPR commenters, there is a second consideration for commercial properties (including multifamily properties)—cash flow from the property. Even though equity is zero or negative, the borrower does not have an economic incentive to default as long as cash flows are positive.

The stress test includes a default option valuation variable that allows for consideration of the cash flow position of the property, while also considering the borrower's equity position. A value for this variable, referred to as the joint probability of negative equity and negative cash flow, is calculated for each loan in each observation period. It measures the potential value of ''putting'' the mortgage to the lender and investor through default, given that both equity and cash flow are important.[116]

As shown in section D. 4. a. i., Joint Probability of Negative Equity and Negative Cash Flow, of the Technical Supplement, the joint probability of negative equity and negative cash flow for a project is the probability of having both LTV greater than 1.00 and DCR less than 1.00. The proposed stress test uses loan amortization schedules, rental inflation, vacancy rates, and interest rates to update LTV and DCR, which are then used to update the joint probability variable values.

(2) Original Versus Current Loan-Purchase Programs

OFHEO faced the issue of what, if any, adjustment should be made in the model to distinguish between loans purchased under original cash-purchase programs (purchased pre-1988 for Fannie Mae and pre-1992 for Freddie Mac) and current programs. As noted by Freddie Mac, the Enterprises computed both DCR and LTV differently for loans purchased under original programs than they compute those ratios today for current purchase programs. OFHEO recognizes that in the 1980s it was a common appraisal practice to adjust actual rents (and therefore net operating income) upward by an estimate of annual inflation and to use optimistic vacancy rate assumptions. This practice resulted in an overstatement of actual DCR and LTV values at the time of loan origination. Current practice does not allow for such inflation adjustments of projected rents, and factors minimum levels of anticipated vacancies into property valuation, even if the property is fully rented at the time of loan origination.

In addition to the overstatement of net income, original multifamily cash-purchase programs at the Enterprises had other significant weaknesses perhaps because the Enterprises only began purchasing conventional multifamily loans in 1983 and did not have experience with the differences from single family lending. Even controlling for the overstatement of rents and for changes in tax laws in 1986 that depressed real estate values, these weaknesses led to extraordinarily high loss rates. OFHEO views these large losses, to a large extent, as nonrecurring startup costs attributable

[112] Cash-purchase programs may involve delivery of loans for cash or for mortgaged backed securities. They are called ''cash'' programs because they involve the purchase of individual loans under published underwriting guidelines and pricing.

[113] A yield maintenance provision permits prepayment, but requires the borrower to pay penalties to compensate the lender or investor for lost interest until the yield maintenance period expires.

[114] Balloon loans with adjustable interest rates (rather than fixed coupon rates) do not have yield maintenance terms, so they only have two relevant periods—pre- and post-balloon.

[115] After the balloon maturity date, the Enterprises may permit loan extension.

[116] The equity and cash flow positions of a property are positively correlated. The joint probability of negative equity and negative cash flow variable used in the proposed stress test captures this relationship.

to inefficiencies involved in learning a new business. For these reasons, OFHEO believes that the Enterprises' multifamily lending programs in the early and mid-1980s are so different from the current programs that it would be inappropriate to consider those early loans to be the same type of mortgage product as the multifamily loans that are made today.

The stress test accounts for the difference in the older loan programs and the newer programs in two ways. First, the stress test adjusts the origination DCRs and LTVs of original cash purchase loans to remove the estimated annual inflation factors and restate those ratios as they would be calculated by the Enterprises in their current program purchases.[117] Second, the stress test includes a variable in the default equation that distinguishes between original and current cash purchase programs. This variable results in higher levels of default on original cash purchase loans than on newer loans.

A significant consideration in OFHEO's proposal to distinguish the original cash purchase loans from loans purchased under current programs was that failing to make that distinction would create a relatively more severe (and far less) loss experience for multifamily loans than the benchmark loss experience creates for single family loans.[118] In OFHEO's view, imposition of such extreme levels of default upon the Enterprises' multifamily loans would be contrary to the intent of the 1992 Act that rates of default and severity be ''reasonably related'' to the benchmark loss experience. It is also possible that basing stress test losses on average default rates of original cash-purchase loans would result in an implied marginal capital requirement so high as to create an inappropriate disincentive to engage in new multifamily lending.

(3) Depreciation Write-offs and Tax Law Changes

In the absence of a price index for multifamily properties, the stress test captures most of the changes in property value by updating DCR and LTV according to changes in rents, vacancies, and interest rates. However, changes in DCR and LTV that are due to other factors are not captured in these procedures. The most important missing factor is the tax benefit afforded to owners of investment real estate through depreciation write-offs. ACB commented that depreciation allowances have important effects on property cash flows. OFHEO recognizes this fact and that the allowances also have important effects on capital gains at the time of property sale. The tax value of depreciation write-offs significantly influences the return from multifamily property investments and, consequently, the default risk of multifamily mortgages.

OFHEO agrees with Freddie Mac that tax law changes affecting multifamily default rates during the 1980's should be taken into account, but that OFHEO should not speculate on the effect of potential legislative or other governmental actions during the stress period. The proposed stress test incorporates an index that measures the value of depreciation write-offs for a new investor. It measures changes in quality due to changes in write-offs and allows OFHEO to reflect the effects of such changes on mortgage defaults historically. The actual index value used in the stress test is an approximation of expected values throughout the stress period.[119] It is calculated based on depreciation rules and tax rates as they existed in 1997, with no adjustments for movements in interest rates since that time, or for the interest-rate shocks that will occur in the stress test. The tax rules governing depreciation allowances have the largest impact on the value of this variable. These rules changed significantly in 1986, but have not changed significantly since. Because the historical database included many loans originated before the tax rule change, OFHEO allowed the value of this explanatory variable to vary for purposes of estimating the statistical equations for multifamily mortgage default. However, due to the subsequent stability in those rules, OFHEO proposes to hold the value of this variable constant throughout the stress test. If the applicable tax rules change in the future, or if OFHEO believes that there are other reasons for either changing the specified value for the stress test or allowing its value to change throughout the stress test, OFHEO will initiate a new rule making process. However, as recommended by Freddie Mac in its ANPR comments, OFHEO will not speculate about tax law changes that might occur during the stress period. Due to data restrictions, the depreciation-allowance is only included in the cash-purchase default equation.[120]

(4) Loan Programs with Seller/Servicer Repurchase Features

Some Enterprise multifamily loan programs require seller/servicer repurchases of loans that become 90-days delinquent. For these programs a 90-day delinquency event is effectively a default, while for all other loans, default means a property loss event (short sale, note sale, third-party sale or foreclosure). To account for this difference when estimating the statistical model, OFHEO applied, as an explanatory variable, the ratio of 90-day delinquencies to full defaults. This treatment is important because the rate of 90-day delinquency events is always higher than the default rate for property loss events, and the loss severity for 90-day delinquencies is lower. By including this ratio, and thus including loans with the 90-day delinquency terminations, OFHEO was able to estimate a negotiated-purchase default equation based on a much larger data set than would have been possible otherwise.

(5) Balloon and ARM Payment Shock Risk

Following HUD's suggestion, OFHEO analyzed defaults of Enterprise balloon loans at the balloon point. As a result, OFHEO proposes to give additional weight to the joint probability of negative equity and negative cash flow variable for balloon loans that survive to the year of balloon maturity. This extra weighting takes into account the increased risk that mortgages with weak financials will default as the balloon point approaches. Also, interest rate movements may create payment shock (change in the periodic mortgage payment) in the post-balloon period, which affects the probability of default. The stress test accounts for the effect of

[117] OFHEO found that loans acquired in negotiated swap arrangements in the early and mid 1980s were highly seasoned and had low default rates. They therefore did not appear to include the inflation factor evident in cash purchases. Therefore, OFHEO does not adjust DCRs and LTVs for loans in negotiated purchase pools.

[118] The relationship of multifamily default rates to the benchmark experience is discussed later in section III. A. 7. c., Relating Multifamily Mortgage Performance to the Benchmark.

[119] The stress test does not capture actual depreciation allowances for borrowers. Enterprise databases do not include the year of property purchase. Therefore, the exact depreciation rules affecting cash flows and investment value to existing owners are unknown. Even on newly constructed projects, the Enterprises generally do not purchase the mortgage until target occupancy rates are met, which may be some time after origination. For these reasons, it would be extremely difficult to determine the actual value of depreciation write-offs to current owners. Although the value to current owners affects the owner's cash flow, the value to potential purchasers (which would be based upon current appreciation rules) affects property value and the owner's equity in the property. Therefore, this explanatory variable for depreciation write-offs helps to reflect more accurately the true LTV of the mortgage.

[120] See section D. 4. a. ii., Construction of the JPt Variable of the Technical Supplement for details.

this shock directly through adjustments to effective DCR in the post-balloon period. These adjustments then affect the joint probability of negative equity and negative cash flow, reflecting the fact that the decision to default or payoff is no longer a function of the original mortgage coupon rate, but of the prevailing market rates at the time of balloon expiration. In sum, the stress test reflects that the value of the default (''put'') option, as measured through the joint probability variable, becomes more significant for default rates in the post-balloon period because there is increased pressure on the borrower to either default or refinance the property.

ARMs also experience payment shock because of changes in market interest rates. ARM payment shock occurs periodically during the term of the loan, and ARMs continue to amortize after the payment shock, according to the original contract term. The ARM prepayment equation in the stress test accounts for these periodic changes in interest rates. In contrast, the payment shock for a fixed-rate balloon loan does not occur until the balloon point. Some loans in Enterprise portfolios are ARMs with a balloon maturity. These loans have payment shock every year and also at maturity. The proposed stress test models the annual changes in their DCRs resulting from changes in mortgage coupon rates and then adds an additional balloon shock through the additional weight given to the joint probability variable in the post-balloon period.

(6) Loan Size

The stress test does not include a variable for loan size. S&P explained that it bifurcates commercial loan pools into two parts to calculate credit loss potential—the largest loan, and all other loans in the pool. S&P assumes 100 percent risk of default on the largest loan and average risk of default on the other loans. This approach is designed to recognize the uneven dollar credit loss risk inherent in pools that contain loans that are large relative to the total size of the pool. Credit risk for the pool is then estimated by S&P to be the sum of estimated credit risk on each part. S&P did not specifically recommend that OFHEO adopt this approach in the stress test.

OFHEO agrees that S&P's methodology is appropriate for analyzing differential impact of large and small loans on potential credit losses in mortgage security pools. However, no one multifamily loan default could have a significant impact on total losses or capital for either Enterprise. For that reason, OFHEO decided not to propose any measure of loan size as an explanatory variable in the multifamily default/prepayment model.

(b) Explanatory Variables in the Five Multifamily Prepayment Equations

As explained above, the multifamily model uses five loan prepayment equations to identify unique product type and life-cycle characteristics. This approach is consistent with Freddie Mac's and MRAC's comments on accounting for mortgage product types and terms in the default and prepayment models. There are some differences in explanatory variables across these five equations, which are discussed below.

(1) Prepayment Option Value

As discussed earlier, OFHEO proposes to use the relative interest rate spread to measure the prepayment option value (mortgage premium value) for prepayments. The relative spread is the ratio of the difference between the coupon rate and the current market interest rate to the coupon rate. To account for the asymmetry of effects from increases and decreases in interest rates, the spread is split into two variables.[121] One is active if current market interest rates are above the mortgage coupon rate, and the other is active if current market rates are below the mortgage coupon rate. Decreased interest rates increase refinancing speeds. Increased interest rates decrease both normal refinancings and cash-out refinancings. Cash-out refinancings are refinancings in excess of the outstanding indebtedness. They are used to achieve a desired debt-to-equity ratio in the property as explained below in the discussion of current LTV. Relative spread variables appear in all prepayment equations except for the balloon and post-balloon payoff equations. At balloon maturity, all spreads become irrelevant, because borrowers are contractually obligated to pay off or refinance the property.

For the ARM prepayment equation, the relative spread variable is calculated by comparing the coupon rate to the current market rate on fixed-rate loans, rather than to the market rate for ARMs. This approach accounts for any incentive to refinance into a fixed-rate loan. Because there are no yield-maintenance terms or special incentives to refinance ARM loans when interest rates fall, the stress test includes one spread variable that captures both increases and decreases in interest rates. In addition, the stress test does not distinguish between life-cycle periods for ARMs; just one prepayment equation is estimated.

(2) Current LTV

Another important issue in modeling multifamily loans is the propensity of investors in multifamily properties to refinance mortgages over time to increase their debt (leverage) ratios, and thus increase returns on invested equity.[122] To capture the borrowers' ability to qualify for a new loan and the incentive to adjust debt-to-equity ratio, the proposed stress test includes current LTV as an additional explanatory variable. If the current LTV falls, investors have more incentive to prepay and are more likely to find a lender willing to refinance the property.

(3) Prepayment Option Value in the Yield-Maintenance Period

During the yield-maintenance period, borrowers may prepay, but they must continue to provide the contractual yield until the yield-maintenance period expires. Thus, a prepayment in the yield-maintenance period can be expensive, particularly in the early years of a mortgage. The more years to go in the yield-maintenance period, the greater the fee.[123] To capture the declining financial cost of prepayment throughout the yield-maintenance period, OFHEO proposes a variable measuring years remaining until the end of the yield-maintenance period. This variable appears in the prepayment equation for fixed-rate loans in the yield-maintenance period.[124]

(4) Prepayment Option Value in the Pre-Balloon Period

During the pre-balloon period, borrowers are uncertain about the level of market interest rates at the future balloon point. Hence, borrowers may be willing to pay in order to lock into a favorable interest rate, rather than take

[121] Such explicit bifurcation is not required for the single family prepayment equations because the categorical nature of the spread variable used there allows for asymmetric effects.

[122] *See* Jesse M. Abraham and H. Scott Theobald, ''Commercial Mortgage Prepayments,'' in Frank Fabozzi and David Jacob, *The Handbook of Commercial Mortgage-Backed Securities*, New Hope, PA: Frank J. Fabozzi Associates, 55–74 (1997).

[123] Because this effect runs counter to the effect of the call option value, OFHEO researched the possibility of a joint effect of the years-to-go and the rate drop variables. The fixed effects of the years-to-go variable proved to be a better predictor of actual, historical prepayments during yield maintenance periods.

[124] For loans with true prepayment prohibitions, or ''lock-outs,'' the variable is set equal to the maximum number of lockout years throughout the lockout period. *See* section 3.5.4.3, Procedures, of the proposed Appendix to 12 CFR part 1750, subpart B for details.

their chances with possible adverse interest rate movements. This risk aversity with respect to interest rate movements prior to the time of balloon maturity gives rise to an additional financial value from early prepayment. OFHEO proposes two explanatory variables to capture the effect of risk aversity on prepayment rates in the pre-balloon period. They measure the additional effects of the primary prepayment option variable-relative spread-when it is in the money (market interest rates are lower than the mortgage coupon rate).

The first variable provides an additional effect for interest rate drops in the year immediately prior to the balloon year, and the second provides for a separate, additional effect for interest rate drops in the second year prior to the balloon year. These two variables allow for increased incentives to refinance if the prepayment option is in the money in the period leading up to balloon expiration. They capture the risk aversity of borrowers with respect to future interest rate changes as balloon maturity approaches.

(5) Balloon and Post-Balloon Payoffs

HUD commented that OFHEO should model the value of the refinancing option at the balloon point on balloon mortgages because the lender often has a contractual obligation to refinance at the borrower's option. OFHEO agrees that payoffs at the balloon point are different from prepayments before the maturity date, but has found that the lender generally does not have an unconditional contractual obligation to provide new funding if the borrower requests it. Payoff of the balloon loan (generally by new borrowing to refinance the property) is contractually required at term. If the borrower is successful at finding new financing at that point, the event that appears in Enterprise records is a payoff of the original loan and not a prepayment. Despite the contractual requirement of balloon payoff, not all loans terminate at the balloon point.[125] Generally, balloon loans are extended beyond the maturity date because, although the property has weak financials, lenders are unwilling to initiate foreclosure on loans that have been making payments at the original coupon rate. To capture the ability of multifamily borrowers to obtain new loans at balloon expiration, and, therefore, to pay off the original mortgage, the model includes a variable similar to the joint probability variable used in the default equations—the joint probability that current DCR and LTV values are sufficient to qualify for a new mortgage. This is the only variable used in the pay-off equation for balloon mortgages, and it is based on minimum qualification criteria for multifamily mortgages, LTV ≤ 0.80 and DCR ≥ 1.20.

(6) Effect of Fixed-Rate Loan Interest Rates on ARM Prepayments

A final variable included in the ARM prepayment equation is the market rate on fixed-rate loans. This variable accounts for incentives to refinance ARM loans into fixed-rate loans to avoid future uncertainty regarding interest rate movements. If the FRM rate is high, borrowers expect interest rates to drop in the future and are likely to delay prepayment of ARMs. Likewise, when interest rates are low—regardless of the spread between FRM and ARM rates—there is an incentive to refinance into a fixed-rate product to avoid potential increases in future interest rates.

6. Loss Severity

Loss severity is the net cost to an Enterprise of a loan default. The three major cost categories are loss of loan principal transaction costs at both foreclosure and disposition, and asset funding costs throughout the process. The net cost is determined by crediting against these costs the revenues associated with the defaulted loan. The major revenues are proceeds from the property sale and from mortgage insurance or other forms of credit enhancement.

In determining how to model loss severity in the stress test, OFHEO considered the following issues:

1. what general approach to take in modeling loss severity,

2. whether the stress test should model individual cost and revenue elements of loss severity or model severity as one single measure,

3. what explanatory variables should be included explicitly in modeling loss severity, and

4. an appropriate house price index for real estate owned (REO) properties.[126]

a. General Approach to Modeling Loss Severity

In the ANPR, OFHEO discussed four general approaches to estimating the separate effects of explanatory variables on loss severity. One approach is to use a multivariate statistical model to estimate the separate effects of explanatory variables on total loss severity rates. A second approach is to use statistical models relating the individual elements of loss severity to explanatory variables. A third approach would set fixed parameters for the elements of loss severity (foreclosure costs, carrying costs, and sales prices), while allowing final loss severity rates to vary based on other factors such as the presence of private mortgage insurance. A fourth, relatively simple approach would be to assume that all defaulted loans face a fixed and equal level of loss severity.

(i) ANPR Comments

ACB and MRAC encouraged OFHEO to use a multivariate statistical model of loss severity. ACB, apparently assuming the stress test would include a statistical model of defaults, stated that ''[i]t is not a rational allocation of resources to develop a sophisticated model of mortgage defaults and then to apply a rule-of-thumb percentage to the unpaid principal balances.'' S&P described its use of data from the Great Depression as the basis for stress tests it uses to rate single-family mortgage pools. Freddie Mac recommended that OFHEO use average loss severity rates from the benchmark loss experience, adjust them to account for the stress test interest rate environment, and apply additional adjustments for various property types.

(ii) OFHEO's Response

OFHEO believes that a statistical model is the best approach to take into account loan seasoning and the dynamic nature of economic changes in the stress period. OFHEO agrees with ACB that it would be inappropriate to develop a sophisticated default model and then to apply a rule-of-thumb percentage to the UPB to determine loss severity. At the same time, OFHEO recognizes that developing statistical models of each loss element is unnecessarily complex. Based on its analysis of the available information, OFHEO proposes a two-part model for single family loss severity: a statistical equation for loss of loan principal and fixed parameters for the other cost elements. Specifically, the statistical model developed by OFHEO estimates loss of loan principal as a function of loan seasoning-updating the original LTV using HPI growth rates and loan amortization. For multifamily loss severity, OFHEO proposes to use only fixed cost element values. The rationale for this is explained below under section III. A.7., Relating Losses to the Benchmark Loss Experience.

[125] *See* Elmer and Haidorfer, ''Prepayments of Multifamily Mortgage-Backed Securities,'' *The Journal of Fixed Income*, March 1997, 50–63 (pointing out that not all loans terminate at balloon point); Abraham and Theobald, op. cit. (referring to this phenomenon as extension risk). OFHEO confirms the existence of post-balloon loans in Enterprise portfolios.

[126] REO properties are properties acquired as a result of foreclosure or similar action.

The approach outlined by S&P would not be appropriate for OFHEO's stress test because it does not adjust for loan seasoning or provide for a reasonable relationship to the benchmark as required by the 1992 Act. However, consistent with the S&P approach, the stress test does provide for a greater than average drop in house prices for foreclosed properties. As discussed below, under section III. A.6. b., Elements of Loss Severity Modeled, the stress test uses a statistical equation to model the expected decline in values on foreclosed properties, which will be greater than the decline in property value associated with HPI assumptions used in the stress test. In addition, as discussed later under section III. A.7., Relating Losses to the Benchmark Loss Experience, the stress test adds an extra loss factor to relate stress test property value loss to the actual experience of the four-State benchmark.

OFHEO agrees that Freddie Mac's recommended approach is simpler than using a statistical model. However, an empirically based statistical model is more versatile and flexible, allowing the stress test to reflect loss severity rates appropriate for each Enterprise's mix of loans and the stress test interest rate environment. OFHEO proposes a hybrid approach that retains the simplicity of fixed cost factors for most severity elements, while developing a more sensitive measure of property value, the element most affected by pre-stress test loan seasoning.

OFHEO does not propose at this time to take property type differences into account in stress test loss severity rates, as suggested by Freddie Mac. Although OFHEO finds higher loss severity rates for investor-owned properties, accounting for this effect would increase significantly the number of loan group records used for starting books of business in the stress test. Given the small percentage of Enterprise portfolios that investor-owned loans comprise, OFHEO felt that the added complexity was not justified by the benefits of calculating severity rates for owner-occupied and investor-owned single family loans separately. Therefore, OFHEO does not propose to apply risk multiples for investor-owned properties in determining loss severities. Rather, the single set of cost elements used in the stress test are determined by Enterprise experience with all single family property types combined.

b. Elements of Loss Severity Modeled

In addition to asking whether OFHEO should use a statistical model of loss severity, the ANPR asked whether the stress test should model loss severity as a single value or model the various cost and revenue elements of severity separately.

All ANPR commenters favored, at varying levels, an element-by-element analysis. The VA recommended that the stress test model the amount and timing of both the cost and the revenue elements of loss severity to provide more accurate estimates of Enterprise cash flows. HUD recommended that the loss severity model include certain individual cost elements, all of which would be valued separately by the proposed severity module. NAR stated that ''the modeling of loan loss severity should only include those factors that are independent of incidence of default'' and emphasized the importance of modeling time in default separately. In contrast, Freddie Mac stated that defaults and severity are products of the same underlying characteristics and economic factors. Freddie Mac suggested that stress test severity calculations differentiate loans by original LTV and coupon class and by product type distinctions. In addition, Freddie Mac favored using the rate of loss of principal balance from the benchmark loss experience.

ACB supported using a sophisticated model of loss severity, which would, presumably, require breaking down severity into its constituent parts for analysis and modeling. MRAC suggested separate analysis of the elements of loss severity, including the estimated sale proceeds, holding time, monthly holding costs, and costs of sale.

OFHEO agrees with the commenters that the stress test should model individual cost and revenue elements separately, rather than model them together as a single cost category. Such an approach allows the stress test to model the interrelationship of those elements that significantly effect loss severity. Accordingly, OFHEO proposes to model elements in three principal groupings: (1) loss of loan principal balance, (2) transaction costs (e.g., expenses related to foreclosure, and property holding and disposition expenses), and (3) funding costs on non-earning assets. OFHEO believes that measuring elements in these groupings is necessary to accommodate differences in the timing of various elements of loss severity and differences in the pre-stress test seasoning of loans. Each cost or revenue factor is applied at one of the following three points in time (each in terms of months from date-of-default): time of loan repurchase (for loans in security pools) or bad-debt write off (for retained loans); time of foreclosure completion; and time of foreclosed property disposition.

In addition, consistent with Freddie Mac's comment, OFHEO's proposed loss severity calculations differentiate by LTV and coupon class. They also include product distinctions where those distinctions involve FHA/VA insurance, interest rates and amortization terms. The amount of the loss of loan principal balance is sensitive to loan amortization. Because 15-year mortgages amortize relatively early and more quickly, their predicted losses are much less than those on otherwise comparable 30-year mortgages.

(i) Loss of Principal Balance

A critical element of loss severity is loss of loan principal balance, i.e., the difference between the outstanding principal balance on the loan at the time of default and the sale price of the foreclosed property. This loss occurs because of general declines in local housing values, the depreciation of the individual property, and/or discounts required to sell properties with ''foreclosure'' labels. To calculate this loss, the stress test uses a statistical model of the historical relationship between actual loss of principal balance on loans that have defaulted and the loss of principal balance predicted solely by calculating amortization on the loan and updating the property values with the HPI. Sale proceeds are then calculated as UPB minus the estimated loss of principal balance. Proceeds vary with differences in house-price appreciation and loan terms.

(ii) Transaction Costs

The stress test includes two transaction cost elements in loss severity calculations: foreclosure/legal expenses, and property holding and disposition costs.[127] Property holding and disposition costs are combined in the proposed stress test because they are both expensed at the time of property disposition. OFHEO proposes to use averages of these cost elements—in percent of outstanding principal balance—from all Enterprise experience with foreclosure and REO properties.

OFHEO did not follow Freddie Mac's recommendation to use all cost elements directly from the benchmark loss experience for transaction costs, because the stress test is national in scope. Therefore, it is appropriate to have a national blend of institutional factors such as foreclosure costs, property management fees, and sales

[127] Legal expenses are dominated by foreclosure costs, but they also include costs associated with gaining releases from borrower bankruptcy stays and property evictions.

expenses, rather than the four-State blend from the benchmark experience.

(iii) Funding Costs

Funding costs are considered an element of loss severity because the Enterprises must fund non-earning assets: first the defaulted loans, and then the REO properties. In its ANPR comments, Freddie Mac suggested that funding costs should be measured at the mortgage interest rate for the period from date of default to foreclosure completion. OFHEO agrees that the stress test should model funding costs. However, Freddie Mac's recommended approach ignores funding costs during the REO time period and would provide inaccurate measures of funding costs during the delinquency/default period. In the down-rate scenario of the stress test, using the mortgage coupon rate for funding costs would overstate funding costs, while in the up-rate scenario it would understate funding costs.

With one exception, the stress test measures asset funding costs through present-value discounting techniques, rather than computing explicit interest charges. Therefore, all severity elements are discounted by a cost-of-funds rate to produce the present value of each element in the month of default, regardless of when it may occur after that date. Cash flow discounting provides a consistent method of accounting for all timing issues involving cash flows from mortgage default to property disposition.

The one exception to the rule of calculating funding costs through present-value discounting techniques is the explicit cost of covering interest passed through to investors in securitized loans (mortgage-backed securities). These passthroughs occur for the first four months of loan delinquency, during which time the stress test uses the passthrough rate (the interest rate paid to holders of the securities) to calculate the asset funding cost. After the fourth month, when the loans have been repurchased from security pools and placed in Enterprise retained portfolios, the stress test treats these defaults identically to defaults in retained portfolios.

(iv) Factors Not Modeled

ANPR commenters suggested several explanatory factors that are not included in the proposed single family loss severity model. These include distinctions based on State foreclosure laws, household liquidity, and the presence of private mortgage insurance.[128]

(a) State Foreclosure Law Differences

Freddie Mac suggested that OFHEO not make State-level distinctions in loss severity calculations, explaining that attributing ''differences in loss rates by states would approach undue intrusion and inappropriate micromanagement of the Enterprises.'' In contrast, NAR recommended that OFHEO make State distinctions.

Although foreclosure time-frames and costs may vary based on State law and practice, OFHEO agrees with Freddie Mac that it would be inappropriate to model State-level differences. First, these differences do not represent loan characteristics, and, therefore, under OFHEO's approach to selecting variables to apply in the stress test, they are not appropriate. Second, if OFHEO were to allow for State-level differences in credit costs, the stress test would, essentially, be establishing State-specific capital requirements based upon nuances of State law. OFHEO would need to monitor developments in the many different State laws over time to adjust the parameters of the stress test. Third, the fact that the stress test uses loan data aggregated at the Census division level means that much of the variability in foreclosure costs observed at the State level disappears.

(b) Independence of Loss Severity Rates From Default Rates

Freddie Mac commented that default and loss severity are products of the same underlying factors, most particularly original LTV and property value appreciation over the life of the mortgage. NAR recommended that the loss severity model ''only include those factors that are independent of the incidence of default.'' OFHEO agrees with Freddie Mac on this point, because OFHEO's research indicates that loan seasoning has an important impact upon severity rates that is independent of its impact on defaults. The use of loan seasoning in the stress test reflects differences in loss severity across loans. This approach is also consistent with NAR's comment, because estimating the impact of seasoning on loss severity independently from its impact on defaults avoids duplicating seasoning's effect on credit losses.

(c) Household Liquidity

NAR stated that liquidity of the household under stress is an important factor in the loss severity equation. OFHEO notes that for the single family loss severity analysis, the stress test considers housing-related liquidity of a household through loan seasoning. That is, updating the LTV provides some indication of the ability of borrowers to sell or borrow against their properties in order to provide liquidity. However, the stress test does not account directly for non-housing wealth or liquidity of borrowers. It is unclear how these factors could be measured or estimated accurately.

(d) Private Mortgage Insurance

NAR also commented that the presence of private mortgage insurance is a variable that can influence the time to foreclosure and therefore, presumably, holding costs. OFHEO, however, has found insufficient evidence that the presence of mortgage insurance has any meaningful impact on foreclosure time. Both Enterprises submit their own foreclosure time guidelines to seller/servicers, which are independent of the presence of mortgage insurance. Accordingly, the presence of private mortgage insurance is not included as a variable in the loss severity equations.

This issue is distinct from the question of how OFHEO should account for private mortgage insurance proceeds in the loss severity calculations. Several commenters noted that the loss severity calculation should deduct mortgage insurance proceeds from losses on loans covered by such insurance. OFHEO agrees that the loss severity calculation should account for mortgage insurance proceeds. This issue is discussed extensively in section III.C., Mortgage Credit Enhancements.

c. REO House Price Index

In the ANPR, OFHEO asked what price index would be appropriate for REO properties. The question arose because defaulted loans generally have lower house-price appreciation rates than the market average, which is captured by HPI growth over time. After considering the ANPR comments and OFHEO's own research, OFHEO proposes an equation to relate actual declines in value for REO properties to changes in the HPI. This approach, which is described in section 3.5.3.3.3.1, Calculate Proceeds from Property Sale, of the Regulation Appendix, provides the information needed to predict accurately the loss of loan principal balance in loss severity calculations, but avoids the added complexity of creating a separate index.

All five commenters that addressed this issue recognized that, without

[128] Although private mortgage insurance is not an explanatory variable, proceeds from such insurance are accounted for in the severity calculation.

adjustment, the HPI would not provide an adequate measure of REO price changes. However, none recommended creation of a separate REO index. Four commenters (MRAC, ACB, VA, and Freddie Mac) recommended modifying the general price index. MRAC suggested that a general HPI be used in conjunction with analysis of variances of prices to determine whether foreclosure prices have experienced slower appreciation or greater depreciation than the market average. ACB suggested that, rather than developing an REO price index, OFHEO study the ''left tail'' of the distribution of house prices in general. The term ''left tail'' refers to those houses with the smallest appreciation rates. S&P provided to OFHEO the rates of property value loss for foreclosures during the Great Depression.

The proposed approach incorporates a statistical model based upon an analysis like that suggested by MRAC and ACB. The model predicts how far into the left tail each REO property value can be expected to be, relative to the outstanding mortgage balance, throughout the stress period. OFHEO's proposed approach essentially follows the specific recommendations of MRAC and ACB for modification of the HPI.

The VA suggested using a general house price index, re-weighted to capture the regional distribution of REO properties. OFHEO agrees that regional differences in REO appreciation rates should be captured. The proposed regulation therefore incorporates Census division differences in historical HPI values and historical measures of the dispersion of house values around levels suggested by the HPI. *See* section III.A.4.d., Property Valuation.

NAR did not recommend a specific approach, but cautioned that an REO price index might not be meaningful for Enterprise loans, because the Enterprises tend to sell REO properties quickly, thus limiting exposure to undue loss of value. For that reason, NAR recommended that any analysis of REO property values be based solely on Enterprise data. OFHEO also concurs with NAR that an REO price index built on non-Enterprise data might be of limited usefulness for Enterprise loans. Given the richness and volume of the Enterprise data, and consistent with all other parts of the stress test, OFHEO has based the model of REO property values on Enterprise data. However, rather than developing a separate price index for REO properties, the proposed stress test models REO property value as a function of the path of the HPI. In addition, OFHEO proposes to adjust the resulting rate of loss of principal balance rate to reflect the fact that REO property values in the benchmark loss experience were lower in relation to the HPI than the REO property values in other Enterprise experience.

d. Multifamily Loss Severity

With respect to loss severity, the stress test uses the same cost elements for multifamily loans as for single family loans. However, there is no loan seasoning, nor is statistical analysis used to determine loss of loan principal balance. All cost and revenue elements of multifamily loss severity rates are averages from Enterprise experience.

7. Relating Losses to the Benchmark Loss Experience

The 1992 Act specifies that the stress test should apply rates of default and loss severity that are ''reasonably related'' to the highest rates experienced by the Enterprises for a period of at least two years in any contiguous areas having at least five percent of the nation's population (the benchmark loss experience).[129] The stress test satisfies this reasonable relationship requirement in the context of two severe interest rate environments that are quite different from the interest rate environment of the benchmark loss experience. At the same time, the stress test also accounts for appropriate distinctions in credit risk across loan types and characteristics. OFHEO believes that the multivariate mortgage performance models developed by OFHEO are the best means of specifying loss rates for the wide variety of loans held by the Enterprises under the different interest rate scenarios specified in the statute. However, for reasons explained below, the models are adjusted to produce loss rates that are reasonably related to the losses experienced on the 30-year fixed-rate, single family mortgages in the benchmark time and place.

Both Fannie Mae and Freddie Mac provided comments on how to implement a statistical model of mortgage performance that would be reasonably related to the benchmark loss experience. As discussed earlier, neither Fannie Mae nor Freddie Mac recommended a joint, multivariate statistical model of conditional default and prepayment rates. However, both discussed how other models could be used in the stress test and commented that a reasonable relation to the benchmark loss experience could be achieved by estimating those models solely on data from the benchmark loss experience.[130] They noted that the advantage of limiting the statistical sample in that way is to allow the resulting equations to capture benchmark economic conditions without having explicit explanatory variables for economic conditions in the stress test.

The suggestion from Fannie Mae and Freddie Mac that the mortgage performance models be estimated solely with data from the benchmark loss experience, although appealing conceptually, turned out to be impractical. The benchmark loans comprise too small and homogeneous a set of loans to estimate models for all the Enterprises' current loans. Using a much larger sample of historical loan performance experience was important when estimating the statistical models, because it provided a wide variety of economic circumstances and mortgage experience upon which to base estimation of the model parameters. Like current Enterprise loan portfolios, the samples used to estimate the statistical equations include mortgages originated over many years and geographic locations, and having distributions across other factors of mortgage performance—such as age, coupon type or amortization terms—that differ from those of the benchmark loans.

The ''reasonable relationship'' requirement of the 1992 Act means that the adverse credit stress of the benchmark loss experience should be reflected in the stress test mortgage losses. However, when the mortgage performance models are applied unadjusted to a pool of loans with the same characteristics as the benchmark loans, using interest rate and house-price appreciation paths equivalent to those of the benchmark time and place, the resulting default and severity rates are slightly lower than the actual rates for the benchmark loss experience. This result should be expected, because the mortgage performance models are estimated from data on a broad range of historical experience, rather than just data from the benchmark loss experience. The benchmark loss experience was from the time and place with the worst mortgage losses for the Enterprises. Therefore it is reasonable to expect it to have default and severity rates somewhat higher than would be predicted based solely upon the explanatory variables used in the stress test. For this reason, the stress test

[129] 1992 Act, section 1361(a)(1) (12 U.S.C. 4611(a)(1)).

[130] Fannie Mae recommended estimation of a statistical model of total terminations and Freddie Mac recommended estimation of a statistical model of prepayments only.

includes adjustments to the models to reflect more fully the additional stress of the benchmark experience.

OFHEO proposes to relate losses projected by the statistical equations to the benchmark loss experience in two ways. First, benchmark house-price growth rates and multifamily (rental) market economic conditions that coincide with the time and place of the benchmark loss experience are applied to loans in the starting portfolio during the stress test period. Second, the default and severity rates predicted by statistical equations are increased, or ''calibrated,'' to the benchmark loss experience rates, so that if newly originated loans with similar characteristics to those comprising the benchmark sample were subjected to the same economic circumstances as occurred in the benchmark loss experience, the statistical model of mortgage performance would project ten-year cumulative default and average severity rates equal to the rates actually observed for the benchmark sample.[131] Under this approach, default and loss severity rates differ from the benchmark rates only to the extent interest rates, property values, and loan characteristics are different from the benchmark sample, or to the extent adjustments are necessary to account for other statutory requirements.[132] Because of the addition of this benchmark ''calibration'' factor to default and loss severity equations, loss rates for all loans are slightly higher than would otherwise be projected.

Although the principles for reasonably relating stress test losses to the benchmark loss experience are the same for single family and multifamily loans, the methods of reasonably relating losses to the benchmark differ and are discussed separately below.

a. Single Family Calibration

For single family loans, calibration constants are added to default and loss severity rates.[133] These constants are set forth in sections 3.5.2.3.2.9 and 3.5.3.3.3 of the Regulation Appendix. Their development is described in section IV.B.8., Consistency with the Historical Benchmark Experience, of the Technical Supplement.

The calibration constants were computed in three steps. First, all benchmark loans were assigned the same historical house-price experience—the ten-year sequence of appreciation rates from the OFHEO HPI for the West South Central Census Division, commencing in 1984, first quarter.[134] Second, using the statistical equations estimated on a broader historical loan sample, OFHEO projected the ten-year experience of loans comprising the benchmark sample, computing the ten-year cumulative default rate and ten-year average loss severity rate. These rates were measured in the same manner for the benchmark in NPR1.[135] Third, these cumulative rates were compared to the actual cumulative default and prepayment rates computed for the benchmark in NPR1, and adjustment constants were calculated that, when applied in the models, would yield the equivalent default and loss severity rates.

The adjustment constant for loss severity rates is not applied to the entire loss severity rate, but rather to the loss of loan principal balance element of the loss severity rate. The constant is computed by subtracting the loss of loan principal balance that was predicted by the single family loss severity model from the loss of loan principal balance that occurred on defaulted loans in the benchmark loss experience. The second element of severity cost, transaction costs, was not adjusted to reflect benchmark conditions. OFHEO found it more appropriate in a national stress test to use a national blend of the institutional factors such as foreclosure costs, property management fees, and property sales expenses that comprise this element. The third element of loss severity cost, asset funding costs, enters the stress test as an imputed interest cost. As described in more detail in section 3.5.3 of the Regulation Appendix, this element is related to the benchmark loss experience through the use of foreclosure and property disposition event timing from the benchmark loss experience. The timing of these events determines the periods over which funding costs are calculated.

b. Relating Other Single Family Products to the Benchmark

In the ANPR, OFHEO asked how to relate other types of mortgages to the benchmark, which was developed based on single family, 30-year, fixed-rate mortgages. The commenters' consensus was that some type of multiplier approach to alternative single family mortgages should be used, except for ARMs. These comments are discussed below.

(i) ANPR Comments

NAR suggested that OFHEO develop statistical models of default for fixed- and adjustable-rate mortgages and relate the performance of other mortgage types to them. NAR also pointed out, however, that this type of relationship might be difficult to establish for new mortgage types for which there is insufficient historical experience. NAR suggested applying the benchmark default experience to these loans rather than measuring the difference in risk from the benchmark experience. VA addressed the same concern, suggesting that multipliers should be based on historical periods in which the other mortgage types had significant shares of the market. Specifically, VA suggested that measures of performance from those periods of other single family mortgage types relative to the 30-year, fixed-rate product could be used to impute the necessary performance differences from the benchmark loss experience to use in the stress test. Freddie Mac stated that any default-rate multipliers should be based on a broader range of Enterprise historical experience than the benchmark time and place.

Freddie Mac, although recommending that OFHEO use simple multipliers, also raised a concern that loans receiving multiple multiplier factors could end up with unreasonably high stress test default rates. It cited, as an example, a balloon loan on an investor-owned condominium. If the stress test were to apply default-rate multipliers for each of these three mortgage type categories

[131] Loans comprising the benchmark sample were 30-year fixed-rate loans.

[132] Differences in interest rates, property values, and loan characteristics can have very significant effects, however. The average mortgage credit loss rate for the two Enterprises in the benchmark sample was 9.4 percent. In the up-rate scenario of the stress test for June 1997, the average loss rate was 1.8 percent, while in the down-rate scenario it was 1.4 percent. The loss rate for the benchmark sample does not take account of mortgage insurance and other credit enhancements. Losses on benchmark loans after accounting for these receipts would have been seven percent.

[133] The calibration constant used in the single family default rate equations is in addition to the particular product-type multiplier factors discussed earlier. The product-type multipliers relate other products to the benchmark 30-year fixed-rate loans, while the calibration constant relates all loans to the severe benchmark loss experience.

[134] The West South Central Census Division does not exactly match the four-State benchmark region, but its use here to represent benchmark economics is consistent with OFHEO's proposal to aggregate data based on Census divisions and to apply historical Census division-level house price growth rates to season loans at the beginning of the stress test. What is most important is that the price series used to calibrate the statistical equations is the same series that will be used in the stress test itself. The actual ten-year house-price experience of the West South Central Division and the four-State benchmark area, 1984–1993, are very similar.

[135] The ten-year cumulative default rate was computed as the sum of original UPBs for defaulted loans, divided by the sum of original UPBs for all loans in the sample. The average severity rate was calculated in similar fashion. Following the method used to identify the benchmark experience, the calibration procedure computes ten-year default and severity rates for each Enterprise separately, and then the two Enterprise-specific rates are averaged.

(condominium, investor-owned, and balloon), the combined risk factor premium could be unreasonably high. To remedy this problem, Freddie Mac recommended that the stress test incorporate limits on the interaction of risk factors.

MRAC suggested that, if sufficient data were available, OFHEO might either create historical tables of default rates by various loan characteristics, in order to establish product-type multipliers, or use some type of regression analysis to discern performance differences among mortgage types. The MBA suggested that multipliers are the best approach because they are currently used by the Enterprises and therefore would provide a simple way for them to implement the risk-based capital standards.

OTS cautioned that multipliers might not be appropriate for ARMs or for multifamily loans, because the credit loss experience of these loans may not correlate well with that of fixed-rate, single family loans. OTS recommended that OFHEO consider using separate benchmarks for different types of loans. ACB, however, commented that there is no statutory requirement to incorporate the worst experience for each mortgage type into the stress test, and that a multiplier analysis for single family loan types would be sufficient.

Consistent with its recommendation that OFHEO not develop a statistical model of conditional default rates, Fannie Mae suggested that multipliers be applied to (cumulative) loss rates, rather than to conditional default rates.

(ii) OFHEO's Response

The stress test approach of adding product type adjustment factors as explanatory variables in a single family default equation is consistent with the multiplier approach recommended by commenters. However, the stress test approach does not have the shortcomings about which some commenters cautioned. It relies upon a broader historical experience than the benchmark sample alone to gauge the relative risk of other mortgage types, and it controls for the multiple multipliers problem outlined by Freddie Mac. The multiple multipliers problem is avoided because product type adjustment factors are estimated as part of the statistical default equation. The equation computes the marginal impact of each product type after controlling for all other explanatory variables. Using simple multipliers with limits on the amount of adjustment, as recommended by Freddie Mac, would either be too imprecise to reflect the relative risk of the loans that fall into multiple product type categories, or else would become as complex as a statistical model in order to account for all of the conceivable combinations of product types.

OFHEO agrees with the OTS comment that a multiplier approach is not appropriate for ARMs. Equations for single family default and prepayment rates in the stress test are, therefore, estimated separately for ARMs. This is appropriate because the adjustable payment features of these loans create unique incentives to either default or prepay that are not found in other mortgage types. The ARM default equation does, however, receive the same benchmark calibration constant used in the other two single family default equations. The use of this constant reasonably relates ARMs to the added stress of the benchmark loss experience in a manner consistent with how other single family product types are related to the benchmark loss experience.

c. Relating Multifamily Mortgage Performance to the Benchmark

In the ANPR, OFHEO requested comment on how the stress test multifamily mortgage performance should be related to the single family benchmark. Respondents to the ANPR mentioned the need to capture the different underwriting variables and economic factors that would influence multifamily performance directly. They warned against applying multipliers to single family losses to generate multifamily losses. These concerns were raised by OTS, MBA, Fannie Mae, and Freddie Mac. In addition, OTS and Fannie Mae suggested that OFHEO may need to explore options other than relating stress test credit losses on multifamily loans to the single family benchmark.

OFHEO agrees with the commenters' concerns about using a simple multiplier approach for multifamily loans, and proposes instead a separate statistical model of multifamily mortgage performance based on multifamily market conditions, property financial characteristics (DCR and LTV), and loan terms—whether fully amortizing or balloon, or having fixed or adjustable interest rates. The statistical model allows the application of OFHEO's first principle, outlined above in section III. A. 5. e., Choice of Explanatory Variables for Default and Prepayment, for relating stress test losses to the benchmark: using economic conditions of the benchmark experience in the stress test. OFHEO believes that multifamily rent and vacancy indexes from the benchmark time and place provide the best means to relate starting multifamily loan portfolios to the benchmark loss experience. These indexes account for the economic decline that occurred in the benchmark region in the economic factors that affect multifamily mortgage credit risk. Therefore, the stress test creates a reasonable relationship to the benchmark loss experience by using vacancy rates from and percent changes in rents from the benchmark loss experience to update property financials (DCR and LTV) throughout the stress period.

Because of the small number (13) of multifamily loans purchased by the Enterprises in the benchmark region during 1983 and 1984, it is not possible to compute calibration adjustments like those in the single family default and severity equations. Instead, OFHEO proposes to treat all defaults as full foreclosure events and apply loss severity rates without consideration of loan seasoning. The effect of this approach is to create higher credit losses than if the stress test were to account for multifamily defaults that are resolved without foreclosure and adjust severity rates to account for the age of loans.

Methodologically, treating all multifamily defaults as foreclosure events is consistent with OFHEO's proposed approach to single family credit loss generation in the stress test. However, OFHEO is aware that use of various default resolution strategies other than foreclosure (loss mitigation) played an important role in controlling multifamily default losses in the severe environment of the late 1980s and early 1990s. Therefore, accounting for loss mitigation in the stress test would tend to decrease losses for any given economic conditions. Treating all defaults as foreclosures for calibration purposes, rather than allowing for loss mitigation efforts, results in an increase in loss severity—before application of any credit enhancements—of 6.5 percent per defaulting loan.[136]

There is an exception to the rule of treating all defaults as foreclosure events for Enterprise loan programs that require the seller/servicer to repurchase loans that become 90-days delinquent. For loans in these programs, the recorded ''default'' event at the Enterprises is the point at which a loan becomes 90 days delinquent, rather than a foreclosure-like event where the Enterprise obtains title to the collateral property.

[136] The 6.5 percent figure is arrived at by multiplying the 13 percent of defaults resolved with alternatives to foreclosure by a 50 percent loss rate reduction factor.

The stress test loss severity rate for these loans is 39 percent.[137] The 39 percent loss severity rate reflects experience of the Enterprises during the stressful conditions of the early 1990s, including approximately 50 percent cures (or modifications) and 50 percent foreclosures on 90-day delinquencies. OFHEO research indicates that this is a reasonable approximation for the stress test.

8. Inflation Adjustment

The 1992 Act specifies that, to the extent that the ten-year CMT increases by more than 50 percent over its average for the nine months preceding the starting date of the stress test, credit losses must be adjusted ''to reflect a correspondingly higher rate of general price inflation.'' [138] In the stress test, mortgage credit losses are not related to rates of general price inflation, but most are related to rates of house price inflation.[139] Implementing this provision of the statute requires consideration of the relationship between interest rates, general inflation rates, and house price inflation rates.

These relationships are complex. Over recent decades, changes in broad inflation measures generally have preceded changes in interest rates in the same direction. And changes in interest rates have been accompanied by changes in house price inflation rates in the opposite direction. Thus, over short and intermediate periods of time, interest rates and house price inflation rates have often moved divergently. For example, consider the three five-year periods beginning in 1975. From the beginning of 1975 to the end of 1979, the ten-year CMT averaged about 8 percent, while house prices rose at an 11 percent annual rate. In the following five-year period, from 1980 to 1984, interest rates were 50 percent higher (12 percent), while house price inflation fell to 4 percent. Then in the third five-year period, 1985 to 1989, interest rates declined to 9 percent, while house price gains accelerated to 7 percent.[140] Over longer periods of time, however, these changes have tended to reverse themselves. For periods of ten years or more, higher (lower) than average interest rate levels have generally been associated with higher (lower) than average rates of general inflation and house price inflation.

In unusual environments, such as those represented by the economic conditions of the stress test, average past relationships between interest rates, general inflation rates, and house price inflation rates may not prevail. The nature or cause of the projected mortgage credit stresses in the stress test are not specified in the statute. They could involve problems particular to housing markets, such that house price behavior deviates persistently from general inflation patterns. Or they could be focused on non-house-price factors, such as unemployment, relocation, or divorce rates.

Except to the extent that the ten-year CMT rises in the up-rate scenario by more than 50 percent, the stress test does not project any differences in house price changes or other sources of credit stress in the two interest rate scenarios. And, aside from the inflation adjustment, the specific pattern of house price changes used in both scenarios is not designed to be consistent with any particular pattern of interest rates. It was chosen to replicate (and encapsulate in one variable) the overall level of credit stress in the benchmark loss experience.

In order to implement the statutory requirement, the stress test projects that cumulative increases in house prices, a component of general inflation, are higher in the up-rate scenario by an amount that reflects, percentage point for percentage point, any positive difference between the ten-year CMT and the level corresponding to a 50 percent increase. Thus, for example, if the ten-year CMT starts at 6 percent and increases by 75 percent to 10.5 percent, the increase in excess of 50 percent is 1.5 percentage points. The cumulative change in house prices during the up-rate scenario would equal the cumulative change during the down-rate scenario plus an upward adjustment. The adjustment is the amount needed to reflect what the cumulative increase would be if the house price inflation rate were 1.5 percent higher, on average, throughout the part of the stress period in which the ten-year CMT exceeds 9 percent.[141]

In recognition of the likely short- and intermediate-term divergence between interest rates and house price behavior, the stress test concentrates all of the adjustment in the final five years of the stress period. Thus, house prices are identical in the two stress test interest rate scenarios during the first five years, but increase much more rapidly in the last five years of the up-rate scenario than they do in the down-rate scenario.

Several respondents to OFHEO's ANPR commented on this issue. VA opposed any adjustment, arguing that while the long-term behavior of house price inflation and general inflation is consistent, the short-term relationship is weak, and the relationship between interest rates and house prices ''is even more tenuous.'' VA further agrees that specific economic conditions can disrupt any general relationships, and that an adjustment would be inconsistent with the approach of private rating agencies. OFHEO believes, however, that some adjustment is required by the statutory language.

HUD argued that adjusting the rate of increase in house prices throughout the stress period on a one-to-one basis with general price inflation would deny the role of changes in real interest rates over time. HUD suggested that OFHEO consider current trends and long-run relationships between real interest rates and house prices. NAR suggested that a one-to-one relationship is appropriate for long-term assumptions, and ACB commented similarly. OFHEO believes that its approach, which uses a one-to-one relationship for the cumulative change but concentrates the change in the last five years of the stress period, is not inconsistent with any of these recommendations.

Freddie Mac recommended that house price inflation should vary with interest rates in a one-to-one relationship, not only with respect to increases in the ten-year CMT exceeding 50 percent, but also with respect to all interest rate changes. House price inflation rates would be based on rates current at the start of the stress period and rise or fall by amounts equal to the change in the ten-year CMT in both scenarios. Such an approach could result in more severe credit losses in the down-rate scenario and very few credit losses in the up-rate scenario. OFHEO believes that the stress test should reflect the possibility that substantial credit losses would occur in either scenario. The recommended

[137] This rate is discounted by 12 months to reflect the average time from the default date (30 days after last paid installment date) to final resolution.

[138] 1992 Act, section 1361(a)(2)(E) (12 U.S.C. 4611(a)(2)(E)).

[139] Multifamily credit losses are related to rent growth rates. The same adjustment described here for house price inflation rates is also made to rent inflation rates.

[140] General inflation rates (based on the CPI) followed a still different pattern. They averaged 8 percent per year during the first five-year period, 7 percent in the second, and 3 percent in the third five-year period.

[141] The stress test would calculate the cumulative adjustment factor in this case to be $1.015^{9\frac{1}{6}}$, so final house price levels in the up-rate scenario would be 14.6 percent higher than they would be in the down-rate scenario. In this formula, $9\frac{1}{6}$ represents the number of years the ten-year CMT exceeds 9 percent by the full 1.5 percentage points plus two months to reflect the period in which the ten-year CMT exceeds 9 percent by a smaller amount. If the ten-year CMT increases 75 percent over the base month, a 50 percent increase will be achieved by month eight. The full increase will be achieved by month 12. For the purposes of this calculation, the result is the same as it would be if the extra 25 percent lasted for nine years and two months.

approach also would not have any obvious relationship to the benchmark loss experience. Applying the approach at the time the benchmark loans were originated would result in much stronger house price growth than actually occurred in the benchmark area.

Freddie Mac further argued that a stress test that incorporated a ten-year CMT that exceeded the rate of house price appreciation by more than 6.5 percentage points over a ten-year period would be inconsistent with national historical experience and, therefore, inappropriate. However, national historical experience is not an appropriate criterion for the stress test's key source of mortgage credit stress. Credit losses in the stress test are required to exceed national historical experience. They are based on the worst regional, not national, experience.[142] More importantly, as discussed above, house price projections in the stress test are not designed to correspond to any particular interest rate level. Rather, they are simply a means of incorporating an overall credit stress level that is comparable to the benchmark loss experience and which may reflect stresses from a variety of non-house price sources not explicitly included in the mortgage performance model.

B. Interest Rates

The 1992 Act specifies the level of the constant maturity Treasury yield (CMT) for ten-year securities during the last nine years of the stress period.[143] However, only general guidance is provided for the levels of yields on Treasury securities with different maturities. Also, yields on other financial instruments are not explicitly mentioned. The behavior of yields on financial instruments other than ten-year Treasury securities will have potentially substantial and pervasive effects on the Enterprises during the stress period. Those yields will determine the cost of new debt issued and earnings on new investments, as well as the interest rates paid or earned on assets, liabilities, or derivatives contracts that are tied to market yield indexes. They will also have a significant effect on the volumes of mortgage prepayments and defaults. The magnitude of the effects on an Enterprise during the stress period will depend greatly on the Enterprise's funding strategies at the start of the stress period.

1. Yields on Treasury Securities

a. Statutory Requirements

The 1992 Act describes two interest rate scenarios (one rising and one falling) based on movements in the ten-year CMT. In the rising or up-rate scenario, the ten-year CMT increases during the first year of the stress test period and then remains constant at the greater of: (1) 600 basis points above the average yield during the preceding nine months; or (2) 160 percent of the average yield during the preceding three years. However, in no case may the yield increase to more than 175 percent of the average yield over the preceding nine months. In the falling or down-rate scenario, the ten-year CMT decreases during the first year of the stress period and then remains constant at the lesser of: (1) 600 basis points below the average yield during the preceding nine months; or (2) 60 percent of the average yield during the preceding three years. However, in no case may the yield decrease to less than 50 percent of the average yield over the preceding nine months.

The 1992 Act does not specify the shape of the yield curve during the stress period. Rather, it simply requires that the levels of other Treasury yields ''change relative to the 10-year Constant Maturity Treasury (CMT) yield in patterns and for durations that are reasonably related to historical experience and are judged reasonable by the Director.'' [144] The statute also does not specify the manner in which the ten-year CMT moves during the first year of the stress period to reach the level required for the remainder of the period.

In its comments to OFHEO's ANPR, ACB suggested that OFHEO consider using stochastic projections of all interest rates, if OFHEO determined that stochastic projections were consistent with statutory requirements. ACB noted that the process could be constrained to insure that the ten-year CMT reached its required level during the final nine years of the stress period on an average basis. OFHEO has determined that such an approach would not be compatible with the 1992 Act. That statute clearly specifies that the ten-year CMT will be constant during the final nine years of the stress period. Furthermore, as Fannie Mae commented, using a stochastic model for determining interest rates would create unnecessary uncertainty about what amount of capital would actually be required for a given set of risk positions. A stochastic model also would add unnecessary complexity to the regulation. Accordingly, OFHEO proposes that all interest rates during the stress period be fully determined by past data on interest rates.

b. Yields of Other Treasury Maturities During the Final Nine Years

(i) Constant or Varying Yields

OFHEO considered whether the Treasury yield curve should be constant over the final nine years of the stress period or whether it should change in some specific manner. OFHEO proposes to use a constant yield curve. While yields are extremely unlikely to remain constant or even roughly so over a period as long as nine years, there are no serious disadvantages to using such an approach in the stress test, and there are compelling advantages.

A constant yield curve is a straightforward approach that is consistent with the statutory specification of a constant ten-year CMT. The purpose of the interest rate component of the stress test is to assess an Enterprise's ability to withstand a prolonged shift to a much higher or much lower interest rate environment. No specific pattern of yield changes can fully capture the range of possible future adverse changes. Based on historical experience, one would expect all interest rates to fluctuate over a broad range during a period as long as nine years. Different underlying macroeconomic circumstances would be associated with different evolutions of the entire yield curve, including the ten-year CMT. Tying the stress test to one specific set of macroeconomic circumstances would tend to limit its general usefulness. The real-life danger the Enterprises face of much higher or much lower interest rates during the next decade is not focused on any particular portion of that ten-year period. Designing a stress test with any specific pattern of interest rate changes after the first year of the stress period would imply a belief that Enterprise risk exposures in some future years would be a matter of greater public concern than in other years. While an argument could be made that near-term risk exposures would create losses with a higher present value, that concern should be balanced by a recognition that the risk of a very different interest rate environment is greater for distant years than for the near-term.

A stress test with interest rates that are especially high or low in particular

[142] The average ten-year CMT exceeded average house price growth in the West South Central Division during the 1980s by 9.5 percentage points. For the benchmark loss experience, the difference was 8.5 percentage points.

[143] 1992 Act, section 1361(a)(2) (12 U.S.C 4611(a)(2)).

[144] 1992 Act, section 1361(a)(2)(D) (12 U.S.C. 4611(a)(2)(D)).

future years would encourage Enterprise hedging strategies to focus on those specific years. Risks in other years, when stress test projections were more moderate, might receive relative neglect. The Enterprise would thus be providing more protection against more adverse, but less likely, interest rates in some years at the expense of less protection against less adverse, but more likely, interest rates in other years. Such an incentive would provide less general protection and thereby increase the risk of failure.

In their ANPR comments, Fannie Mae and VA suggested specific fixed yield curves, consistent with OFHEO's proposal in this regard. Freddie Mac recommended a considerably more complex approach that would generally result in relatively more adverse short-term interest rates in the early part of the final nine years of the stress period and less adverse short-term interest rates later. OFHEO believes its proposal is much simpler and will provide better general protection against Enterprise failure for the reasons discussed above.

Freddie Mac argued that a fixed yield curve would be unreasonable for two reasons. First, Freddie Mac stated that a fixed curve would be inconsistent with the statutory requirements that changes in yields on Treasury securities with maturities other than ten-years ''will change relative to the 10-year constant maturity Treasury yield in patterns and for durations that are reasonably related to historical experience.'' It is clear from the legislative history that Congress did not intend to prohibit constant yield curves, per se, but rather wanted to prohibit unusual yield curves lasting for a longer time than could be reasonably related to historical experience. The language of the statute follows the original Senate-passed bill, except that ''reasonably related to'' in the quoted phrase was substituted for ''within the range of,'' and a specific restriction on unusual yield curves was removed. The Senate Committee, in explaining its understanding of the yield curve provision, actually recommended that the yield curve be fixed during at least the final five years of the stress period.[145]

Second, Freddie Mac argued that a constant yield curve ''would be of little value in measuring the ability of an Enterprise to absorb losses in relation to its risks'' because interest rate volatility would disappear and the prices of options would approach zero. Market estimates of interest rate volatility, however, play no important role in the stress test OFHEO is proposing. The Enterprises are not projected to buy or sell any options, as this is a ''no new business'' stress test. While option value does affect decisions about option exercise, and those decisions are an important element of the stress test, the interest rate movements in the stress test are quite large. In such circumstances, Enterprise decisions about option exercise will generally be relatively insensitive to precise measures of option value. Homeowners' decisions to exercise their options to prepay their mortgages are also based on past homeowner responses to large changes in interest rates and not on specific measures of volatility. Stress test projections relating to the exercise of options implicitly assume that expectations about volatility are within normal ranges, despite the lack of change in interest rates. The proposed approach is an efficient simplification that does not distort Enterprise risks in any meaningful way.

[145] S. Rep. No. 102–282, at 22 (1992).

(ii) Choice of Fixed Yield Curve Shapes

OFHEO proposes that all Treasury yields for key maturities (three-and six-month; one-, three-, five-, and 20-year) in the final nine years of the up-rate scenario be equal to the ten-year CMT. In the final nine years of the down-rate scenario, OFHEO proposes that all key Treasury yields have the same ratio to the ten-year CMT that they had, on average, during the nine-year period from May 1986 through April 1995. The proposed yield curves for both interest rate scenarios correspond to historical experience.

OFHEO based its selection of yield curves on an examination of historical data on Treasury yields. Data are available starting in December 1958. OFHEO focused on the relationship between a short-term (six-month) yield and the ten-year yield.[146] From 1959 through 1996, the average yield curve slope, measured by the ratio of the six-month CMT to the ten-year CMT, was 0.88, a moderate upward slope. However, when calculated on a monthly basis, this slope has varied considerably through time (*See* Table 26, Frequency Distribution of Yield Curve Slopes, 1959—1996). Monthly slopes have been as low as 0.48 (September and October 1992) and as high as 1.29 (March 1980). In more than half of the months, yield curves were roughly flat or downward sloping (slopes above 0.95) or were steeply upward sloping (slopes below 0.75).

[146] In the following discussion, yields of six-month Treasury bills are expressed on a bond-equivalent basis. The six-month maturity has the advantage that the timing of its payments are consistent with the interest rate payment cycle of Treasury notes and bonds, ensuring comparability of yields across maturities.

Table 26. Frequency Distribution of Yield Curve Slopes, 1959 - 1996

Ratio of 6-Month CMT to Ten-Year CMT	Number of Months
1.25 - 1.35	2
1.15 - 1.25	21
1.05 - 1.15	41
0.95 - 1.05	77
0.85 - 0.95	89
0.75 - 0.85	111
0.65 - 0.75	80
0.55 - 0.65	21
0.45 - 0.55	14

Of particular relevance are the average slopes over periods of 108 months (nine years) and their relationship to previous increases or decreases in yields. Ratios of the average six-month Treasury CMT to the average ten-year CMT for periods of 108 months ranged from 0.77 (for periods ending from January 1994 through April 1996) to 0.99 (for periods ending from September 1981 through June 1982). OFHEO must project yields curves for a nine-year period in which the ten-year CMT has increased by 75 percent, and decreased by 50 percent, from its average in the nine months ending one year before the beginning of the nine-year period.[147] Accordingly, OFHEO sought to determine whether historical data suggest any relationship between changes in average ten-year CMT and yield curve slopes for relevant time periods.

At no time during the past 40 years have ten-year CMTs changed as greatly as required in the stress test. The largest comparable increase was 56.3 percent from the nine-month average of 6.04 percent during November 1971 to July 1972 to the nine-year average of 9.44 percent during August 1973 to July 1982. The ratio of six-month to ten-year yields during the later period was 0.98. The largest comparable decrease was 38.9 percent from the nine-month average of 12.74 percent during February to October 1984 to the nine-year average of 7.78 percent during November 1985 to October 1994. That change was associated with a slope of 0.77 during the nine-year period.

The pattern of relatively flat yield curve slopes after interest rate increases and steep yield curve slopes after interest rate decreases is consistent with the data. In all nine-year periods in which the average ten-year CMT was above its average during the relevant earlier nine-month period, the yield curve slope was greater than 0.87. In all nine-year periods in which the average ten-year CMT was below its average during the relevant earlier nine-month period, the yield curve slope was less than 0.87. Furthermore, the greater the increase in the ten-year CMT, the flatter the yield curve slope tended to be, and the greater the decrease in the ten-year CMT, the steeper the yield curve slope tended to be. Results of an ordinary least squares regression imply that a sustained 75 percent increase in the ten-year CMT would likely result in a CMT yield curve slope of 1.00, while a sustained 50 percent decline provides an expected slope of 0.77.[148]

If the macroeconomic circumstances associated with a future shift in yields were to differ from those that engendered interest rate changes in recent decades, different results might easily occur. Nevertheless, the historical experience of the past four decades, as indicated both by the actual yield curve slopes in the episodes when the ten-year CMT changed most greatly and by the more general results, suggests an essentially flat yield curve in the up-rate scenario, and a curve with a relatively steep upward slope in the down-rate scenario.

Although the highest yield curve slope was 0.99, OFHEO chose a more straightforward yield curve slope of 1.00 for the up-rate scenario. The largest historical interest rate increase resulted in an almost flat yield curve, and that increase was still well below the increase of the up-rate scenario of the stress test. In addition to the six-month yields, OFHEO also proposes that all other key Treasury yields be equal to the ten-year CMT in the up-rate scenario. When the six-month CMT equals the ten-year CMT, setting all the other key

[147] In high yield environments, the changes in interest rates would be somewhat smaller, but past and recent data suggest that the changes will generally be of this magnitude.

[148] An ordinary least squares regression describes the results quantitatively. The dependent variable (Y_t) is the ratio of the average six-month CMT to the average ten-year CMT during the nine years ending in month t. The independent variable (X_t) is defined as the ratio of the average ten-year CMT in the nine years ending in month t to the nine-month average of the ten-year CMT from month t-128 to month t-120. The regression results are: $Y_t = 0.86 + 0.19\ X_t$.

Although this regression is based on monthly data over a 38-year period, it is a small data set for investigating this issue. The yield data start in December 1958, but each observation needs 128 months prior data, so the first observation used in the regression is August 1969. That leaves 326 observations through September 1996, but because of the lags, each observation is very similar to the one preceding it. There are really only four fully separate dependent variable observations. In these circumstances, the coefficient estimates are unbiased, but the usual regression statistics are not meaningful. In an alternative regression, the data were reorganized as follows. The 326 observations were rank-ordered by the independent variable and divided into quartiles. Using average values of the two variables from each quartile, the regression was rerun with the resulting four observations. The results are: $Y_t = 0.86 + 0.20\ X_t$.

Differences in parameter estimates from the full sample regression were small, less than 0.01, and the standard error of the coefficient of Xt was 0.022. Even though the observations for these regressions were limited, to the extent the data do exist, they support OFHEO's yield curve proposal.

Treasury yields equal to the same levels is straightforward and appropriate. In the down-rate scenario, however, setting the six-month and the ten-year yields does not directly suggest appropriate rates for instruments with other maturities. OFHEO proposes in this scenario that slopes of key CMTs to the ten-year CMT be based on a specific historical experience in a straightforward way that incorporates long-term relationships between yields of instruments with different maturities. The slope of the average six-month CMT to the average ten-year CMT during the nine-year period ending in April 1995 closely approximates the yield curve slope suggested by the regression equation.

Several commenters responded to a question in OFHEO's ANPR about the Treasury yield curve. Consistent with OFHEO's proposal, Fannie Mae recommended that OFHEO focus its approach to projecting yield curves on the ratio of the six-month Treasury yield to the ten-year Treasury yield. However, Fannie Mae recommended that the ratio of the six-month CMT to the ten-year CMT be set at a long-run historical average in both interest rate scenarios. Such an approach would not be consistent with actual experience that large sustained interest rate increases are accompanied by relatively flat yield curves and that large, sustained interest rate decreases are accompanied by relatively steep yield curves.

The Department of Veterans Affairs recommended a yield curve formula that would depend heavily on the shape of the yield curve at the start of the stress test. OFHEO considered such an approach, but found no evidence in historical data that the yield curve shape at the start of a ten-year period is related to the average shape over the final nine years of that period.

Freddie Mac suggested an approach based on an assumption that the statutory changes in interest rates represent a ''regime shift.'' As market participants adjust to the new regime, Freddie Mac argued, average yield curve relationships should return. OFHEO believes it is more appropriate to base projections of yield curve relationships on what has actually occurred in the past with the most similar changes in ten-year CMT levels.

NAR recommended that OFHEO take into account Treasury refunding behavior during the stress period. In order to keep the stress test as general as possible, OFHEO chose not to make any specific projections about Treasury debt issuance during the stress period.

c. Yields of Treasury Securities During the First Year

OFHEO proposes that during the first year of the stress period, the yields on Treasury securities of all maturities adjust linearly from their levels in the month proceeding the stress period to their levels during the final nine years of the stress period. In comments to OFHEO's ANPR, Fannie Mae stated that movements of the six-month and ten-year CMTs should be consistent during an adjustment period of one to two years. OFHEO agrees and believes its proposal will result in sufficiently consistent movement.

Freddie Mac suggested an approach under which, before the end of the first year, the yield curve might invert in the up-rate scenario and become very steeply upward sloping in the down-rate scenario. As previously discussed, OFHEO believes this approach is unnecessarily complex.

2. Yields of Non-Treasury Instruments

a. In General

Payments during the stress period associated with many Enterprise assets, liabilities, and derivatives contracts and the performance of mortgages, especially prepayment behavior, are dependent on future levels of yields on non-Treasury instruments and levels of non-Treasury interest rate indexes. OFHEO proposes to project these yield levels using econometric models relating non-Treasury interest rate series to yields on Treasury securities of comparable maturity.

The econometric specifications were based on two primary criteria. First, whenever possible, the non-Treasury interest rate series were modeled using the relative (rather than absolute) spread over comparable CMTs. Second, the specifications balanced the desire for simplicity with the need to account for the time-series properties inherent in the data.

Autoregressive integrated moving average (ARIMA) models were used to model the behavior of the non-Treasury interest rate series.[149] The models capture the average historical relationships between specific CMTs and non-Treasury interest rates. OFHEO believes this approach is consistent with recommendations of all commenters to a question on this issue in OFHEO's ANPR.

b. Yields on Enterprise Debt

OFHEO proposes that yields on Enterprise debt be projected in the same manner as yields on other non-Treasury instruments, except that a 50 basis point premium is added after the first year of the stress period. After one year of stress test conditions, the Enterprises might appear strong based on accounting measures of earnings and net worth. However, market values of the Enterprises' assets, liabilities, and derivatives contracts would fully reflect the effects of the interest rate shock and some of the credit quality deterioration of the stress test. Investors would be aware of these changes in market value and adjust their evaluations of the Enterprises' financial health accordingly. Because the Enterprises' ability to withstand further interest rate and credit shocks likely would be low, the Enterprises in the final nine years of the stress period would likely not meet their risk-based capital requirement and would, therefore, be subject to dividend restrictions. Such events might strengthen investor concerns about the Enterprises' financial health.

As government sponsored enterprises, the Enterprises likely would suffer much smaller debt market penalties than fully private firms in the same circumstances. However, the historical experiences of Fannie Mae and the Farm Credit System during periods of financial stress strongly suggest that borrowing costs would include some risk premium during economic conditions such as those in the stress test. As illustrated by data reported in the General Accounting Office's 1990 report on government sponsored enterprises, Fannie Mae's short-term

[149] An ARIMA (p,d,q) model implies p autoregressive terms, d differences of the original series, and q moving average terms. Generally speaking, differencing is undertaken to render a series ''mean-stationary,'' which is a requirement for statistical analysis of autoregressive models. For example, observations from a random walk include the cumulative effect of all past shocks (random disturbances) and/or trends. Differencing can net out the effect of persistent movements and make a series stationary. Autoregressive terms also represent the persistence of past shocks, but where the effect of the shock diminished over time. Moving average terms represent the effects of shocks that disappear completely after some finite number of periods.

In some situations the original series may also exhibit non-stationarity in the variance, requiring other normalizing transformations (e.g., taking logarithms). Also, visual examination of the data series and residual analysis based on appropriate statistical criteria (e.g., Ljung-Box Q-statistics) were used to guide the model selection process.

In some cases, a constant term has been included. This has the effect of preserving the historical average relative spread between the index and the corresponding Treasury rate when projecting future values. This is only done when there is some evidence that this historical difference is statistically significant. While differencing is necessary in many models to achieve stationarity in the mean, the use of relative spreads over Treasury rates of comparable maturities generally appears to make the original relative rate series variance stationary.

borrowing costs during 1980 through 1982 were generally about 80 basis points in excess of yields on comparable maturity Treasury debt, rising at one point to 200 basis points above Treasury yields. Spreads receded after sharp declines in interest rates greatly improved Fannie Mae's condition to a more normal range centered roughly at 20 basis points. Spreads were high again in the late 1980s for both Fannie Mae and the Farm Credit System, ranging from 40 to 100 basis points over a two-year period during the Farm Credit System's time of greatest financial difficulty.[150]

In stress test simulations based on the quarter ending in June 1997, the Enterprises' borrowing costs, including the 50 basis point premium, are 78 basis points above comparable Treasury yields in the up-rate scenario and 56 basis points above in the down-rate scenario after the first year of the stress period. Such spreads are appropriate because it is essential that the Enterprise be adequately prepared for widening debt yield spreads in periods of financial stress.

In its comments to OFHEO's ANPR, ACB pointed to Fannie Mae's difficulties in 1980 to 1982 as a possible basis for assessing likely borrowing spreads in the stress period. ACB also suggested that OFHEO might consider projecting the Treasury Department's use of its statutory authority to lend money to the Enterprises in stressful circumstances. OFHEO believes the stress test should assess the Enterprises' abilities to withstand the stress test without borrowing from the Treasury Department.

Freddie Mac commented that OFHEO should assume that the market's perception of an implicit government guarantee on Enterprise debt protects the Enterprises against any increased risk premium in borrowing spreads. OFHEO disagrees and believes the historical evidence is inconsistent with that view. OFHEO does agree that financial weakness of the Enterprises during the stress period should not be expected to have the same effect on borrowing costs that it would for firms that are not government sponsored enterprises. Nonetheless, some increase in risk premiums is appropriate. As the Enterprises' offering prospectuses clearly state, Enterprise obligations are not backed by the full faith and credit of the Federal government. OFHEO also agrees that attempting to calculate appropriate borrowing spreads at different times during the stress test, based on specific measures of Enterprise stress, would unnecessarily complicate the test. Accordingly, OFHEO proposes a constant risk premium during the final nine years of the stress period.

C. Mortgage Credit Enhancements

1. Background

The Enterprises use mortgage credit enhancements to reduce their credit risk exposure. For single family loans with LTV ratios in excess of 80 percent, the Enterprises must use certain statutorily enumerated credit enhancements. The Charter Acts prohibit the purchase of conventional single family mortgages with LTV ratios in excess of 80 percent unless: (1) the seller retains a participation interest of 10 percent or more; (2) the seller agrees to repurchase or replace the mortgage upon default (seller recourse); or (3) the amount of the mortgage in excess of 80 percent is insured or guaranteed.[151] Multifamily mortgages are not subject to such a requirement, but may also be credit enhanced.

The Enterprises currently use several different types of credit enhancements: (1) Private mortgage insurance on individual loans, which usually covers a percentage of the gross loss, or ''claim amount,'' [152] (2) seller recourse agreements, which require the seller/servicer to repurchase loans in the event of default, either for all loan defaults (unlimited recourse) or for all defaults up to a specified amount (limited recourse); (3) indemnification, which requires the seller/servicer to reimburse the Enterprises for losses (either unlimited or limited) on defaulted loans after final resolution by the Enterprise; (4) pool insurance, which covers losses on a pool of loans up to a specified percentage of the aggregate unpaid principal balance (UPB), usually after private mortgage insurance has been applied; (5) spread accounts maintained by the Enterprise or a custodian to offset losses, funded by part of the spread between the interest rate on the loans in a pool and the coupon passed through to the investor; (6) collateral pledge agreements under which the Enterprise obtains a perfected interest in securities held in an account (usually Treasury securities or mortgage-backed securities), to offset losses on a pool of loans when a seller/servicer hits certain financial triggers or when the loans are high risk; and (7) cash accounts funded by the seller/servicer that are available to offset losses.

2. Modeling Approach

The stress test calculates the loss coverage provided by credit enhancements in one of two ways, depending on the credit enhancement type. Private mortgage insurance, unlimited recourse, unlimited indemnification, and risk-sharing agreements provide coverage for a percentage of the loss incurred. The dollar value of these credit enhancements is not known at the beginning of the stress period because it depends on the size of the loss that occurs in the future. What is known is the percentage of the loss that will be covered. Therefore, these credit enhancement types are referred to herein as ''percent-denominated'' enhancements. The other credit enhancement types are referred to as ''dollar-denominated'' enhancements, because the total coverage provided can be expressed in dollar amounts without knowing the size of the losses in advance.

The stress test applies the loss coverage provided by credit enhancements to the loan groups into which individual loans have been aggregated for modeling efficiency. (*See* section II. A., Summary of the Stress Test, for a description of the characteristics that are the basis for aggregation.) The loss coverage is a weighted average of the credit enhancements applicable to any loans in the group. In situations where a loan group is covered by both percent-denominated enhancements and dollar-denominated enhancements, the two different types of credit enhancements are applied sequentially. First, the loss severity of a loan group is reduced by an amount that is determined by the percentage coverage of the applicable percent-denominated credit enhancements. Then, the dollar coverage available from dollar-denominated credit enhancements is applied to the remaining losses on the loan group until all of the available dollar coverage for that loan group is used up. This approach permits percent-denominated credit enhancements (such as private mortgage insurance) to be applied before dollar-denominated credit enhancements (such as pool insurance) are applied, capturing the benefits of multi-layered credit enhancements.

[150] U.S. General Accounting Office (1990), *Government Sponsored Enterprises: The Government's Exposure to Risk,* Washington, DC: U.S. General Accounting Office, (GAO/GGD–90–97) 87–88.

[151] *See* sections 305(a)(2) and (4)(C) of the Federal Home Loan Mortgage Corporation Act (12 U.S.C. 1454(a)(2) and (4)(C)) and sections 302(b) and (5)(C) of the Federal National Mortgage Association Charter Act (12 U.S.C. 1717(b)(2) and (4)(C)).

[152] The claim amount includes the defaulted principal balance, unpaid interest, and associated expenses. It does not reflect subsequent proceeds from the sale of REO.

Some dollar-denominated enhancements provide coverage in a dollar amount that is fixed and known at the time the agreement is executed. These include pool insurance, limited recourse, limited indemnification, and cash accounts. Other dollar-denominated enhancements provide coverage in a dollar amount that is subject to variation during the term of the agreement. These include spread accounts and collateral pledge agreements. Changes in these balances due to reasons other than loss coverage are not modeled. Rather, balances are treated as cash [153] and drawn upon after dollar losses are determined, until the total amount is exhausted.

Some credit enhancements, namely private mortgage insurance, recourse, pool insurance, and indemnification, are subject to the institutional credit risk of the provider, i.e. the risk that the counterparty providing the credit enhancement will default on its obligation. Where institutional credit risk is present, the stress test applies a discount factor, or ''haircut,'' based on the credit rating of the counterparty.

The haircuts that have been adopted by OFHEO are set forth by rating category in Table 27:

Table 27. Rating and Cumulative Haircut

Month	AAA	AA	A	< = BBB
12	1%	2%	4%	8%
24	2%	4%	8%	16%
36	3%	6%	12%	24%
48	4%	8%	16%	32%
60	5%	10%	20%	40%
72	6%	12%	24%	48%
84	7%	14%	28%	56%
96	8%	16%	32%	64%
108	9%	18%	36%	72%
120	10%	20%	40%	80%

The haircuts reflect the probability that some counterparties will be unable to meet their obligations during the stress period. Haircuts become progressively larger as the counterparty rating decreases, with parties rated BBB or lower and unrated parties receiving the most severe haircut. The haircut for each rating category is cumulative rather than additive. It increases for each month of the stress period, beginning in the first month of the stress test and increasing by equal amounts (i.e., linearly), until the full amount of the discount is reached in the 120th month. Table 27 reflects the size of the haircut at the end of each 12-month period during the stress period. Rating downgrades are not modeled. Instead, deterioration in the financial condition of counterparties due to the stressful environment is reflected in the linear increase of the haircuts.

3. Comments and Alternatives Considered

In the ANPR, OFHEO requested comments on how to calculate the loss coverage provided by credit enhancements and on what assumptions to make about the scope of coverage and the failure of counterparties during the stress period. These and other issues, relevant comments received, and OFHEO's rationales for the selected approaches are discussed below.

a. Modeling Approach

ANPR commenters suggested a variety of modeling approaches. MICA stated that the capital requirements for the Enterprises should be consistent with capital requirements for banks and thrifts and reflect the underlying product risk associated with each class of mortgage-related assets. MICA recommended that OFHEO assign relative ''capital relief'' values to ''the three allowable credit enhancements'' [154] based on the quantity and quality of the credit enhancement. MICA further recommended that OFHEO consider mortgage insurance provided by a company with at least a AA claims-paying rating and providing at least the minimum coverage required by the Enterprises' charters as the ''benchmark credit enhancement.'' The benchmark credit enhancement should receive the ''maximum amount of capital relief,'' and other forms of credit enhancement should receive values relative to this benchmark, based on the quality and quantity (i.e. the amount of the loss it covers) of the enhancement. (*See* section III.C.3.c., Discounting for Counterparty Risk for a discussion of MICA's comments related to the quality of the credit enhancement.) MICA views this approach as consistent with risk-based requirements for banks and thrifts, which require uninsured high-LTV

[153] Although dollar balances for these types may in reality vary during the stress period, the stress test uses the balance stated at the beginning of the stress period.

[154] OFHEO interprets ''three allowable credit enhancements'' as a reference to the three types of credit enhancement mentioned in the Charter Act exception to the prohibition on purchasing loans with LTVs in excess of 80 percent.

loans held in portfolio to have twice as much capital as high-LTV loans that are privately insured.

Freddie Mac suggested a two-step process similar to the process it uses in its internal models for pricing transactions. Freddie Mac first estimates the value of the credit enhancement by estimating the proportion of default losses that would be covered, and then discounts the estimated value to reflect the institutional credit risk of the provider, if any. Although Freddie Mac's credit enhancement valuation process occurs at the transaction level for pools of mortgages, Freddie Mac suggested that such a transaction-level approach might not be well suited for OFHEO's stress test. Rather, it recommended aggregating credit enhancements into categories before applying the two-step process. Freddie Mac further recommended that private mortgage insurance be modeled in connection with the modeling of loss severities. Other types of credit enhancements, Freddie Mac suggested, could be converted to ''collateral-equivalent'' amounts and, after discounting for applicable institutional credit risk, aggregated into a large collateral-equivalent pool and used to offset stress test losses dollar for dollar. Freddie Mac made specific recommendations for collateral-equivalent conversions: collateral pledge agreements and spread accounts should be included on a dollar-for-dollar basis and future inflows to spread accounts should be estimated based on the weighted average life (WAL) of the pool; [155] pool insurance should be included to the policy limit, i.e. the percentage limitation multiplied by the original UPB; and recourse and indemnification agreements should be treated as if 100 percent of the losses from mortgage defaults in the applicable pools were covered until such time as the seller/servicer failed.

The approach adopted by OFHEO is similar in many respects to the approach suggested by Freddie Mac. Like Freddie Mac's approach, it estimates the probable coverage of credit enhancements and discounts for counterparty risk where it is present. The value of private mortgage insurance and other forms of credit enhancements that cover a percentage of loss is estimated in connection with loss severities, as suggested by Freddie Mac. The approach adopted by OFHEO differs from the approach suggested by Freddie Mac in some of the details of how credit enhancement coverage is estimated and how discounts for counterparty risk are calculated. These differences are discussed further below.

b. Aggregation

A threshold issue for OFHEO was whether to track and model each credit enhancement with the loan or pool to which it relates or to use some level of aggregation for credit enhancements to increase modeling efficiency. Tracking and modeling each individual credit enhancement agreement with the particular loan or pool to which it is related would yield the most precise estimate of the value and behavior of credit enhancements, but would make the model very complex. Aggregating credit enhancements for efficiency in modeling, on the other hand, gives rise to ''cross support,'' which overestimates the amount of credit enhancements that would actually be used to offset losses. ''Cross support'' means that credit enhancements provided on a particular loan or pool are available to offset losses on another loan or pool, when in practice they would be available only to offset losses on the particular loan or pool for which they were provided and would be partially unused if losses were lower than the amount of the coverage. However, in a model that aggregates credit enhancements and applies them to loan groups, the unused portion of a credit enhancement is available to cover losses in the same loan group. The greater the aggregation of credit enhancements in the stress test, the more cross support occurs, and the more the estimated value of the credit enhancements is overstated. Aggregation up to a very high level can introduce an unacceptable level of cross support.

OFHEO considered converting each credit enhancement type to a dollar-equivalent amount, aggregating these amounts across all credit enhancement types into a single pool of collateral-equivalent dollars, and applying them dollar for dollar against stress test losses. While this approach is simpler and would have required less intensive tracking, it would permit an unacceptable level of cross-support by credit enhancements of different types and for different loan groups. Just as importantly, this approach would not have produced accurate results for the coverage associated with percent-denominated credit enhancements, such as private mortgage insurance. The dollar amount of coverage of these credit enhancements cannot be calculated until losses are determined. These losses can only be calculated during the course of the stress period; they are not known at the beginning of the stress period.

The approach adopted by OFHEO strikes a balance between the benefits of simplicity and efficiency and the benefits of precision while imposing minimal regulatory burden. By estimating the coverage provided by each type of credit enhancement on the basis of loan groups, tracking credit enhancements for each loan group can be accomplished efficiently. The large number of loan groups used by the stress test minimizes cross support between different types of credit enhancements, loans, and time periods.

c. Discounting for Counterparty Risk

Another issue faced by OFHEO was whether and how to take into account the risk that the counterparty's ability to perform on the credit enhancement agreement would be affected by the conditions of the stress test.

OFHEO received a number of suggestions on the treatment of counterparty risk in response to the ANPR. Freddie Mac, MICA, and ACB recommended incorporating an assumption that some of the counterparties would fail during the stress period and suggested that OFHEO look to private rating agencies for guidance. ACB suggested that the OFHEO analysis of the actual coverage provided by mortgage insurance during the stress period could be ''piggybacked'' on S&P's analysis. ACB further stated that OFHEO could make reasonable adjustments to align the worst-case scenario in S&P's stress test with that in the OFHEO analysis, and that it would not be necessary to extend the analysis beyond private mortgage insurers.

As noted earlier, MICA recommended a matrix for determining ''capital relief'' for credit enhancements relative to a benchmark credit enhancement. One dimension of the recommended matrix is the credit rating of the counterparty, reflecting an assumption that the values assigned to various credit enhancements should reflect a differentiation on the basis of the provider's claims-paying rating. However, MICA's recommendation that OFHEO give ''maximum capital relief'' (at least 50 percent of the normal capital charge) to a AA-rated insurer providing at least the minimum coverage required by the Enterprises' charters appears to be equivalent to a recommendation that AA-rated counterparties not be discounted at all.[156] MICA asserted that

[155] This could be done by multiplying the WAL by the average yearly spread going into the spread account and then by the UPB.

[156] The risk-based capital requirements for banks and thrifts are not determined by a statutorily prescribed stress test but by establishing a standard

this recommendation is supported by the historical default experience for corporate bonds in the 1970–89 period, particularly the 0.9 percent default rate for AA-rated bonds.[157] From this MICA concluded that 99.1 percent of mortgage insurance would be available to the Enterprises during the stress period.

Freddie Mac recommended that evaluation of counterparty risk be based on the probable length of time an institution would continue meeting its loss-paying obligations in the stress period, which would be determined by the institution's rating at the beginning of the stress period. This method, Freddie Mac asserted, is similar to one used by Moody's. Specifically, AAA-rated companies would be assumed to cover all obligations for the entire ten-year stress period. AA-rated companies would be assumed to cover all obligations for seven years and none thereafter, A-rated companies for five years, and companies rated BBB and lower, only three years. Freddie Mac also recommended that institutions that are required to post collateral under a collateral pledge agreement be ranked with AAA-rated institutions. For recourse and indemnification agreements, Freddie Mac suggested that OFHEO could assume the agreement would last until the institution failed, a time determined by the institution's rating. It noted, however, that a similar effect could be achieved by adjusting the loss severities based on institution ratings, where the adjustment to loss severity would be lower for a higher institutional rating. However, Freddie Mac cautioned that if this approach were used, the difference between the present-value cost of losses occurring at the end of the stress period and losses occurring at the beginning of the stress period would have to be taken into account. That is, an institution that honors its recourse agreement for the first five years of the ten-year stress period would pay out much more than half of the present value of the losses.

Only one commenter suggested that credit enhancements having counterparty credit risk not be discounted for the risk. The MBA expressed concern about the burden it would place on the Enterprises to determine the financial strength of third parties and suggested that credit enhancements need not and should not be discounted for credit risk of the counterparty. The reasons cited were three. First, the Enterprises generally accept credit enhancements only from well-capitalized companies. Moreover, the Enterprises are in a good position to evaluate the counterparty's financial strength,[158] and the seller/servicer agreement often provides added protection from default on repurchase or indemnification obligations. Second, an assessment of counterparty credit risk is reflected in guarantee fees, which can be adjusted with each commitment. And third, mortgage insurers are nationally rated by recognized organizations that routinely adjust ratings based on changes in financial status. As a result, trends in their financial health can be monitored easily. The MBA urged OFHEO to ground its assumptions and conclusions in historical experience and ''real world'' conditions, which, in its view, argue for not discounting credit enhancements for counterparty risk.

OFHEO believes that some counterparty failure would be likely under the stressful conditions imposed by the stress test and that discounting for counterparty credit risk is necessary to avoid overstating the effect of credit enhancements in covering losses. The statutorily required benchmark stress period is considerably more severe than the national historical experience of corporate bonds cited by MICA. Also, as noted by Anthony Yezer, Professor of Economics at George Washington University, the failure of private mortgage insurers was important in the collapse of the thrifts in the 1930s.

Although the stress test reflects assumptions about the claims-paying abilities of counterparties during the stress period that are similar to Freddie Mac's, OFHEO did not adopt Freddie Mac's assumption that counterparties would pay 100 percent of their obligations as long as they paid at all. In OFHEO's judgment, this assumption is inconsistent with the pattern of counterparty defaults on obligations that one would expect during a stressful period and inconsistent with the pattern of defaults observed in the past. For example, Moody's study of corporate bond defaults [159] showed that cumulative defaults in each of the various ratings categories increased gradually over time. Also, it is likely that the primary market and credit enhancement counterparties would be affected by the stress test conditions relatively early in the stress period. Freddie Mac's approach would not capture this early impact. If mortgage losses were to occur during the first half of the stress period, the importance of reductions in credit enhancements due to counterparty risk would be understated because, as noted by Freddie Mac, mortgage losses occurring during the first half of the stress period constitute much more than half of the present value of total losses. Therefore, credit enhancements offsetting those losses would be more valuable. A more realistic assumption is that the rate of counterparty defaults would increase gradually during the stress period.

OFHEO did not adopt Freddie Mac's recommendation to treat seller/servicers who are required to post collateral when certain financial triggers are met [160] the same as AAA-rated institutions. Freddie Mac contends that the existence of these agreements would provide coverage equivalent to a AAA-rated credit enhancement. However, whether collateral would actually be posted when required is an additional source of counterparty risk and whether that collateral would provide coverage equivalent to a AAA-rated credit enhancement is difficult to evaluate in a regulatory context. Such an evaluation would require OFHEO either to develop the capacity to rate each seller/servicer with a collateral pledge agreement and the impact of the agreement on the seller/servicer's rating, or to require the Enterprises to obtain public ratings for such seller/servicers that take these agreements into account. In light of the small impact that this degree of precision is likely to have on the capital requirement, OFHEO believes that developing such a rating capacity is not an appropriate use of regulatory resources, and that requiring the Enterprises to obtain public ratings would impose an undue regulatory burden. Consequently, the proposed stress test does not model the value of collateral pledge agreements. Instead, it only models coverage provided by collateral that is already available in an Enterprise or third-party account.

This treatment is consistent with the treatment of such agreements under OFHEO's minimum capital regulation. Collateral is not recognized for purposes

capital charge for all assets that is expressed as a fixed percentage of the face amount of the asset. Capital relief for particular assets is achieved by risk weighting them at less than 100 percent of the face amount. Risk-based capital regulations for banks and thrifts risk-weight mortgage loans at 50 percent of the UPB. In a stress test regulation, the most favorable capital treatment is achieved by giving full credit for the credit enhancement without any discount.

[157] ''Approach to Rating Residential Mortgage Securities,'' Moody's Investor Service, April 1990.

[158] This results, MBA noted, from close relationships between the Enterprises and seller/servicers based on frequent marketing contacts, Enterprise auditing activities, and lender reporting obligations.

[159] ''Historical Default Rates of Corporate Bond Issuers, 1920–1997,'' Moody's Investors Service, February 1998.

[160] Seller/servicer agreements may include such a requirement when there is a decline in the institution's rating or a decline in its capital levels below a specified amount.

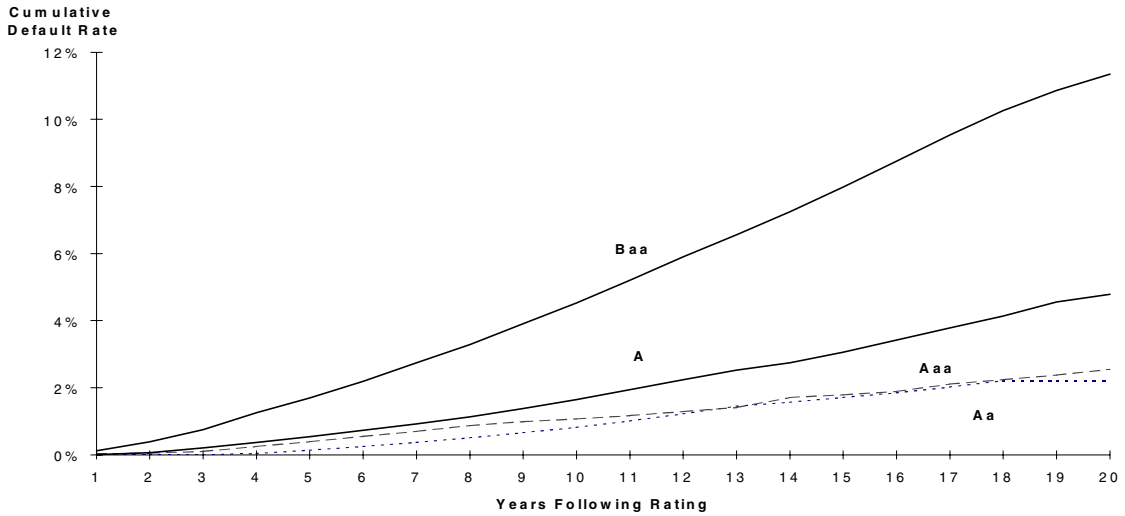
of satisfying the minimum capital standard unless it is actually held and legally available to absorb losses. Also, to be consistent with the minimum capital restrictions on the forms of collateral that are acceptable, the proposed stress test will give credit for the coverage provided by collateral only if it is among the following types: cash on deposit; securities issued or guaranteed by the central governments of the OECD-based group of countries,[161] United States Government agencies, or United States Government-sponsored agencies, and securities issued by multilateral lending institutions or regional developments banks.

In determining the size and timing of the discounts (haircuts) to the value of the credit enhancements, OFHEO considered Moody's study of corporate bond default rates and methodologies used by S&P and Duff & Phelps (D&P). Moody's analysis of corporate bond issuers from 1920 to 1997 [162] showed cumulative default rates over various time horizons for each rating category. The average ten-year cumulative default rate over the entire period was 1.17 percent for Aaa issuers, 3.32 percent for Aa issuers, 3.87 percent for A issuers, 8.08 percent for Baa issuers. These data suggest that the ten-year cumulative default rate roughly doubles for each one-level drop in rating category. Defaults for Aa issuers were higher relative to those for Aaa and A issuers than this doubling relationship would suggest. However, Aa issuers from the mid-1970s forward had ten-year cumulative default rates that were much lower relative to issuers in other rating categories.

The Moody's approach and the approach recommended by Freddie Mac is a survival approach in which it is assumed that an institution meets 100 percent of its obligations for as long as it survives, and relative risk is expressed as the number of years an institution survives. The approach used by S&P and D&P [163] is a haircut approach in which it is assumed that institutions will meet some, but not all, of their obligations, and the haircut is the percent of obligations they will fail to meet. Specifically, S&P discounts the claims-paying ability of mortgage insurers in a AA stress level environment by 20 percent for AA-minus-rated mortgage insurers, 50 percent for A-rated mortgage insurers, and 60 percent for A-minus-rated mortgage insurers. D&P discounts mortgage insurers in a AAA stress level environment by 35 percent for AA-rated reinsurers, 70 percent for A-rated reinsurers, and 100 percent for BBB-rated reinsurers. For S&P, the haircuts apply in full from the second year of the stress period. Also, the haircut is related to the stress level of the environment, and an insurer with a rating equal to or greater than the stress level is not discounted.

Moody's corporate bond study shows that the cumulative default curves for companies with ratings of BBB and above were essentially linear.

Figure 2. Cumulative Default for Corporate Bonds by Rating Category



OFHEO's approach to applying haircuts is similar to S&P's and D&P's, but differs in three ways. First, the stress test does not apply the full amount of the haircut immediately but applies a haircut that increases each month until reaching the full amount in the 120th month. This reflects the general industry view that defaults increase gradually in a stress scenario. Further, as illustrated by the graph in Figure 2, the linear growth specification of the stress test is a reasonable one in light of actual historical patterns of default. Second, the stress test haircuts are in no case as low as zero and in no case as high as 100 percent. This reflects historical default patterns, which suggest that counterparties or issuers in each rating category would pay at least some claims, and no rating category would be immune from any claims-paying defaults. With respect to the absence of a rating category with zero defaults, Moody's data show that, in a difficult but far from severe environment, 3.2 percent of issuers

[161] The OECD-based group of countries comprises all full members of the Organization for Economic Cooperation and Development and countries that have concluded special lending arrangements with the International Monetary Fund (IMF) associated with the IMF's General Arrangements to Borrow, but excludes any country that has rescheduled its external sovereign debt within the previous five years.

[162] ''Historical Default Rates of Corporate Bond Issuers, 1920–1997,'' Moody's Investors Service, February 1998.

[163] ''S&P's Structured Finance Criteria,'' Standard & Poor's Corporation, 1988; ''Evaluation of Mortgage Insurance Companies,'' Duff & Phelps, November, 1994.

rated Aaa at the beginning of 1983 defaulted within 10 years. Third, the stress test haircuts are not tied to the stress level. While OFHEO's NPR 1 showed credit stress at roughly a AA+ level, the stress test as a whole does not translate to any particular level because OFHEO's methodology as required by the 1992 Act differs in several key respects from that used by rating agencies.

Although OFHEO considered developing a probabilistic survival function for counterparties that would provide an estimate of failure in each year of the stress period, such a methodology would be difficult to specify, implement, and replicate, especially if recovery rates on bankrupt counterparties were modeled. OFHEO concluded that, short of a probabilistic function, imposing a linearly increasing haircut on all counterparty credit enhancement proceeds through the entire stress period would be the most representative of all the other options of how the rate of counterparty defaults would increase during the ten-year stress period.

The size of the haircuts proposed for the stress test, ten percent for AAA-rated companies, 20 percent for AA-rated companies, 40 percent for A-rated companies, and 80 percent for BBB-rated companies, are far more severe than recent default experience but less severe than Depression-era experience. They are about six to ten times the severity of average ten-year cumulative defaults during 1920–1997 in the Moody's analysis. The haircuts double for each drop in rating category, consistent with the Moody's bond default analysis. Some default occurs among AAA-rated companies, while BBB-rated company defaults are not 100 percent.

OFHEO's approach is transparent, easily replicated, and consistent with industry practice. It draws on the best aspects of S&P's approach to modeling mortgage insurer performance, and Moody's corporate bond study in applying company defaults over time. It also recognizes that, while the impact of the stress test environment on Enterprise losses might not be large in the first two years of the stress period, the primary mortgage market (i.e., the seller/servicer counterparties) likely would feel the impact of a stressful environment almost immediately.

d. Unrated Seller/Servicers

OFHEO considered whether unrated seller/servicers should be treated the same as other unrated counterparties or whether they should be treated differently because of their close relationships with the Enterprises.

Both Freddie Mac and MBA argued that even though seller/servicers are typically unrated, the close relationship between the Enterprise and its seller/servicers enables the Enterprise to monitor their financial strength. Freddie Mac stated that the seller/servicer agreement provides added protection against default on recourse and indemnification obligations because it gives Freddie Mac the right to the servicing of all Freddie Mac loans then serviced by the institution in the event of default on these obligations. Freddie Mac asserted that the value of the servicing is likely to cover a substantial portion of the defaults covered by a seller/servicer recourse agreement.[164] For these reasons, Freddie Mac considers all sellers/servicers to be at least BBB for purposes of evaluating institutional credit risk and urged OFHEO to consider the added layers of protection provided by the servicing rights.

The stress test treats unrated seller/servicers, like other unrated counterparties, the same as it treats BBB counterparties, which is consistent with the thrust of Freddie Mac's ANPR comments. Although OFHEO does not explicitly price the added layer of protection provided by mortgage servicing rights in its stress test, this added layer of protection was considered as a factor in deciding that unrated counterparties should be treated as BBB. OFHEO believes that any imprecision resulting from assigning unrated seller/servicers to the BBB or lower rating group would have a small impact on the resulting capital requirement. Seller/servicer recourse represents a small percentage of the credit enhancements used by the Enterprises. In addition, the Enterprises' largest customers tend to have public ratings.

Although the Enterprises assign internal ratings to seller/servicers, OFHEO did not use these ratings for three reasons. First, these ratings and the methodology for developing the rating are proprietary information and not publicly available. Therefore, they cannot be included in the regulation or used by third parties to evaluate the risk-based capital requirement. Second, each of the Enterprises has developed its own unique rating system. These rating systems may result in different ratings of the same parties. One of the underlying requirements of this regulation is the development of a capital requirement that is applied uniformly to both Enterprises. This requirement cannot be met if different rating systems are applied to each Enterprise. Finally, using such ratings without independent validation by OFHEO would compromise the independence of the regulatory process.

e. Fluctuations in Value

The dollar value of some credit enhancements, such as spread accounts and securities deposited in an account under collateral pledge agreements, fluctuate over time, for reasons other than withdrawals to cover losses. Spread accounts are funded by a portion of each loan payment and hence increase in value as loan payments are made. Securities deposited in an account under collateral pledge agreements,[165] which are marked to market periodically, fluctuate in value due to movements in interest rates during periods that fall in between the marks to market. In addition, posting requirements of collateral pledge agreements can cause additional collateral to be deposited to the account.

The stress test does not model these fluctuations. Rather, it uses the dollar value of spread accounts, cash accounts, and collateral posted under collateral pledge agreements on the first day of the stress period and draws on this dollar amount throughout the stress period to cover losses. Modeling fluctuations in the value of collateral posted under collateral pledge agreements would have added a level of complexity that is not justified by the incremental precision that would be gained. Similarly, the stress test does not model the accumulation of interest in the spread account according to the terms of the spread account agreement because this would have introduced a level of complexity that is not justified by the probable impact on the ultimate capital requirement.

Freddie Mac suggested that OFHEO estimate future inflows by multiplying the weighted average life (WAL) of the mortgage pools by the average yearly spread going into the spread account and then by the UPB. However, such an approach would also have made the stress test excessively complex. Loans covered by a spread account agreement may be in different loan groups in the stress test, and determining the WAL of

[164] Freddie Mac estimates that these servicing rights are normally worth about 25 basis points of income per year, and can be sold to another servicer for 100 to 150 basis points.

[165] As stated earlier, the stress test recognized the coverage provided by collateral pledge agreements only if collateral has actually been posted and resides in an account as of the beginning of the stress period. Otherwise, collateral pledge agreements are not modeled in the stress test.

all the loans covered by each spread account would require tracking each spread account loan and processing spread account characteristics at the transaction level.

OFHEO will continue to monitor the relative volume of spread accounts and collateral pledge agreements and consider whether an amendment to the regulation is needed if it should appear that the impact on the capital requirement might be significant.

f. Credit Enhancement on High LTV Loans

Certain credit enhancement types used by the Enterprises are not mentioned in the Charter Acts' exceptions to the prohibition on purchasing single family loans with LTVs in excess of 80 percent, namely spread accounts, collateral pledge agreements, cash accounts, pool insurance, and indemnification. This fact raised the issue of whether the stress test should take them into account when they are intended to satisfy the statutory requirement for credit enhancement on loans with LTVs in excess of 80 percent. In its comment letter, Freddie Mac argued that an expansion of the list of recognized credit enhancements to include collateral pledge agreements, spread accounts, and indemnification would be consistent with the intent of Congress in giving the OFHEO Director discretion to make reasonable assumptions about factors that would affect the severities of loss on mortgage defaults, including ''the value of mortgage insurance [and] the value of various forms of credit enhancements such as recourse agreements, collateral, and spread accounts.'' [166] MICA, on the other hand, argued that only the three types mentioned in the statutory exceptions should be considered.

Although OFHEO recognizes that some types of credit enhancements not expressly referenced in the Charter Acts may provide equal or superior loss protection, OFHEO does not believe that they satisfy the statutory requirement for credit enhancements for single family loans with LTVs in excess of 80 percent. OFHEO does not concur with Freddie Mac that the legislative history of the 1992 Act gives OFHEO the latitude to expand the list of statutorily authorized credit enhancements for single family loans with LTVs in excess of 80 percent. OFHEO believes that taking into account credit enhancements not expressly referenced in the Charter Acts when they are used to satisfy the statutory credit enhancement requirement for single family loans with LTVs in excess of 80 percent would undermine OFHEO's efforts to ensure that the Enterprises operate within the Charter Acts.

g. Scope of Coverage

The ANPR asked for comments on how the regulation should address the scope of coverage provided by credit enhancements. Freddie Mac, the only commenter on this question, stated that all credit enhancements except private mortgage insurance can be assumed to cover all loss elements, including loss of property value, lost interest, real estate commissions, attorney fees, taxes, and preservation costs, where as private mortgage insurance sometimes excludes certain expenses after the property becomes REO.

Based on an analysis of available information, OFHEO proposes to make credit enhancements coverage available for all types of losses associated with stress test defaults. The benchmark data reveal that loss severities before credit enhancements were applied for single family loans in the benchmark time and place were consistently in the 50 percent to 60 percent range. At the same time, private mortgage insurance coverage typically ranged from 12 percent to 30 percent coverage of the gross claim amount. Since the severities far exceed the coverage of private mortgage insurance, the stress test assumes that the private mortgage insurance would be used up covering expenses that the mortgage insurance typically covers, and that the REO-related expenses would be reflected in the uncovered losses.

h. Termination of Private Mortgage Insurance

Modeling private mortgage insurance required a determination of how to treat the potential for termination of mortgage insurance while the loan is outstanding. Termination occurs either because the borrower exercises an option to cancel the insurance when the equity in the loan reaches a predetermined threshold, or because cancellation is automatic under the provisions of the recently enacted Homeowners Protection Act of 1998.[167] For loans originated before the July 1999 effective date of the Homeowners Protection Act, termination resulting from the borrower's exercise of the right to cancel the insurance when sufficient equity in the loan is attained presents a difficult issue, because data on this phenomenon are scarce, and there is an insufficient basis on which to draw firm conclusions. OFHEO considered three options: (1) assume that borrowers do not exercise this right when they are eligible; (2) assume all borrowers exercise this option when they become eligible; or (3) assume some percentage of borrowers, less than 100 percent, exercise this option when they become eligible.

After considering these options, OFHEO concluded that the first option was the preferred option because it is the option likely to produce the least distortion. The second option would understate the amount of credit enhancement available and the third would require an assumption based on very sparse data. Although assuming that insurance is not terminated may be a source of some imprecision, the impact of such imprecision is not likely to be significant in determining capital needed under the stress test. The loans most likely to default are those loans with high current LTV ratios, which will not be eligible for termination of private mortgage insurance because of the high LTVs. Conversely, those loans with low enough current LTV ratios to be eligible for termination are much less likely to need the coverage, and whether it is unused or is assumed to be terminated will make little difference. The largest potential for error is with loans with high original LTV ratios that have aged prior to the stress test just to a point where coverage can be terminated. OFHEO will monitor this issue and consider proposing an amendment to the regulation if another option appears to be more appropriate.

The Homeowners Protection Act provides that mortgage insurance will terminate automatically when the loan balance is scheduled to reach 78 percent of the original value of the property securing the loan, provided payments on the loans are current. For loans that do not meet the LTV test and for high-risk loans with original principal balances that do not exceed the conforming loan limit, mortgage insurance will terminate when the loans reach the mid-point of their amortization periods if payments are current. The Enterprises will publish guidelines to describe high-risk loans. OFHEO proposes to apply the provisions of the Act by eliminating mortgage insurance coverage in calculating loss severities for loans that reach 78 percent of their original value during the stress period or at the midpoint of their amortization periods for ''high risk'' loans, as defined by the Enterprises.

[166] H.R. Rep. No.102–206, at 67 (1991).

[167] Pub. L. No.105–216, 112 Stat. 897–910 (12 U.S.C. 4901–4910).

D. Liabilities and Derivatives

The Enterprises issue a variety of debt instruments that comprise their liability portfolios. To understand the types of liabilities issued by the Enterprises it is useful to group the liabilities into categories based on similar characteristics related to the instrument's coupon type, optionality, or other structuring features. The liabilities issued by the Enterprises are primarily one of three coupon types: fixed-rate, floating-rate, or zero-coupon. The Enterprises use these different types of coupons to manage both their exposure to interest rate risk and their cost of funding. The optionality of a financial instrument refers to whether that instrument contains an embedded option—in the case of the Enterprises liabilities, generally a call option. The embedded call option gives the Enterprises the opportunity to pay off (call) the debt, at a time prior to its contractual maturity. The Enterprises issue a mix of callable and non-callable (bullet) debt in order to manage their exposure to the prepayment risk inherent in their retained mortgage and mortgage security portfolios.

The Enterprises also issue liabilities that have unique structuring features, such as complex principal, coupon, or optionality characteristics. An example of a complex liability is a Euro discount note. To the extent that these notes are issued in foreign currencies, the Enterprises are exposed to foreign exchange risk, which is offset with hedging transactions at the time the discount notes are issued. An example of a liability with complex coupon characteristics is an inverse floater. For example, this instrument may pay a fixed rate of interest for a given period of time and then revert to an interest payment based on the formula 12 percent less six month LIBOR. In this case, the Enterprises incur higher interest costs as LIBOR decreases. In most situations, the complex risk characteristics of these liabilities are hedged at the time of issuance, leaving the Enterprise with synthetic ''plain vanilla'' liabilities, which have the coupon and option features of a more typical Enterprise liability. These liabilities generally are used by the Enterprises to obtain funds at a lower net cost than could be obtained by issuing simpler forms of debt.

In addition to the types of liabilities discussed above, the Enterprises also provide investment vehicles, termed Guaranteed Investment Contracts (GICs), to various institutions that have specific cash flow requirements or need flexibility in making cash withdrawals. They comprise a very small percentage of the Enterprises' liabilities. GICs can pay or accrue interest. Their principal balances can increase, decrease or remain the same.

The Enterprises, like most large financial institutions, use derivatives to help manage the interest rate risk of their assets and liabilities. The term ''derivatives'' covers a broad range of instruments, the value of which is based on or linked to (i.e., ''derived'' from) another instrument or a financial market such as stocks, interest rates or currencies. A common derivative is an interest rate swap, which derives its value from the changes in value of interest rates paid on various types of debt instruments. Derivatives can be used to hedge the unusual or complex risk characteristics of individual debt instruments, such as the complex structured liabilities described above. They also can be used to rebalance the interest rate risk of an entire portfolio. In short, derivatives, like most financial instruments, can either add or reduce various types of risk. The risk-based capital regulation, therefore, must account for derivatives in order to reflect accurately the risk profile of the Enterprises.

In developing an approach for modeling the cash flows of the Enterprises' liabilities and derivatives, OFHEO had to address four issues discussed below: (1) should liabilities and derivatives be modeled at the instrument level or should they be aggregated in some manner; (2) how should instruments linked to foreign currencies or unusual risk factors be modeled; (3) how should callable debt and cancellable derivatives be modeled; and (4) how should the stress test account for the risk of derivative counterparty defaults?

1. Modeling Methodology

The first issue for OFHEO was whether to model liability and derivative cash flows at the instrument level or to aggregate individual instruments with similar terms and risk characteristics and model the aggregated cash flows based upon average maturities, coupons, options, and other features. In response to an ANPR question about how OFHEO should simulate gains and losses on derivative activities, Freddie Mac suggested that the underlying instruments should be modeled. Likewise, Freddie Mac's discussion of liabilities in its comments assumes that most liability instruments will be modeled individually. The only other comment was ACB's suggestion regarding accounting for the risk of counterparty default. ACB's recommendation that the stress test ''haircut'' (meaning reduce by a percentage) derivative positions when they were ''in the money'' (meaning the derivatives have a net positive value to the Enterprises) would require modeling cash flows of derivatives individually.

The issue of modeling liabilities and derivatives on an aggregated versus instrument level usually requires a trade-off between accuracy, model complexity, and information system resources. In most cases, the model for generating cash flows uses the same types of information for an individual instrument as it would for a group of similar instruments. For this reason, OFHEO's information system resources are capable of processing the large number of individual liabilities and derivatives in a reasonable amount of time. Therefore, OFHEO proposes to model the cash flows of all existing types of liabilities and derivatives individually, except certain instruments that have terms or risk characteristics based on a foreign currency, which are discussed below as a separate issue.

As with most other liabilities, the stress test will model GICs individually. However, given the variety of their terms and purposes, it was necessary to simplify the cash flow model for these instruments. The stress test models each GIC as if it pays out its specified interest on the starting balance amount over the entire stress period, unless the GIC includes an explicit maturity date. In the latter case, the stress test pays interest only until the maturity date, at which point it pays out the total principal.

2. Foreign Currency Linked or Unusual Instruments

The second liabilities-related issue arises because, from time to time, the Enterprises issue foreign currency-denominated debt and structured notes that are linked to a foreign currency. As discussed above, the Enterprises currently hedge all foreign currency-linked securities with derivatives or other financial instruments, resulting in synthetic securities denominated in U.S. dollars. Freddie Mac, the only ANPR commenter to address this issue, recommends modeling foreign currency-linked transactions differently from other instruments, explaining that ''hedge cash flows or the netted cash flows need to be calculated * * *.''

OFHEO agrees that currency-linked securities and the associated hedging instruments are different from other types of liabilities and derivatives of the Enterprises in that the cash flows of the individual instruments are linked to changes in currency values. OFHEO also

recognizes that, in current practice, the Enterprises issue a limited volume of currency-linked instruments and transfer all currency risk to third parties by hedging instruments. Further, with the exception of debt linked to foreign currency, the Enterprises have not issued liability instruments that were linked to indices or values (such as commodities or stock prices) that are not projected in the stress test.[168]

OFHEO concurs with Freddie Mac's comments that where all the currency risk is hedged, by swapping the foreign currency payments into dollars, the stress test could calculate the cash flows by creating a single synthetic liability, denominated in dollars and paying the net amount due under the related transactions. The stress test, therefore, applies that approach to instruments that are fully hedged. However, in the event that OFHEO finds that the foreign currency risk on any liability or derivative instrument has not been transferred fully to a third party, the stress test models the cash flow on such instruments as follows.

The stress test creates significant losses in unhedged currency positions in both the up-rate and down-rate scenarios. In the up-rate scenario, the stress test applies an exchange rate that increases the value of the foreign currency against the dollar by the same percentage that interest rates increase. For example, if the ten-year CMT shifts up by 50 percent, then the foreign currency value is shifted up by 50 percent against the dollar for the up-rate scenario.[169] The effect in this example would be that the Enterprise would be paying 50 percent more dollars due to the unhedged exchange rate shift.

A different adjustment is applied in the down-rate scenario. In that case, the stress test decreases the exchange rate of the dollar proportionately with the decline in the ten-year CMT, creating a decrease in the value of the dollar similar to that in the up-rate scenario. Thus, a downward shift in the ten-year CMT of 50 percent would be associated with a shift down of 50 percent in the exchange rate of the dollar. The effect in this example is that the Enterprise would be paying twice as many dollars due to the unhedged exchange rate shift.

This approach is simple, conservative and reasonable. The stress test recognizes that there can be substantial risk associated with unhedged positions in foreign currencies or other indexes or values to which instruments can be linked, but that it would be impractical for OFHEO to develop indexes for foreign currencies and all other values to which liabilities or derivatives could be linked. The exchange rate in the up-rate scenario is not based upon a model or an economic prediction, but does reflect a recognition that there have been occasions in the past where the dollar has declined in value as CMT rates have been increasing. Likewise, the dollar has also declined at times when CMT rates have decreased. Therefore, it is appropriate in a stress test to assume that the dollar moves in an unfavorable direction in both scenarios, to avoid creating a windfall to the Enterprises and to ensure significant financial stress in both scenarios. Moreover, OFHEO does not anticipate at this time that the Enterprises will be issuing foreign currency or unusual debt derivatives without using appropriate and complete hedges. If the Enterprises do alter their current businesses to enter into such debt, OFHEO will consider at that time whether a different treatment for the instruments involved is appropriate.

3. Call and Cancellation Options

An Enterprise will retire an outstanding issue of callable debt in order to issue new debt at favorable rates. For similar reasons an Enterprise may cancel a swap. For example, an Enterprise can cancel a pay-fixed/receive-floating swap—which, together with discount notes, creates a synthetic fixed-rate liability—in order to enter into a new swap that lowers the effective cost of the synthetic liability. OFHEO recognizes that, in general, an Enterprise will exercise its option when the net interest cost savings on a replacement security or contract, exceeds some threshold.

OFHEO received several comments to the ANPR that emphasized the importance of modeling the exercise of the call option. OFHEO concurs with these comments and, accordingly, treats callable debt in a manner that takes into consideration the exercise of the call option. OFHEO considered developing a financial model to value call and cancellation options and determine when they would be exercised in the stress test. However, the added precision of such a valuation model, as opposed to a simpler approach, would not have a significant effect on the capital requirement because the severe nature of the interest rate shocks included in the stress test result in either all eligible debt being called in a short period of time or no debt being called over the entire period. In addition, a valuation model would add a considerable amount of complexity to the cash flow model. Therefore, OFHEO sought to develop an alternative approach for decisions to exercise call and cancellation options that would provide a reasonable approximation of the Enterprises' procedures for exercising such options without increasing the complexity of the model.

OFHEO proposes to use, as a proxy for this threshold option value, the spread between the coupon rate of an outstanding actual or synthetic debt security and the Enterprise cost of funds for a new replacement security (the call-spread). Thus, in the stress test, the call option is exercised and the debt retired when the cost of the new debt plus the call-spread is less than the cost of the existing debt instrument. This methodology is often used as a simplified approach in modeling applications and was suggested by Freddie Mac in its comments to the ANPR. No other commenter suggested a specific approach.

To calculate an appropriate call spread, OFHEO received data from the Enterprises on the threshold value of call options on debt, in terms of a call-spread, over a range of reasonable times to maturity and valuation model parameter settings. After reviewing this information, OFHEO proposes to use a call-spread in the stress test of 50 basis points over the cost of issuing new bullet debt with the same time to maturity as the callable debt. This call-spread provides a reasonable debt call rule, without adding a considerable amount of complexity to the model.

4. Counterparty Risk

The ANPR sought comment about how, if at all, OFHEO should incorporate the effect of derivative counterparty defaults into the stress test. The Enterprises frequently enter into derivative contracts that, combined with various types of debt instruments (including structured notes), create synthetic liabilities at lower cost then actual debt with the same characteristics. Other derivative contracts are used as macro hedges against portfolio level risks. However, all swaps expose an Enterprise to counterparty credit risk, which is the risk that the counterparty may default on its contractual obligation at a time when the derivative contract has a positive market value to the Enterprise.

[168] However, wherever the terms ''foreign currency'' or ''currency'' are used, they should be read to include any unit or value, except those interest rate indices that are included in the stress test, in which debt or derivatives may be denominated or to which such instruments may be linked.

[169] Shifting the value of the other currency up 50 percent has effect of decreasing the value of the dollar against that currency by ⅓. In other words, one could buy the same amount of dollars with only ⅔ the amount of other currency.

Currently, the Enterprises limit their exposure to counterparties by entering into swap transactions only with counterparties rated investment grade and by requiring all counterparties to execute collateral pledge agreements. These pledge agreements require any counterparty currently rated or subsequently downgraded to a less than a AAA credit rating to post collateral to the extent that net losses on its contracts [170] with an Enterprise exceed threshold levels. The threshold levels vary based on the counterparty's rating. The Enterprises do not require AAA-rated counterparties to post collateral, but if any counterparty is downgraded, the collateral pledge agreements subjects it to the more stringent collateral requirements of its new lower rating. Freddie Mac, in its comments, describes additional measures it uses to mitigate counterparty risk, which include using contracts with close-out and netting arrangements that allow Freddie Mac to offset losses on one contract with a particular party against gains on another contract. Freddie Mac also described its practice of requiring guarantees from well-capitalized parent companies and of periodically marking each contract to market at full replacement value.

In commenting on the ANPR, Freddie Mac stated that its management of credit risk on derivatives is such that the stress test should specify no losses due to counterparty default. Freddie Mac suggested that any losses would be covered adequately by the 30 percent add-on that the 1992 Act requires for management and operations risk and by the minimum capital standard. ACB, commenting generally on the subject of counterparty risk, stated that where collateral is provided, the risk of counterparty failure is remote. ACB suggested that, at most, a straightforward ''haircut'' on ''in the money'' derivative positions should be applied.

After consideration of these comments, OFHEO determined that reducing the haircuts for derivative counterparty risk by 80 percent from haircuts on other types of third party credit risk would provide appropriate recognition for Enterprise collateral agreements. However, OFHEO did not agree with Freddie Mac that the stress test should apply no haircuts. There always remains the possibility that counterparties could default on their obligations due to a sudden calamity that could prevent collateral from being posted. Also, collateral values can decline over time or collateral may be subject to competing claims. Sudden business bankruptcies and decline or impairment of collateral value would be even more likely than usual under the harsh economic circumstances of the stress test. Accordingly, and for the same reasons that similar haircuts are applied to mortgage credit enhancements and non-mortgage investments, OFHEO proposes to specify losses in the stress test due to failure of derivative counterparties.

OFHEO proposes to take into account the amount of loss due to derivative counterparty default as follows. As illustrated in Table 29, the stress test applies haircuts that increase linearly (by equal amounts) each month to the net payments from derivatives with a given counterparty over the term of the contracts with that counterparty. That is, if the Enterprise's net swap position across all contracts with a particular counterparty imply cash payment to the Enterprise during a given month, that cash payment is reduced (''haircut'') by an amount determined by the public credit rating of the counterparty and period in which the payment is owed. The calculation is performed for each counterparty and for each month in which a counterparty has swap agreements with the Enterprise. The cash flows for all derivatives with each counterparty are netted, except swaps that exchange into U.S. dollars any currency in which Enterprise debt may be denominated. Haircuts are applied separately to these derivatives, as explained below.

Table 28. Haircuts To Income From Derivatives

Month	AAA	AA	A	BBB
12	.2%	.4%	.8%	1.6%
24	.4%	.8%	1.6%	3.2%
36	.6%	1.2%	2.4%	4.8%
48	.8%	1.6%	3.2%	6.4%
60	1.0%	2.0%	4.0%	8.0%
72	1.2%	2.4%	4.8%	9.6%
84	1.4%	2.8%	5.6%	11.2%
96	1.6%	3.2%	6.4%	12.8%
108	1.8%	3.6%	7.2%	14.4%
120	2.0%	4.0%	8.0%	16.0%

[170] These losses are calculated on a mark-to-market basis, because most derivatives involve features, such as payment streams and options, the values of which fluctuate with changes in the yield curve.

The haircuts reflect the probability that some counterparties will be unable to meet their obligations during the stress period. Haircuts become progressively larger as the counterparty rating decreases, with parties rated BBB or lower and unrated parties receiving the most severe haircut. The haircut for each rating category is cumulative rather than additive. It increases linearly for each month of the stress period, beginning in the first month of the stress test until the full amount of the discount is reached in the 120th month. Table 29 reflects the size of the haircut at the end of each 12 month period during the stress test. Rating downgrades are not modeled. Instead, deterioration in the financial condition of counterparties due to the stressful environment is reflected in the linear increase of the haircuts.

The proposed approach recognizes that both Enterprises utilize netting and close out arrangements such as those described by Freddie Mac in its comments. If OFHEO determines that not all derivatives with a particular counterparty are covered by a single arrangement, the derivatives' cash flows will not all be netted together. Instead, the stress test will group the derivatives by netting agreement and apply haircuts separately to the net cash flow for the derivatives covered by each agreement. For derivatives covered by no netting agreement, the haircut would be applied on an instrument by instrument basis to any derivatives that are ''in the money.'' In the event that any derivatives contracts do not include standard Enterprise collateral agreements, the haircut percentages imposed will be those in Table 27 in section III.C., Mortgage Credit Enhancements.

As mentioned above, the stress test will apply haircuts separately to swap agreements that exchange into U.S. dollars any other currency in which Enterprise debt may be denominated. Because these agreements entail the Enterprise receiving payment denominated in other currencies, which the stress test does not model, the stress test cannot net them against more usual interest rate swaps. Neither can the stress test net these agreements against each other, since they use variety of currencies. Therefore, the stress test applies haircuts to each individual contract. Because the collateral agreements and investment ratings do not differ for the counterparties to these agreements, the stress test applies the same counterparty haircut percentages to them as it does for interest rate swaps. However, the haircut is applied to the 'pay' side of these contracts rather than to the 'receive' side. The effect will be a loss on each swap transaction equal to the haircut amount. This approach recognizes that the Enterprises use these swap agreements only to match a debt position for which the swap agreement is a hedge.

E. Non-Mortgage Investments

In addition to mortgage investments, the Enterprises hold non-mortgage investments [171] that include Treasury securities, federal funds, time deposits, Eurodollar deposits, asset-backed securities [172] (ABS), corporate securities, and state and municipal bonds.[173] As of December 31, 1997, non-mortgage investments at Fannie Mae constituted about $66.8 billion (17 percent of on-balance sheet assets) and $13.8 billion (7.0 percent) at Freddie Mac.

OFHEO considered several issues related to how the stress test should model the cash flows associated with the Enterprises' non-mortgage investments. The first issue concerns whether the stress test should model cash flows from such investments at the instrument level or at an aggregated level. Such aggregation entails grouping individual instruments with similar terms and risk characteristics and modeling the group as a single instrument. The proposed stress test models the cash flows of all non-mortgage investments on an instrument-by-instrument basis. Evaluating whether to model non-mortgage investments on an instrument versus an aggregated level represents a trade-off between accuracy, model complexity, and information system resources. Instrument level modeling provides greater accuracy than modeling aggregated investments because aggregating instruments may result in losing information. On the other hand, instrument level modeling may result in added complexity and require additional information system resources. Neither of these concerns poses a significant constraint in the case of modeling the Enterprises non-mortgage investments. Accordingly, OFHEO believes that modeling cash flows from non-mortgage investments is practicable and appropriate. With respect to complexity, the model for generating cash flows uses the same types of information for an individual instrument as it would for a synthetic instrument representing a group of actual instruments. With respect to information resources, OFHEO systems are capable of processing the large number of individual investments in a reasonable amount of time.

The second issue concerns whether there should be any simplifying assumptions in modeling the cash flows associated with non-mortgage investments. OFHEO has decided to include the following three simplifying assumptions which will facilitate this modeling, without having a significant effect on the risk-based capital requirement. First, for investments with common characteristics, the stress test specifies one payment frequency for those instruments. Second, the stress test standardizes prepayment speeds for ABS, i.e., how fast principal (both scheduled principal and prepayments) is returned. Third, the stress test will not apply different ABS prepayment speeds in different interest rate environments, because ABS typically pay off quickly and therefore are not significantly affected by interest rates. In addition, the effect of specifying different prepayment speeds on the risk-based capital requirement would not be significant, and would add unreasonable additional complexity to the stress test.

OFHEO next considered whether the proposed stress test should, with respect to non-mortgage investments, model their credit risk, i.e., the risk that there will be a default on an instrument. OFHEO has determined that it is appropriate to model such credit risk because some issuers would be unable to meet their obligations during the stress period. The proposed stress test ties the credit quality of non-mortgage investments to the credit rating specified by one or more nationally recognized public rating organizations, such as S&P or Moody's. While public offerings usually have a single rating, they occasionally have split ratings. In the case of split ratings, the stress test will use the lowest rating.

The stress test first generates cash flows for a given instrument and then reduces those cash flows by a specified percentage (i.e., ''haircut'') based on the public rating organization. The percentage haircut increases as the

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[171] Both OFHEO and HUD are authorized to regulate the Enterprises' non-mortgage investment activities. OFHEO has specific authority to ensure that the Enterprises are adequately capitalized and operating safely (1992 Act, section 1313 (12 U.S.C. 4513)), and HUD has general regulatory authority over the Enterprises to ensure that the purposes of the 1992 Act are accomplished (1992 Act, section 1321 (12 U.S.C. 4541)). While HUD's current regulations do not contain specific provisions about the Enterprises' non-mortgage investments, HUD issued an advance notice of proposed rulemaking (ANPR) seeking comment about the need for it to regulate such investments. (62 FR 68060, December 30, 1997)

[172] ABS are similar to MBS but are backed by nonmortgage assets, such as receivables on car loans and credit cards.

[173] Although they are generally tax-exempt, for purposes of the stress test, mortgage revenue bonds (MRBs) are not included in the category State and municipal bonds. MRBs are discussed in the section titled ''other housing assets.''

rating decreases so that a highly-rated instrument will have a lower haircut than a lower rated instrument. In the absence of a rating, the stress test would apply the lowest rating category. The haircuts increase linearly (i.e., in equal increments) during each month of the stress period. Table 29 illustrates the ending haircuts in the 120th month for each rating category. Refer to section III. C., Mortgage Credit Enhancements for the discussion of the proposed haircuts.

Table 29. Rating and Stress Period Ending Haircuts

Rating Category	AAA	AA	A	BBB
All counterparties and securities except derivative counterparties	10%	20%	40%	80%

An instrument that is unrated or has a rating that is below investment grade will receive the most severe haircut. This reflects OFHEO's determination that it is appropriate for the stress test to reflect high credit losses for non-mortgage investments that are more risky than the instruments that are now included in the Enterprises' current holdings. The Enterprises' non-mortgage investments are currently of high quality,[174] but the Enterprises are not statutorily or otherwise legally required to invest solely in high quality instruments. It is possible that an Enterprise might change its investment practices to include non-mortgage investments with lower credit quality.

F. Other Housing Assets

Other housing assets are a small category of Enterprise assets that need to be modeled differently than retained whole loans and mortgage-backed securities are modeled. They are primarily mortgage revenue bonds (MRBs). They also include certain Real Estate Mortgage Investment Conduits (REMIC) securities issued by private entities and some interests in partnerships and joint ventures. These assets have cash flow characteristics that vary from investment to investment, and the data required to model cash flows precisely is not readily available. The impact of how these assets are modeled on the stress test results will be modest.

1. Mortgage Revenue Bonds

Mortgage revenue bonds are issued by state and local housing authorities to raise funds for single family and multifamily mortgage lending programs. Both single and multifamily mortgage revenue bonds are secured by mortgage loans, reserve funds, and other credit enhancements. Government subsidies to some multifamily projects also provide implicit credit support. Most MRBs are tax exempt. The Enterprises are permitted to hold up to two percent of their assets in tax exempt securities.

OFHEO considered whether to model MRB cash flows on individually or on an aggregated basis. The stress test models MRB cash flows bond-by-bond. Although one modeling approach is to group securities and use weighted average interest rates and terms to calculate future cash flows, OFHEO determined that calculating cash flows individually is simpler. Available computer hardware and software allow the calculation of cash flows on many individual securities in almost the same amount of time it takes to calculate a single cash flow using average rates and maturities for a group. In addition, any decrease in precision that might be introduced through pooling is avoided.

OFHEO next considered whether to calculate interest and principal payments for the MRBs based on each security's actual structure or to use a proxy for calculating bond payments. Interest on MRBs is paid at the bond rate on the principal amount of the bond, but MRBs have different schedules for principal repayment. In some MRBs, the issuer may use principal repayments from mortgages associated with one MRB transaction to retire bonds from another transaction. In many transactions, issuers have substantial discretion to retire bonds early. There is no single source of information on MRB structures, nor is the information readily available from multiple sources.

OFHEO determined that the modeling approach used to calculate cash flows on Ginnie Mae securities would provide a reasonable proxy for cash flows on mortgage revenue bonds. Specifically, the bonds are modeled as passthrough securities, with the underlying mortgage collateral bearing a coupon 75 basis points higher than the bond coupon. Although MRB payments are not passthroughs of mortgage loan payments, the MRB payments are related to the mortgage payments. MRB payments and Ginnie Mae security payments would be affected similarly by loan terminations and by economic conditions. Further, borrowers benefiting from MRB programs are similar to borrowers for the FHA and VA loans that collateralize Ginnie Mae securities, and the loan characteristics are similar. Therefore, the stress test calculates cash flows for MRBs essentially the same way that it calculates cash flows for Ginnie Mae securities. It amortizes the bond principal using loan termination rates for FHA and VA loans that have the maturity of the MRB and coupons equal to the MRB coupon plus a spread.

OFHEO considered whether to design a modeling approach specifically for multifamily MRBs or to model cash flows for single family and multifamily MRBs the same way. The stress test models cash flows for multifamily MRBs as though they were single family Ginnie Mae securities, just as it does for single family MRBs.

Modeling multifamily MRB cash flows according to the structures of the securities is hampered by the same data problems that affect modeling single family MRB cash flows. Therefore, the stress test needs to use a proxy. The choice of proxy is limited. Information on Government-insured multifamily loans is not readily available. Enterprise multifamily MBSs are not an acceptable proxy for multifamily MRBs, because the Enterprises' multifamily loans differ from the loans that collateralize multifamily MRBs, and multifamily MBSs pay differently from multifamily MRBs. Because multifamily MRBs are a very small percentage of each Enterprise's assets and their impact on risk-based capital is minimal, OFHEO determined that single family Ginnie Mae securities would be used as a proxy for multifamily MRBs.

The stress test addresses the credit risk associated with MRBs by applying the haircuts that are tied to the public

[174] For instance, in response to HUD's ANPR, Fannie Mae commented that ''Nearly two-thirds of the [liquid investment] portfolio is rated AAA (or the equivalent), and nearly all (98 percent) of the portfolio is rated at least A (or the equivalent).

credit ratings of the bonds. The haircuts will be in the same amount and will be applied in the same way as haircuts for credit enhancements and non-mortgage investments. Currently, a sizeable majority of the MRBs held by the Enterprises are rated AA and above.

2. Private Label REMICs

The Enterprises own a small amount of REMIC securities that are issued by private sector entities. For most of these securities, the information that would be necessary to calculate cash flows for the REMIC collateral and thus for the REMIC securities is not readily available.

As with mortgage revenue bonds, OFHEO considered whether to model the cash flows of the REMIC securities or to model cash flows using a proxy. The stress test uses a proxy. The stress test models cash flows for private REMIC securities using the same modeling approach as it uses for MRBs. The stress test amortizes the principal of the REMIC securities using the appropriate termination rates for the coupons and maturities.

Data that is needed to project precise cash flows is not readily available. The costs of developing the data and reverse engineering the REMIC securities are not warranted by any incremental refinement that might result. Most of the REMIC securities held by the Enterprises are rated AAA. The credit risk of the private issue REMICs will be taken into account by applying the same haircuts as those used for MRBs.

3. Interests in Partnerships and Joint Ventures

OFHEO decided not to model gains or losses on interests in partnerships or joint ventures, a category that totals less than $200 million, or less than 0.03 percent of Enterprise assets. These assets carry little credit risk but generate tax losses that benefit the Enterprises. OFHEO has determined that projecting cash flows and tax benefits of these assets would create significant additional complexity in the stress test, without having any material impact upon the risk-based capital requirements. Accordingly, the stress test treats these assets as though they remain on the balance sheet with no run-off and no associated income. In the future, if these investments become a larger proportion of either Enterprise's book of business, OFHEO will reconsider how they are modeled in the stress test.

G. Commitments

The 1992 Act specifies that during the stress period the Enterprises will purchase no additional mortgages nor issue any MBS, except that—

> [a]ny contractual commitments of the enterprise to purchase mortgages or issue securities will be fulfilled. The characteristics of resulting mortgage purchases, securities issued, and other financing will be consistent with the contractual terms of such commitments, recent experience, and the economic characteristics of the stress period.[175]

The term ''contractual commitments'' generally refers to binding agreements that the Enterprises enter into with seller/servicers to purchase mortgages or to swap mortgages for MBS. The term also refers to agreements to sell such securities to investors. The total of outstanding purchase or swap commitments at both Enterprises at any point in time is generally in the tens of billions of dollars. The following discussion describes the issues faced by OFHEO in determining the appropriate volume and characteristics of mortgages delivered under commitments.

1. Definition of the Term ''Commitment''

The proposed risk-based capital regulation incorporates, by reference, the definition of ''commitment'' from OFHEO's minimum capital regulation. OFHEO defines ''commitment'' in the minimum capital regulation as follows:

> Commitment means any contractual, legally binding agreement that obligates an Enterprise to purchase or to securitize mortgages.[176]

This definition includes ''mandatory'' and ''optional'' commitments. Mandatory commitments bind the seller to deliver, and the Enterprise to accept, a certain volume of mortgages. Optional commitments are delivery contracts that commit the Enterprises to purchase or swap a specified volume of loans, but do not commit the seller to deliver any loans. The definition includes commitments that do not specify fixed prices or volume, but otherwise legally bind an Enterprise.

Freddie Mac, the only ANPR commenter to address the definition of commitments, recommended that contractual commitments be defined to include only agreements that legally bind the Enterprises to purchase mortgages. According to Freddie Mac, ''[u]nder fundamental contract law, an agreement is only binding if all of its key terms are included and agreed upon.'' Freddie Mac further stated that price and volume are two key terms and that only commitments containing this information are legally binding contracts for the Enterprises. This comment suggests that OFHEO should not model commitment contracts that do not contain price and volume information (e.g., master commitments for cash purchases).

OFHEO has found no reason to adopt a different definition for purposes of computing risk-based capital from that used for computing minimum capital. In both cases, the term should mean any legally binding agreement that obligates an Enterprise to purchase or securitize mortgages. OFHEO does not believe it necessary or appropriate to restrict the definition of the term ''commitment'' by reference to price, volume, and fees, because agreements may be legally binding even when they lack specificity on all terms.[177] It would add unnecessary complexity to attempt to reflect the myriad details of diverse State contract laws in the regulatory definition. Moreover, to do so would be inadvisable in light of Congress' specific concerns regarding the need for capital to support commitments and other off-balance-sheet obligations. For example, in discussing the need for the capital requirements of the 1992 Act, Congress expressed the concern that the risk in off-balance-sheet obligations had not been captured under prior capital standards:

> The capital provisions of the GSEs' charter Acts limit their debt to 15 times their capital unless HUD sets a higher ratio * * * This is unsatisfactory because no capital need be held against the GSEs' $750 billion of off balance sheet guarantees * * *[178]

Recognizing this concern, it would be inappropriate for OFHEO to promulgate a narrow definition that could exempt certain legally binding commitments from the risk-based capital requirement.

Freddie Mac also recommended a definition of commitments that excludes all optional commitments, including those containing price and volume

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[175] 1992 Act, section 1361(a)(3)(A) (12 U.S.C. 4611(a)(3)(A)). The 1992 Act does provide for later amendment of the rule to address new business during the stress period, but not until after this regulation is final. The 1992 Act requires that, within one year after this regulation is issued, the Director of the Congressional Budget Office and the Comptroller General of the United States shall each submit to the Congress a study of the advisability and appropriate form of any new business assumptions to be incorporated in the stress test. Section 1361(a)(3)(C) (12 U.S.C. 4611(a)(3)(C)). Subparagraph 1361(a)(3)(B) (12 U.S.C. 4611(a)(3)(B) authorizes the Director to consider these studies and make certain new business assumptions. However, that subparagraph does not become effective until four years after this regulation is issued.

[176] 12 CFR 1750.2; *See* 61 FR 35610, July 8, 1996 (explanation of definition).

[177] *See* Restatement (Second) of Contracts § 204 (1981).

[178] S. Rep. No. 102–282, at 11 (1992) (referring to the existing capital standard, which the 1992 Act repealed).

information. Specifically, Freddie Mac suggested the following definition:

> Contractual commitment means an obligation of an Enterprise that legally binds the Enterprise to issue securities or purchase mortgages and *legally binds a third party* to purchase securities or deliver mortgages, and that sets forth all terms of the transactions including price, volume, and fees.

(emphasis added).

The phrase ''legally binds a third party'' would define a commitment to include only an agreement that binds the counterparty to deliver mortgages or to purchase securities, thus excluding optional commitment contracts.

OFHEO disagrees with this comment and includes optional commitments in the stress test definition. The 1992 Act is clear on this issue, because it refers to ''commitments of the *enterprise* to purchase * * * or issue'' (emphasis added) but includes no requirement that the commitment bind others to deliver mortgages. Optional commitments obligate the Enterprise to purchase and are optional only for the seller. Therefore, optional commitments fall squarely within the statutory definition.

2. Retained vs. Securitized Mortgages

The proposed regulation specifies that all loans delivered under commitments are packaged into securities (securitized) and sold. This specification avoids requiring OFHEO to predict business decisions by the Enterprises that are highly judgmental and impossible to predict accurately. OFHEO recognizes that in practice the Enterprises make day-to-day decisions to sell or retain loans. However, the simple rule proposed by OFHEO avoids the complexity of attempting to model such business decisions.

ACB commented that ''[a]ny loans not presold by the GSEs should be assumed to be retained in portfolio and carry both the credit and IRR [interest rate risk] exposure.'' OFHEO disagrees with ACB's suggestion, because it would add undue complexity to the stress test. At no time are the Enterprises obligated by the terms of a commitment to retain mortgages in portfolio. Furthermore, retaining these mortgages in portfolio in the stress test would require OFHEO to predict how the Enterprises would finance and hedge the interest rate risk associated with the purchases. These predictions would increase greatly the complexity of the stress test and introduce assumptions about future Enterprise management, which OFHEO, as a general rule, has found inappropriate in a ''no new business'' stress test.

For these reasons, OFHEO determined that proposing that all loans delivered under commitments will be securitized and sold is a reasonable, straightforward approach.

3. Modeling Delivery Percentages

The stress test will provide that, in the down-rate scenario, 100 percent of all loans that the Enterprises are obligated to accept will be delivered and, in the up-rate scenario, 75 percent of those loans will be delivered. As explained below, OFHEO considered the relevant comments on this issue and found the proposed rule to be a reasonable and practical method of estimating the volume of new mortgages that will be delivered in the stress test.

In determining the appropriate percentage, OFHEO looked first to the 1992 Act, which provides that commitments will be ''fulfilled.'' In contractual parlance this term means that the parties will fulfill their contractual obligations under these instruments. Therefore, OFHEO decided to propose a simple rule, based upon estimates of the delivery volumes that would be likely to occur if both parties fulfill those obligations.

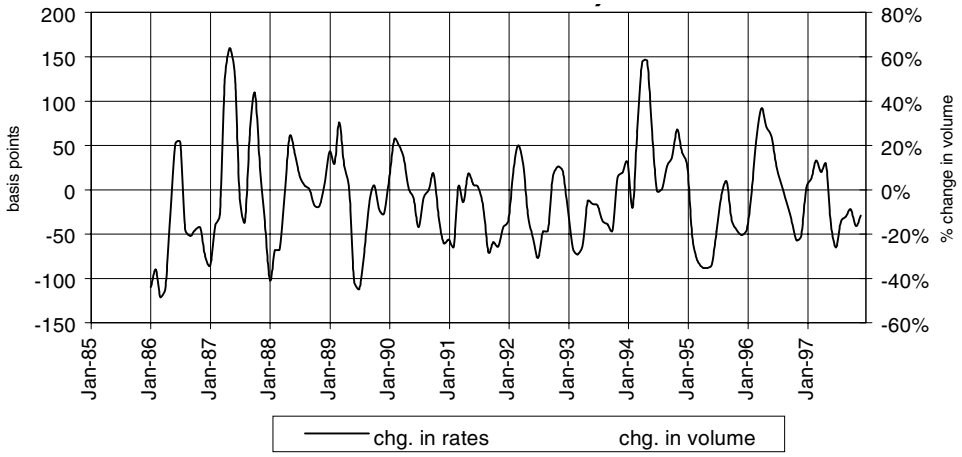
Not all mortgages that the Enterprises are obligated to accept under commitments are actually delivered. Optional commitments obligate the Enterprise to purchase up to a specified dollar amount of mortgages, but do not obligate sellers to deliver any mortgages. They can be fulfilled by both parties even though fewer than all the loans specified in the commitment are delivered. Under a mandatory commitment, the Enterprise is also obligated to purchase a specified dollar value of loans, but the seller fulfills the contract either by delivering the specified volume of loans or by paying a ''pair-off'' fee specified in the commitment agreement. These fees are a form of liquidated damages that, under the terms of mandatory commitments, are payable by sellers who fail to deliver the full amount of mortgages specified in the commitments. Therefore, under either type of commitment, less than all the stated mortgage volume may be delivered.

As mentioned above, the proposed regulation specifies that, in the down-rate scenario of the stress test, 100 percent of loans the Enterprises are obligated to buy or securitize will be delivered under all types of commitments. In the up-rate scenario, 75 percent of those loans will be delivered. This specification reflects the fact that when interest rates decline significantly, the volume of new purchase mortgages and mortgage refinancings generally increases. Therefore, in the down-rate scenario, lenders should have plenty of mortgage volume to meet or fill all commitments. In contrast, when interest rates rise significantly, the demand for mortgages tends to fall. Therefore, in the up-rate scenario, sellers would find it difficult to generate enough mortgages to meet outstanding commitments. Because the proposed regulation provides that all loan deliveries will be made in the first three to six months of the stress period (see section III.G.4., Delivery Timing below), those deliveries are particularly sensitive to short-term changes in interest rates. Thus, the steeply rising rates in the first few months of the up-rate scenario have a significant impact upon delivery percentages. It would be inappropriate, however, to assume that loan deliveries would decline more than 25 percent, given that many of the commitments are mandatory and that existing home purchase contracts will require financing. Lenders will also have a certain volume of outstanding loan commitments with locked rates, most of which would close.

Figure 3 below shows that, during the most recent increase in rates of any significance (the first half of 1994), a three month increase in interest rates of 150 basis points led to a drop in market origination volume of roughly 30 percent. Also, during the 12-year period shown, market volumes never decreased over any three-month period by more than 25 to 30 percent. Because the stress test will include rate changes of 150 basis points or less in the first quarter, the data led OFHEO to conclude that a 75 percent delivery rate would be a reasonable specification for the up-rate scenario of the stress test.

The proposed regulation does not credit the Enterprises with income from ''pair-off fees'' in the up-rate environment for two reasons. First, there is no usable data on the payment of these fees or on the percentage of deliveries under commitments. Therefore, attempting to model these fees would require estimating, with no supporting data, the percentages of loans to be delivered under mandatory, as opposed to optional, commitments. Second, the fees are not always charged by the Enterprises. Therefore, including the fees would require OFHEO to speculate how frequently or under what circumstances the Enterprises would impose them.

Figure 3. Change in Rates vs. Change in Volumes (over 3 months)



In its ANPR comments regarding delivery percentages, Freddie Mac recommended that OFHEO develop an econometric model of delivery percentages for commitments. This model would be based on recent prepayment experience of each Enterprise and the prepayment rates produced by OFHEO's default/prepayment model. The model that Freddie Mac recommended would compute commitment delivery percentages as follows:

1. OFHEO would determine a means of estimating the extent to which sellers would fulfill mortgage purchase commitments by (a) delivering mortgages or (b) paying a pair-off fee without delivering the mortgages.

2. Then, OFHEO would determine a stress period delivery percentage under all commitments to reflect the effect of stress period conditions. Specifically, Freddie Mac suggested that a good approximation of this effect would be the ratio of the sum of the prepayment rate and the purchase-growth rate (rate of increase or decrease in the volume of loans purchased by the Enterprises) during the relevant portion of the stress period to the sum of the prepayment rate and the purchase growth rate during a recent period immediately prior to the stress period. This ratio would be multiplied by a ''baseline'' delivery percentage, which is the normal delivery percentage during times of little interest rate fluctuation. Under this approach, the stress test delivery percentage would be expressed as follows:

$$\text{Delivery \%} = \frac{(\text{ppmt. rates during stress pd.}) + \text{growth rate during stress pd.} \times \text{base-line delivery \%}}{\text{recent ppmt. rates} + \text{recent growth rate}}$$

The stress period growth rate would be zero until such time as OFHEO included new business assumptions in the stress test, and the stress period delivery percentage would not be allowed to exceed 100 percent.

Freddie Mac bases its approach on two assumptions. First, the volume of outstanding commitments at the beginning of the stress period (i.e., the then current volume of outstanding commitments) is assumed to be related to the volume of mortgage purchases that the Enterprises and sellers anticipated at the time they entered into the commitments. Second, the sellers' actual rate of deliveries during the stress period under outstanding commitments is assumed to be closely related to actual mortgage purchase activity during the relevant portion of the stress period.

OFHEO agrees with these assumptions and used them to determine appropriate stress test delivery percentages. OFHEO also agrees that an econometric approach such as that proposed by Freddie Mac might provide a relatively sophisticated representation of what would actually occur under stress test conditions. However, there are insufficient data to construct such a model of commitments at this time. Historical data available to OFHEO do not reveal what percentages of commitments have been delivered. The Enterprises have provided descriptions of commitment types and made statements about their general business practices and the length of and delivery patterns of commitments. However, OFHEO has found available data are inadequate to associate actual mortgage purchases with commitments. Therefore, neither of the two steps in the Freddie Mac proposal currently is possible. There is no source of data to determine a reasonable estimate of pair-off fee payments or to determine a historical baseline delivery percentage.

ACB's ANPR comments suggested that a historically based dropout factor be applied to account for failure to ''make/take delivery by counterparties.'' The lack of historical data regarding actual delivery percentages under commitments limits the accuracy with which such a factor or factors can be calculated. However, OFHEO proposes an approach consistent with the ACB comment. The stress test specifies fixed delivery percentages for commitments in the down-rate and the up-rate scenarios. These percentages are based on historical information, displayed in Figure 3, about mortgage volume in the entire mortgage market during periods when rates have risen and fallen sharply. This information demonstrates that declining interest rates are generally accompanied by or followed shortly by increases in the volume of

the one-year CMT, along with the average margin for ARM loans originated within the past six months, to determine mortgage rates on newly delivered ARMs.

In its ANPR comments, Freddie Mac recommended two methods of modeling loan mix. Freddie Mac recommended that the loan mix of mortgages delivered under commitments could be the same as the loan mix of the Enterprises' outstanding portfolios. Alternatively, Freddie Mac suggested that OFHEO look to historical experience and base the stress period mix on the mix during past up-rate and down-rate environments. Freddie Mac further commented that the mix of mortgages delivered under outstanding commitments should not be modeled based on recent mortgage deliveries. Its rationale was that the capital requirement associated with commitments could vary dramatically because of one-time special purpose transactions. Freddie Mac cited, as an example, the distorting effects created by an Enterprise purchase of a large Cost Of Funds Index (COFI) ARM portfolio representing 30 percent of a quarter's purchases.

OFHEO did not adopt Freddie Mac's first suggestion because OFHEO believed that the mix of loans in an Enterprise's overall portfolio has only a limited relationship to the loans that will be delivered under current commitments. An Enterprise's portfolio at any given time contains loans obtained over many years during periods when economic conditions may have been quite different from the conditions that will exist at the start of the stress test. Current commitments, by contrast, are more likely to reflect Enterprise management's efforts to adjust the mix in its portfolio than they are to reflect the current mix in the portfolio. For these reasons, OFHEO found the current mix of loans at the Enterprises to be an unsatisfactory proxy for the mix of loans to be delivered under current commitments.

Using a two-quarter (versus a one-quarter) period to compute the loan mix addresses Freddie Mac's concern over distortions created by occasional special purpose purchases. However, if large special purpose purchases of unusual mortgages occur frequently, it is appropriate that the stress test reflect some higher-than-usual risk by projecting continuing purchases of such mortgages.

OFHEO also examined Freddie Mac's suggested alternative methodology—basing the loan mix on the ''mix that prevailed'' during prior up-rate and down-rate scenarios. Given the lack of historical data regarding deliveries under commitments, there is no direct evidence of what the experience of those deliveries has been. At best, information might be inferred from data regarding total deliveries, either at the Enterprises or in the market as a whole. However, OFHEO's research has found that, although long term increases in interest rates produce more ARMs and long term decreases produce more FRMs, short term changes in interest rates have little discernable affect on the ratio of ARMs to FRMs that are delivered to the Enterprises.

For these reasons, OFHEO concluded that a more detailed and complex model based upon historical patterns of loan deliveries would be unlikely to improve the stress test's accuracy or sensitivity to risk or yield a significantly different result. OFHEO is confident that the proposed approach reflects a reasonable delivery mix for the stress test and that any fine-tuning that might result from a more complex model would have only an incremental effect. Also, because the proposed regulation specifies that these new loans will not be held in portfolio, they create little interest rate risk for the Enterprises. For all these reasons, OFHEO does not propose the type of detailed model of loan mix contemplated in Freddie Mac's comments.

ACB also commented on loan mix, explaining that the mix of commitments should be ''as of the actual reporting date, subject to adjustment for any demonstrable 'window dressing' practices by the GSEs.'' ACB assumed that data were available to determine what loan mix was specified under outstanding commitments at any point in time. As explained above, those data are not available. OFHEO interpreted ''window dressing,'' to mean attempts that an Enterprise might make to alter temporarily the loan mix in its commitments just prior to the beginning of a particular quarter. OFHEO believes that the proposed approach, which looks to the mix of loans actually delivered over the last two quarters, addresses ACB's concern that an Enterprise might engage in ''window dressing.''

6. ''No New Business'' Rule

World Savings commented in response to the ANPR that the stress test model should reflect ongoing business, not a wind down scenario. The comment stated that the assumption of no new business except for fulfillment of contractual commitments is ''fundamentally flawed,'' because it assumes the Enterprises will be prescient about the magnitude of the financial stress. World Savings commented that this assumption causes the test to underestimate the Enterprises' need for capital, because it causes their portfolios to shrink unrealistically. By contrast, a comment by Professor Yezer of George Washington University advocated placing limits on the size of the Enterprises' portfolios in the stress test. He concluded that ''one needs a model of [Enterprise] response to stress that makes sense in terms of modern financial theory of investment, not passive reaction to adverse changes as contemplated in the proposed rule.''

Both of these comments suggest an alternative approach to new business that cannot be addressed at this time because the approach in the regulation is mandated by section 1361(a)(3) of the 1992 Act.[180] That section requires that the initial risk-based capital regulation assume that the Enterprises take on no new business other than deliveries under existing commitments. After the issuance of the regulation, the 1992 Act requires studies by the Congressional Budget Office and the Comptroller General of the United States of the advisability and appropriate form of any new business assumptions to be incorporated in the regulation. Only after completion of those studies and their submission to the Congress may the Director, after considering them, propose amendments to the regulation that would incorporate new business assumptions during the stress period.[181]

H. New Debt and Investment Rules

During the stress period, an Enterprise invests and borrows, as needed, based on net cash flows. The stress test projects cash inflows and outflows for each month of the stress period. To the extent cash inflows exceed cash outflows in any month, the stress test must specify how an Enterprise employs the excess funds. Conversely, to the extent that cash outflows exceed cash inflows in any month, the stress test must specify how an Enterprise obtains the funds to cover the cash deficit.

The 1992 Act provides no specific guidance for new debt issuance or new investments during the stress test. OFHEO sought new debt and new investment rules that would alter as little as possible the credit and interest rate exposures of an Enterprise generated by its initial asset, liability, and derivative positions.

The proposed approach provides that all new debts and investments are short-

[180] 1992 Act, section 1361(a)(3) (12 U.S.C. 4611(a)(3)).

[181] 1992 Act, section 1361(a)(3)(B)–(D) (12 U.S.C. 4611(a)(3)(B)–(D)).

term instruments. More specifically, OFHEO proposes that the Enterprises fund all monthly net cash outflows during the stress test by issuing six-month discount notes. OFHEO also proposes that excess funds will be invested at the six-month Treasury bill rate in instruments that mature one month later.

1. Rationale for New Debt and New Investment Rules

The purpose of a ''no new business'' stress test is to subject an Enterprise's business at the beginning of the stress period to adverse conditions, without introducing during the stress period any business responses to deteriorating business conditions that would tend to increase or decrease risk. Consistent with this purpose, the proposed new debt and investment rules are designed to project the effects during the stress period of specific stressful circumstances on the Enterprises, given the risks embodied in their business positions at the start of the stress test, while minimizing the introduction of any new risks.

Accordingly, the stress test uses simple rules for the issuance of debt or the investment of liquidity. OFHEO intentionally does not propose to predict what asset-liability management decisions an Enterprise might make, predictions that would be difficult in any event.[182]

The hazards of predicting the response of financial institutions to stressful conditions are well illustrated by the behavior of the thrifts during their financial crisis in the 1980s. While some institutions sought to limit or reduce their risks in that difficult environment, others made choices that greatly increased risk, in effect gambling that a fortunate turn of events would be their best chance of financial salvation. These choices largely determined the fate of the institutions. Similarly, incorporating activities that project the Enterprises's responses to the duration or severity of economic conditions during the early part of the stress period, while these conditions are deteriorating rapidly, could profoundly affect the Enterprises' financial performance in the stress period.

For these reasons, the stress test makes no provision for an Enterprise to rebalance its portfolio as its asset and liability positions evolve during the stress test. The Enterprises are exposed to interest rate risk principally because changes in interest rates cause changes in the market (and economic) values of their long-term, fixed-rate assets and liabilities, and of their derivative contracts. These changes in value are reflected in subsequent accounting statements of earnings and net worth.

If an Enterprise's asset, liability, and derivatives positions are well matched, the effects will be minimal. But if, for example, an Enterprise were to fund long-term, fixed-rate mortgages with short-term debt, then an increase in market yields would cause the value of the mortgages to fall, but the value of the short-term debt would be little changed. In subsequent periods, interest income on the mortgages would be unaffected, but interest expenses would be higher because new debt would need to be issued at the new higher interest rate. Earnings and equity would suffer. Conversely, a fall in market yields would increase the value of the mortgages, and that higher value would be reflected in subsequent earnings and equity gains. If an Enterprise were to fund short-term assets with long-term, fixed-rate debt, its debt would change in value, but its assets would not, producing the opposite effect.

If changes in interest rates continue over a period of time, then a decision to issue long-term debt or purchase long-term assets in the middle of the stress period would create a new source of changes in value over the remainder of the period. The effects of the change in interest rates on future earnings and equity would then reflect the changes in value of both the original positions and the new long-term debt or assets.

In the proposed stress test, interest rates change substantially and continuously during the first year of the stress period and then are constant in the last nine years. If an Enterprise were projected to issue long-term debt or purchase long-term assets during the first year, the new investments would change in value during the remainder of the year and affect subsequent earnings and equity. Such an approach would distort the stress test's evaluation of starting risk positions.

The proposed rule avoids these problems by making all new debt and investment short-term instruments. Investments are made in Treasury bills to avoid introducing credit risk; new debts are in the form of discount notes. Maturities of six-months were chosen as a representative short term.[183]

2. Analysis of ANPR Comments

In the ANPR, OFHEO posed several questions related to new debt and investments during the stress period. HUD and ACB recommended in their comments that OFHEO develop an econometric model of Enterprise funding decisions. OFHEO believes, however, that it would be inappropriate to build such a model. The factors that would have to be incorporated into such a model would require OFHEO to make complex judgments about the decisions an Enterprise's management might make in response to future economic conditions. HUD's comment that ''OFHEO may be able to base modeling of GSE liability management * * * on presumptions concerning how GSEs would formulate and exercise broad financial management objectives during a winddown'' would require similar judgments. ACB also commented that ''excess cash balances should be assumed to be deployed to minimize remaining interest rate risk exposure since the costs of such a hedging strategy are zero.'' OFHEO determined that this approach could change the risk profile of an Enterprise during the course of stress period and is, therefore, inappropriate for the stress test.

Freddie Mac also addressed the question of new debt in the stress test. Freddie Mac proposed that OFHEO assume the Enterprises would generally adhere to their respective asset and liability management principles in a stress test environment. More specifically, the Enterprises would rebalance their portfolios of assets and liabilities during the stress period, in an attempt to maintain a specific relationship between the net effective maturity and net callability of assets and liabilities. Freddie Mac further suggested that OFHEO should use a simple rule that includes this concept for the issuance of new debt in the stress test. As a possible rule, Freddie Mac offered the following example: 30 percent short-term and 70 percent long-term debt in the up-rate scenario and 70 percent short-term and 30 percent long-term debt in the down-rate scenario. The intent of the stress test is, however, to test the ability of an Enterprise's initial asset and liability mix to survive stressful conditions. Therefore, OFHEO preferred an approach that did not

[182] In a stress test that incorporates new business, the context would be different. Should OFHEO choose to incorporate new business in a later regulation, a different approach to asset-liability management during the stress period could be appropriate. See 1992 Act, section 1361(a)(3)(C) (12 U.S.C. 4611(a)(3)(C)).

[183] Recurring patterns in cash flows can cause an Enterprise to hold substantial volumes of new six-month investments at the same time that it has substantial volumes of new six-month debt outstanding. This creates an unnecessary balance sheet expansion. A more realistic solution would be to assume that maturities of new debts and investments were spread across a variety of terms less than one year. OFHEO proposes to approximate that result by assuming that any outstanding new six-month investments are redeemed at par at the end of each month.

actively alter the consequences of the interest rate risk exposure inherent in the Enterprises' business at the beginning of the stress period.

At HUD's suggestion in its comments on the ANPR, OFHEO reviewed the role of new debt in the wind down scenarios described in HUD's *1987 Report to Congress on FNMA,* issued on September 27, 1989. Although OFHEO agrees with HUD that there is a close connection between investing cash, hedging activities, and liabilities, OFHEO believes that the purpose of the ''no new business'' stress test is to project the results of existing risk positions in stressful environments. This approach differs significantly from HUD's 1987 wind down scenarios, which were designed to project Fannie Mae's performance during an intentional wind down of Fannie Mae's mortgage portfolio in preparation for a hypothetical privatization of that Enterprise.

I. Operating Expenses

Operating expenses include non-interest costs, such as those related to an Enterprise's salaries and benefits, professional services, property, and equipment. The operating expenses of each Enterprise comprise a relatively small portion of their overall expenses. For instance, in 1997, Freddie Mac's interest-related expenses were $10.6 billion, while its operating expenses were $495 million. Similarly, Fannie Mae's interest-related expenses were $22.4 billion, while its operating expenses were $636 million that year.

The 1992 Act is silent on how operating expenses should be treated in the stress test. Nevertheless, the legislative history states that the Director should exercise discretion about variables such as the Enterprises' operating expenses, provided that they are ''reasonable and to the extent possible based on historical data.'' [184] In addition, the stress test's treatment of operating expenses is guided by the 1992 Act's ''no new business'' requirement.[185] That provision requires OFHEO to project the income and expenses associated with the existing business positions of the Enterprises over a ten-year period. The purpose of the ''no new business'' requirement is for the stress test to capture the risks of an Enterprise's existing assets, liabilities, and off-balance sheet obligations as of the beginning of the stress period. It is not intended to represent any combination of events that might occur in the actual course of an Enterprise's business activities.

In the proposed regulation, operating expenses decline during the stress period in direct proportion to the decline in the volume of each Enterprise's total mortgage portfolio (i.e., the sum of the outstanding principal balance of its retained and sold mortgage portfolios). The stress test first projects how an Enterprise's mortgage portfolio decreases during the stress period on a monthly basis. After determining the percent of these assets that remain at the end of any month during the ten-year stress period, OFHEO simulates the reduced operating expenses in each month by multiplying this percent by one-third of the amount of the Enterprise's operating expenses in the quarter immediately preceding the start of the stress test. This computation is used to determine the Enterprises' operating expenses for each month of the stress period. As described in more detail in this section below, under this approach, the expense reduction pattern for the up-rate scenario will differ from the down-rate scenario, and the pattern within each scenario will vary depending on changes in the characteristics of an Enterprise's total mortgage portfolio.

In the ANPR, OFHEO raised several questions about how the stress test should model operating expenses. These issues are considered below.

OFHEO first considered whether there should be any reduction in operating expenses during the stress period. The stress test should include such a reduction because many of the Enterprises' operating expenses are tied to the size of their mortgage portfolios. Both commenters on this issue, Freddie Mac and ACB, supported this view.

OFHEO next considered whether there should be a variable or straightline reduction in operating expenses. OFHEO determined that a variable reduction pattern would be more appropriate. The underlying characteristics of mortgages held or guaranteed by an Enterprise or the interest rate conditions of the stress period would substantially affect the rate of reduction in outstanding mortgage balances. Because a large portion of expenses are directly tied to outstanding loan balances, a variable reduction based on those balance patterns will better correspond with the cost reductions that would occur under the stress test scenarios.

Notwithstanding this general approach, OFHEO notes that expenses in some categories are not closely tied to current loan balances. These expenses might be expected to change at different rates from loan balances in a stressful no-new-business environment. As Freddie Mac commented in response to the ANPR, a large portion of its operating expenses are associated with either new business or long-term research and development, including product and systems development, and so might be reduced more dramatically under a no-new-business assumption. Conversely, Freddie Mac stated that some other operating costs that are associated with ongoing costs of managing the mortgage portfolio are relatively fixed, i.e., they are independent of the size of the portfolio. On balance, tying expenses to loan balances will produce a reasonable approximation of an Enterprise's costs in the stress test scenarios.

The proposed approach to modeling operating expenses differs from the recommendations made by ACB and Freddie Mac. Rather than a variable approach, these commenters favored a model applying a straightline reduction in operating expenses. Freddie Mac commented that a straightline approximation is sufficient, because the resulting capital requirement should depend primarily on the present value of the operating expenses and not on the exact timing of those expenses. However, OFHEO believes it is appropriate to adopt an approach that more precisely takes timing into consideration, because the timing of expenses affects an Enterprise's performance during the stress test and the resulting risk-based capital requirement. Furthermore, a straightline approach still requires a basis on which to determine the rate of expense reduction. The proposed approach simultaneously takes timing into account and determines the overall rate of reduction.

The next issue concerned whether the model should reflect decisions that might be made by an Enterprise if it was intentionally winding down its business. On that issue, HUD recommended two alternative approaches: either that OFHEO model the behavior of an Enterprise on issues such as liability management, dividend policy, and operational management as if it were aware that a wind down is in effect, or that OFHEO proceed in a ''more formalistic fashion,'' i.e., without regard to whether they did or did not know. OFHEO analyzed this issue, not only within the context of operating expenses, but also as it relates to the underlying concepts of the stress test and many of its components. OFHEO determined that it would be inconsistent with the 1992 Act and the overall purposes of the stress test for the

[184] H.R. Rep. No. 102–206, at 65 (1991).

[185] 1992 Act, section 1361(a)(3)(A) (12 U.S.C. 4611(a)(3)(A)).

model to attempt to reflect decisions that would be made by an Enterprise that was intentionally winding down its operations. Instead, the stress test applies the alternative approach discussed by HUD in which an Enterprise would not know that a wind down was in effect. As discussed earlier, this approach is appropriate because the stress test is intended to capture the actual risks of an Enterprise's existing business as of the beginning of the stress period rather than events that might occur during the actual course of its business.

OFHEO next considered whether it is appropriate to treat categories of operating expenses differently. OFHEO has determined that disaggregating the operating expenses into several categories would add needless complexity without providing any significant corresponding benefit to ensuring an Enterprise's capital adequacy. While some expense categories might reasonably be assumed to decline faster than the mortgage portfolio, some others might decline more slowly, and some might be expected to increase. OFHEO agrees with ACB and Freddie Mac that since operating expenses constitute a relatively small portion of an Enterprise's overall costs, they should not be subject to complicated modeling. Accordingly, OFHEO proposes to consider operating expenses in a single category rather than disaggregating them into distinct categories.

Finally, OFHEO considered whether the operating expenses of each Enterprise should be modeled in the same manner. Freddie Mac recommended that instead of distinguishing between the Enterprises, the stress test should reduce operating expenses of each Enterprise in the same manner. Freddie Mac stated that any attempt to make fine distinctions between how each Enterprise might actually manage its operating expenses during the stress period could lead to extensive analysis that ought to have little affect on the overall capital requirement but, could increase the danger of different capital treatment for each Enterprise based on differences in accounting treatment of expenses.

OFHEO agrees with Freddie Mac's recommendation not to distinguish between the Enterprises with respect to modeling operating expenses. A fundamental concept of the risk-based capital requirement is that the stress test establish a single set of rules that apply equally to both Enterprises. It would be inappropriate to establish a different stress test for each Enterprise. As a result, differences in operating expenses during the stress test between the Enterprises will reflect only differences in initial expense levels and mortgage portfolio composition, not any projected behavioral differences.

J. Dividends and Other Capital Distributions

1. Introduction

The definition of a ''capital distribution'' in the 1992 Act includes the payment of common stock dividends, preferred stock dividends, and the repurchase or retirement of shares of stock.[186] In recent years, both Enterprises have consistently paid significant amounts of dividends and have repurchased significant amounts of common stock.

The 1992 Act directs OFHEO to consider dividends in the stress test. When an Enterprise makes a capital distribution and the amount of that distribution, however, are not specified in the 1992 Act. The only requirement is that dividends should be consistent with the stress test environment.[187] Because capital distributions decrease equity, the more distributions an Enterprise makes during the stress test period (or during a real-life stressful environment), the more likely that an Enterprise will fail to meet its risk-based capital requirement.

2. Statutory Provisions

The 1992 Act and the Charter Acts determine the authority of the Enterprises to make capital distributions.[188] Under these statutes, an Enterprise may make a capital distribution without restriction when the Enterprise would remain adequately capitalized following the distribution.[189] In all other circumstances, a capital distribution is prohibited outright or requires the approval from the Director of OFHEO.

Prior approval by the Director is required when an Enterprise is undercapitalized or if a capital distribution would cause the Enterprise to be undercapitalized.[190] The legislative history of this requirement makes clear that, while approval in these circumstances can be granted, such approval ''should be the exception and not the rule.'' [191] The Director's prior approval also is required when an Enterprise is significantly undercapitalized; however, the 1992 Act places conditions on the granting of such approval. In those circumstances, the Director may only approve a distribution if the Director determines that it will: (1) Enhance the Enterprise's ability to meet its capital requirements, (2) contribute to the Enterprise's long term safety and soundness, or (3) is otherwise in the public interest.[192] No approval may be granted for a distribution that would cause the Enterprise to be significantly undercapitalized or critically undercapitalized.[193]

This statutory structure draws a clear distinction between an Enterprise that fails to meet its risk-based requirement and one that fails to meet its minimum capital requirement. When an Enterprise fails to meet the risk-based capital requirement, the Director has full discretion to grant or deny approval for a capital distribution. However, when an Enterprise fails to meet the minimum capital requirement, the Director's discretion is limited. Moreover, the Director is prohibited from approving a distribution that would cause the Enterprise to fail to meet the minimum capital requirement.

3. Proposed Approach

The proposed regulation provides that during the stress period:

- When paid, dividends are paid at rates consistent with historical experience;
- Dividends are paid on common stock when the Enterprise meets the risk-based capital requirement and the minimum capital requirement;
- Dividends are paid on preferred stock when the Enterprise meets the minimum capital requirement; and
- No dividends are paid when the Enterprise does not meet or would not

[186] 1992 Act, section 1303(2)(A) (12 U.S.C. 4502)(A)). The notable exception is the repurchase of shares for employee stock ownership programs under section 401 of the Internal Revenue Service Code of 1986.

[187] 1992 Act, section 1361(b)(2) (12 U.S.C. 4611(b)(2)). ''Characteristics of the stress period other than those specifically set forth in subsection (a), such as prepayment experience and dividend policies, will be those determined by the Director, on the basis of available information, to be most consistent with the stress period.''

[188] Fannie Mae's Charter Act and Freddie Mac's Corporation Act collectively are referred to as the ''Charter Acts.''

[189] In general, an Enterprise is considered ''adequately capitalized'' when it meets both the risk-based and minimum capital levels. It is ''undercapitalized'' when it does not meet the risk-based capital level, but does meet the minimum capital level. It is ''significantly undercapitalized'' when it does not meet either the risk-based capital level or the minimum capital level, but does meet the critical capital level. *See* section 1364 of the 1992 Act (12 U.S.C. 4614), and section 303(c)(1) of the Charter Act and section 303(b)(1) of the Corporation Act.

[190] Section 303(c)(2) of the Charter Act and section 303(b)(2) of the Corporation Act.

[191] S. Rep. No. 102–282, at 24 (1992).

[192] 1992 Act, section 1366(a)(2) (12 U.S.C. 4616(a)(2)).

[193] 1992 Act, sections 1365(a)(2); 1366(a)(2)(A) (12 U.S.C. 4615(a)(2); 4616(a)(2)(A)).

after payment of the dividend meet the minimum capital requirement.

In making this proposal, OFHEO emphasizes that there are significant differences between establishing a dividend payment policy for the risk-based capital requirement and acting on a dividend approval request from an Enterprise that is no longer adequately capitalized. Accordingly, provisions of the stress test which provide for the payment of dividends by an undercapitalized Enterprise in some circumstances and not others should not be interpreted as an indication of how OFHEO will act on any specific dividend approval request. In practice, OFHEO will evaluate any request for approval of a dividend payment on the basis of a case-by-case analysis of all the relevant facts and circumstances.

a. Preferred Stock

Under the proposed regulation, dividends are paid on preferred stock during the stress period when the Enterprise meets its estimated minimum capital requirement. Preferred stock dividends are based on the coupon rates of the issues outstanding. The coupon rates for any issue of variable rate preferred stock is calculated using projections of the appropriate index rate.

To determine whether the Enterprise meets the minimum capital requirement, the stress test computes the minimum capital level each month by applying the appropriate leverage ratios to all assets (2.50 percent) and off-balance sheet obligations (0.45 percent). OFHEO notes that interest rate and other off-balance sheet contracts also affect the minimum capital number.[194] However, incorporating these features in the calculation would require OFHEO to compute the credit equivalent amount of interest rate and foreign exchange contracts, which would add unnecessary complexity but provide little corresponding benefit. Accordingly, for purposes of determining dividend payouts in the stress test, OFHEO believes that the approach described above provides a reasonable approximation of the minimum capital calculation.

As noted above, preferred stock dividends are paid in some circumstances in which common stock dividends are not paid. The stress test includes this distinction based on the recognition that when a corporation issues preferred stock, it is making a higher level of commitment to those investors than when it issues common stock. Preferred stockholders have a first claim on distributions. Therefore, failure to pay dividends on both classes of stock likely would have greater repercussions on an Enterprise's funding costs and ability to attract new equity capital than would a failure to pay common stock dividends while preferred stock dividends were maintained. Accordingly, when an Enterprise is classified as undercapitalized, the stress test pays preferred stock dividends, but not common stock dividends.

b. Common Stock

Under the proposed regulation, dividends are paid on common stock during the first four quarters of the stress period. The stress test specifies that common stock dividends cease after that, reflecting the strong likelihood that an Enterprise would not meet the risk-based capital requirement during the final nine years of the stress period. The rate at which dividends are paid is based on the trend in the Enterprise's earnings. If earnings are positive and increasing, dividends are paid based at the same dividend payout ratio as the average payout ratio of the four quarters preceding the stress test. Otherwise, dividends are paid based at the preceding quarter's dollar amount of dividends per share. Dividends would be cut off before the end of the first year if an Enterprise failed to meet its estimated minimum capital requirement.

OFHEO believes this rule is based on a reasonable representation of when an Enterprise will no longer be adequately capitalized. The conditions of the stress test are sufficiently stressful to assure that the Enterprise would be undercapitalized by the end of the first year of the stress period. By that time, an Enterprise's portfolio would have been subjected to very large interest rate increases or decreases. If, at that point, it was subjected to those same large increases, i.e., a total of up to 1200 basis points over two years, it is reasonable to assume that the Enterprise would be undercapitalized. The Enterprise would have to withstand more severe credit losses because the hypothetical stress tests would also compound declines in house prices associated with the actual stress test. Estimating with greater accuracy whether an Enterprise would meet its risk-based capital requirement at any time during the stress period is inherently difficult. This would require simulating a series of hypothetical ten-year stress tests, the last of which would involve generating cash flows extending ten years beyond the end of the actual stress period. This would add great technical complexity to the stress test without providing any meaningful benefit.

c. Other Types of Capital Distributions

The proposed regulation does not provide for any other types of capital distributions, such as repurchases of common stock, or redemption of preferred stock. Although the Enterprises have both repurchased a significant number of shares of their own common stock in the past several years, the stock buybacks were irregular events based on the current share price, expected return on potential investments, and the profitability of each Enterprise. The Enterprises have made no firm commitment to investors to continue share repurchases. Furthermore, OFHEO believes that the stress test environment would not be conducive to share repurchases.

4. Analysis of ANPR Comments

In response to questions in the ANPR, Freddie Mac emphasized that any assumptions that OFHEO makes regarding dividend payments must be consistent with the 1992 Act, particularly the provisions related to how capital classifications affect dividend payments. With regard to preferred stock dividends, Freddie Mac recommended that OFHEO assume that an Enterprise pays dividends on such stock so long as it satisfies its minimum capital requirement and discontinues preferred dividends thereafter. With regard to common stock dividends, Freddie Mac recommended that OFHEO assume that an Enterprise pays a constant dividend payout ratio on common stock until earnings become negative, at which time common stock dividends would be discontinued.

The proposed regulation, which ties dividend payouts to capital classifications, is consistent with the 1992 Act and is generally consistent with Freddie Mac's recommendations. More specifically, OFHEO agrees with Freddie Mac's recommended approach for paying preferred stock dividends until an Enterprise's capital falls below the minimum level. OFHEO believes this treatment of preferred stock dividends properly reflects the high level of commitment of the Enterprises to investors in their preferred stock.

In addition, eliminating common stock dividends after an Enterprise becomes undercapitalized is roughly equivalent to Freddie Mac's recommendation to cut off common stock dividends when an Enterprise's earnings turn negative. However, while Freddie Mac would reduce dividends proportionately if earnings decline, the proposed regulation provides for the

[194] 12 CFR 1750.4.

payment of a constant dollar amount. OFHEO believes the payout rule in the stress test appropriately reflects the current dividend payout history of the Enterprises. Both Enterprises have made fairly strong commitments to investors regarding dividend payouts, and have been slow to lower their dividend payments in the face of declines in earnings.

ACB recommended that dividends be suspended immediately in the stress test, since the Enterprises are assumed to be in a wind down and shareholders would be strictly residual claimants. ACB's recommendation to suspend all dividends immediately is not consistent with the apparent intent of the 1992 Act, which specifically mentions dividend policies and directs OFHEO to consider dividend policies that would be ''most consistent with the stress period.''[195] As discussed above, OFHEO believes that the proposed capital distribution rule is consistent with the stress test period. Furthermore, the stress test would fail to incorporate a likely source of capital depletion that would affect an Enterprise in a real-life stressful environment if all capital distributions were eliminated during the entire stress test period.

ACB's comment that shareholders would be strictly residual claimants, which implies that the stress test is a liquidation situation, is not consistent with the concepts underlying the stress test. A wind down or ''no new business'' stress test is not the equivalent of a liquidation. Rather, it is a test of how much capital an Enterprise would need to survive.

K. Other Off-Balance Sheet Guarantees

In addition to guaranteeing mortgage-backed securities they issue as part of their mainline business, the Enterprises occasionally guarantee other securities. Such guarantees are referred to as ''other off-balance sheet (OBS) guarantees.'' Examples of other OBS guarantees include guarantees of tax-exempt multifamily housing bonds issued by state and local government agencies, Enterprise-issued whole loan REMIC securities to security, and private label (non-GSE-or GNMA-issued) REMIC securities. In general, an Enterprise's guarantee is protected by other credit enhancements, including reserve funds, insurance arrangements, and/or subordinated security tranches.

For the following reasons it is not now feasible to simulate the detailed financial impact on an Enterprise of other OBS guarantees over the 120 months of the stress period. First, the mortgage collateral for such securities is often dissimilar from the Enterprise's mortgages on which the stress test's mortgage performance models are based. Second, current data on the status of the underlying collateral is difficult to obtain. Third, the structures of the securities and the nature of credit enhancements vary, requiring the individual modeling of each guaranteed security, which would, at this time, require an inordinate amount of resources.

The stress test utilizes a proxy for the detailed modeling of the impact of other OBS guarantees on the amount of starting capital that an Enterprise would need to just maintain positive capital during the stress period. The proxy treatment consists of multiplying the outstanding balance of all other guarantees at the beginning of the stress period by .0045, and adding the result to the amount of starting capital calculated for all other aspects of an Enterprise's operations. The multiple .0045 corresponds to the minimum capital requirement associated with these other OBS guarantees.

L. Calculation of the Risk-Based Capital Requirement

1. Proposed Approach to Calculating Capital

The 1992 Act requires an Enterprise to meet the risk-based capital requirement. To determine this requirement, the statute establishes a two-step process. The first step is to determine the amount of capital that an Enterprise needs to just maintain positive capital during a ten-year period of economic stress. The second step is to increase that amount of capital by another 30 percent to capture management and operations risk.

OFHEO proposes to use a present value approach to calculate the capital that an Enterprise needs to just maintain positive capital during the stress test. Once the stress test has projected the capital of an Enterprise at the end of every month in the stress period, the capital calculation process discounts the monthly capital balances back to the start date of the stress period. The Enterprise's starting capital is then adjusted by subtracting the lowest of the discounted capital balances to account for the smallest capital excess or largest deficit (subtracting a negative number in the case of a deficit). The discount factor used to discount a monthly capital balance is based on after-tax borrowing or investing yields (as appropriate) for that month and all previous months during the stress period.

After the stress test ascertains the amount of capital necessary to just maintain positive capital during the stress test, it then multiplies that amount by 1.3 to arrive at the risk-based capital requirement.

2. Justification for Using a Present Value Approach

The 1992 Act requires OFHEO to determine the amount of capital that is sufficient for an Enterprise to just maintain positive capital during the ten-year stress period. However, when an Enterprise has more (or less) capital than it needs to just maintain positive capital, the law does not specify the procedure for calculating how much capital it would need to just maintain positive capital.

In analyzing the best method to calculate capital during the ten-year stress period, OFHEO considered two approaches: (a) the present value approach, described above, and (b) an ''iterative approach'' in which the stress test would be run multiple times with hypothetical adjustments made to each Enterprise's balance sheet prior to each run. The present value approach more efficiently produces results comparable to the iterative approach. Both approaches recognize that a dollar today is worth significantly more than a dollar ten years from now, because the dollar can be invested so as to return more in a later year.

Under the iterative approach, the capital calculation process begins by running the stress test on the basis of an Enterprise's actual assets, liabilities, net worth, and off-balance sheet items as of a given date. The first stress test run would be used to identify the lowest capital balance that the Enterprise has during the stress period. Then, based on that result, adjustments would be made to the starting capital and the assets and/or liabilities on the Enterprise's balance sheet. The goal of these adjustments is to construct a starting position book of business that, when subject to the stress test, will result in the Enterprise just maintaining positive capital during the stress test. If a run results in the Enterprise's capital reaching a minimum point greater than zero, OFHEO would reduce the starting capital in order to move the minimum point down toward zero in the next run. If a run resulted in the Enterprise's capital reaching a minimum point less than zero, then OFHEO would increase the starting capital in order to move the minimum point up toward zero in the next run. If the second run did not achieve the desired result, successive runs would be made following further

[195] 1992 Act, section 1361(b)(2) (12 U.S.C. 4611(b)(2)).

adjustments to the starting position balances.

OFHEO is proposing the present value approach rather than the iterative one based on the following considerations. The present value approach is comparatively simple and easy. It will not require explicit changes to an Enterprise's actual assets, liabilities, net worth, and off-balance sheet items as they exist at the start of the stress test, and it achieves results comparable to the iterative approach. It achieves these results because the discount factors used in the present value calculations, which calculate the surplus or deficit of starting capital, are consistent with the effects during the stress period of the balance sheet adjustments required by the iterative approach. The discount factors reflect the yields on additional debt or investments offsetting necessary changes in starting capital. For example, consider a scenario in which an Enterprise holds more starting capital than necessary to maintain positive capital throughout the stress period. Balance sheet adjustments made for the final iteration would likely involve substituting for the surplus starting capital an equal amount of debt. Discounting the appropriate monthly capital balance during the stress period, using stress period yields, results in a comparable amount.

Based on these considerations, the present value approach would be a more appropriate methodology for carrying out the purposes of the statute. The iterative approach would add needless complexity and require OFHEO to make changes to the balance sheets of the Enterprises. Each iterative run, would be based on hypothetical representations of the Enterprise's position. The present value approach eliminates the need for these artificial adjustments and the unwarranted complexity that the iterative approach's adjustment process would entail.

Under the present value approach, it is necessary to determine the appropriate monthly discount rates. In determining the monthly rates, OFHEO sought a set of discount rates that would reflect the time value of money to an Enterprise during the stress period. Accordingly, the discount rates applied in the stress test are computed as an after-tax rate. Such an after-tax rate reflects the fact that any borrowing necessary to fund an Enterprise's business activities would be deductible for income tax purposes. Conversely, any additional earnings would be subject to income taxes.

These discount rates are intended to reflect the fact that interest rates will differ dramatically between the rising and falling rate scenarios and at given times in each scenario. When an Enterprise is borrowing new funds during the stress period, the marginal effect that a change in its cash position in one month will have on its equity in a subsequent month will be reflected by its after-tax cost of borrowing during the intervening period. Alternatively, if the Enterprise is a net investor in a given month, the marginal effect is reflected by its after-tax earnings on new investments in Treasury bills.

This discounting procedure will reasonably relate changes in capital to changes in an Enterprise's risk position. For example, if an Enterprise were to take an incremental risk position that resulted in an incremental loss during the first month of the stress period, that loss would compound during the stress period at the Enterprise's after-tax borrowing or investment rate. If an Enterprise is borrowing, this one month's incremental additional loss would require additional borrowings during the balance of the stress period. These additional borrowings would create additional interest payments for which further borrowing would be required. If the Enterprise is investing, the loss would leave smaller amounts to be invested, which would earn less interest. After applying the discount factors, the change in each future month's capital would equal the initial loss. Thus, the change in the estimated amount of the first month's incremental capital needed to just maintain positive capital during the stress test would also equal that initial loss. More generally, if a new asset were to generate a stream of losses over the course of the stress period, the amount of starting capital needed would rise by the present value of this stream of losses.

IV. Technical Supplement

A. Purpose and Scope

This technical supplement provides detail on the specification and estimation of statistical (econometric) models for mortgage performance, and how those statistical models are applied in the proposed risk-based-capital stress test. The supplement focus is on technical aspects of the statistical modeling. This focus includes: theoretical considerations, sources and uses of historical data, functional forms for statistical models, development of explanatory variables for the statistical analyses, results of statistical model estimations, and application of the resulting statistical equations to predict mortgage performance in the stress test. Each of the following parts of this supplement covers these elements for its respective part of mortgage performance. The topic areas covered here are:

- Single Family Default/Prepayment,
- Single Family Loss Severity,
- Multifamily Default/Prepayment,
- Multifamily Loss Severity, and
- Property Valuation.

An additional, and important component of this Supplement is the description of how the statistical models of mortgage performance are reasonably related to the benchmark loss experience (BLE) identified in NPR1. The first way in which OFHEO reasonably relates the mortgage performance component of the stress test to the BLE is through application of housing market conditions that represent the conditions of that experience. Those conditions include house price growth rates, rent growth rates, and rental vacancy rates. The next part of this supplement, Property Valuation, details how OFHEO developed these variables for use in the stress test. How these variables are actually used in the stress test is covered in the section 3.5, Mortgage Performance, of the Regulation Appendix, although some general information is provided here.

The second way in which mortgage performance in general, and credit losses in particular, are related to the BLE is through calibration mechanisms that adjust statistically derived equations to match the actual loss rates of the BLE. These adjustments are required because the statistical equations are estimated over a wide range of data, of which the benchmark experience is only a small part. To reasonably relate mortgage losses to the BLE, the stress test imposes housing market conditions from the time and place of the BLE. In addition, the stress test adjusts defaults and severities by factors that cause the test to replicate critical aspects of the BLE when the statistical models are applied to benchmark loans. The methods of deriving these calibration adjustment factors are described in the Single Family Default/Prepayment and Single Family Loss Severity parts of this Supplement.

B. Single Family Default/Prepayment

1. Introduction

To develop the stress test model of single family default and prepayment rates, OFHEO analyzed the historical experience of Enterprise single family loans from 1979 through 1995. This experience is defined by an econometric model in which probabilities of default and prepayment in each time period are

determined jointly using a multinomial logit specification. The theoretical foundation used for choosing variables to use in the model is financial options theory. This is the predominant theory used in mortgage performance research. It suggests that borrowers make choices regarding maintaining or terminating mortgages based upon the relative financial value of those choices. In this context, each borrower has the choice, in each time period, to make the payment and maintain the mortgage, pay off the mortgage in full (a prepayment), or stop making payments and default.

Owing to the large amount of data available to estimate this model, OFHEO chose techniques that captured the essence of individual borrower choice, consistent with efficient use of computer resources. These techniques start with estimating separate sets of default and prepayment equations for fixed-rate mortgages (FRMs) and for adjustable-rate mortgages (ARMs).[196] A third set of equations was estimated to project the performance of less-prevalent single family loan types relative to the dominant 30-year fixed-rate mortgages. The second method of capturing borrower choice characteristics while limiting computer resources was to use random samples of fixed-rate loan products, rather than attempting to estimate the model on all loans ever purchased by the Enterprises. The third method was to use quarters rather than months as the observation time period. This time period is important because each loan enters the analysis in the form of an event history: every time period for which the loan was active provides an observation for the statistical analysis. Using quarters reduces the number of observations used in the statistical analysis without losing any essential detail regarding borrower choices. The last method of maintaining the quality of individual loan analysis while limiting computer resources was to use a weighted regression scheme, so that all loans do not need to enter the analysis individually. All loans with the same characteristics are treated as one loan, with the actual number of loans with those characteristics used as a weighting factor.

The equations that result from the statistical analysis were adjusted or calibrated to the BLE before use in the stress test. The calibration procedure adjusts the default equations so that if the actual benchmark loans (as defined in NPR1) were input into the equations, with benchmark house price growth rates and interest rates, the resulting 10-year cumulative default rate would identically match that of the BLE (14.9 percent).

The remainder of this supplementary material is organized as follows: Section 2 provides a summary of the conceptual framework underlying the estimation of the statistical model of single family mortgage default and prepayment. Section 3 describes the loan level data used in the empirical analysis. Section 4 outlines the general approach to the statistical analysis of default and prepayment events, based on the application of the multinomial logit model. Section 5 defines the explanatory variables used in that analysis. The empirical results are presented in section 6, which is followed in section 7 by a discussion of the application of the estimated default and prepayment equations in the stress test. Section 8 ends this supplementary material by describing how the estimated model is used in the stress test to produce results consistent with the BLE.

2. Conceptual Framework

Financial options theory is the most widely accepted theoretical framework for the analysis of residential mortgage default and prepayment. This framework hypothesizes that mortgage borrowers will exercise embedded call (prepayment) or put (default) options when either of these alternatives becomes financially optimal. The financial options theory assumes that an individual mortgage borrower can increase his lifetime wealth by defaulting on a mortgage when the market value of the mortgage exceeds the market value of the house, implying a direct empirical link between changes in housing values, borrower equity, and the decision to default. Likewise, the option to refinance the mortgage when market rates fall below the current rate on the mortgage provides a means for borrowers to increase their wealth by prepaying, and links observed prepayment behavior to changes in interest rates.[197]

Previous empirical studies on mortgage terminations have provided empirical support for the options theory, as various approximations to the financial values of the options have been found to be strongly associated with observed default and prepayment outcomes.[198] However, some of the same studies also indicate that borrowers do not behave in the ''ruthless'' manner suggested by the pure options theory. These empirical studies vary in the degree to which the full implications of the theory are incorporated, mainly due to limitations on the available data and the ability to measure or impute options values to individual borrowers.

The measurement of borrower equity has been addressed in essentially two ways in the academic literature. One approach employs stochastic simulations to impute aggregate distributions of properties with positive or negative equity, while simultaneously accounting for the impact of default and prepayment events on these distributions. This is the approach used by Foster and Van Order (1984, 1985). Another approach, adopted in recent work by Deng, Quigley, and Van Order (1996) and Deng (1997), has been to combine mathematical assumptions about the diffusion of housing values with loan-level data to assign ''ex ante'' probabilities of negative equity to individual properties.[199] Both approaches are generally consistent with the assumptions of the option theory, and they differ mainly in their application to aggregate versus loan-level data.

In recent years, a consensus seems to have emerged among practitioners that the option values, to the degree that they can be measured, remain important for predicting default and prepayment,

[196] In this model, ARMs include all mortgages that have variable payment features.

[197] There may also be secondary effects of borrower equity on prepayment, and of interest rates on default. For example, attempts by borrowers to prepay their mortgages may be frustrated due to declining house prices and failure to qualify for refinancing. On the other hand, borrowers in a negative equity position may be reluctant to default if they have current mortgage coupon rates that are less than the prevailing market rate of interest. In this second case, the asset value of the low interest rate mortgage would be foregone if the put option is exercised and the borrower defaults. However, the empirical significance of mortgage value for default is questionable given the inability of borrowers to trade on this asset, other than by selling the property and taking back a mortgage at a rate between the original note rate and the current market rate. This option is precluded by the ''due-on-sale'' provisions of most residential mortgage contracts. The extent to which this option is used informally is unknown.

[198] Examples of empirical models based on the options framework include: Dunn and McConnell (1981), Foster and Van Order (1984, 1985), Buser and Hendershott (1984), Brennan and Schwartz (1985), Kau, Keenan, Muller, and Epperson (1985, 1990), and Hendershott and Van Order (1987).

[199] Probabilities assigned in this way are ''ex ante'' because they depend only on information about individual mortgages available at origination and subsequent changes in the mean (drift) and variance (volatility) of house price appreciation rates. No information on the incidence of default or prepayment among other loans is used to adjust the projected distribution of housing values used to assign probabilities of negative or positive equity to loans that remain active.

but provide only necessary, rather than sufficient, conditions. For example, in the case of mortgage default, negative equity alone may not be sufficient to induce a borrower to default, but given some other ''trigger event,'' such as job loss or marital disruption, the decision to default would then depend on whether equity was positive or negative. In the case of prepayment, borrowers who would otherwise appear to have a financial incentive to refinance (prepay) to obtain a lower interest rate, may not wish to incur the associated transactions costs given their expected time horizons for occupying the home.

While the option theory succeeds as a general framework, empirical models of mortgage default and prepayment must be flexible enough to account for variation in mortgage performance that may not appear to be fully consistent with optimal behavior, such as borrowers defaulting when house prices are increasing or prepaying when interest rates are increasing. The empirical model must account for limitations on the information available to compute the exact values of embedded options for individual borrowers. In addition, a wide variety of loan characteristics must also be accounted for, which has led to the widespread application of what are generally referred to as ''options-based'' empirical models, such as those cited above. The models applied in the stress test are typical of those that use the options-based approach.

3. Data

OFHEO obtained loan-level information on previous Enterprise single family mortgage originations and used these data to estimate models of mortgage performance. The data included information on the origination characteristics of mortgages, information on last-paid installment dates, and loan status outcomes from the Enterprise loan-tracking systems. This information allowed OFHEO to reconstruct ''event histories'' of the period-by-period performance of individual loans, from the date of origination to either the point where the loan terminated or the end of the sample period. OFHEO combined loan-level information from both Enterprises to develop its own data files for statistical analysis. Standardized or ''normalized'' data files were constructed to assure similar content and structure across Enterprises.[200]

The options theory views mortgage default and prepayment events in terms of decisions by individual borrowers to terminate their loans. This view has implications for the way mortgage outcomes and their associated probabilities are specified in the statistical analysis. Default and prepayment are specified to occur in the month following the date of the last-paid-installment. After mortgage prepayment, the Enterprises are likely to update the loan status almost immediately. By contrast, due to the varying length of the mortgage foreclosure process, the Enterprises may not classify defaulting loans as defaults until some months after the last-paid-installment date. However, in the model, the default event is nevertheless considered to have occurred at the point the borrower ceases payment on the loan.[201] The event history used for that loan ends at that point in time. The data used in the statistical analysis included mortgage originations for the period from January 1979 to December 1993, with mortgage performance measured through December 1995. Therefore, these data provided a minimum of two years of loan experience for the most recent origination cohorts.[202]

Ideally, models would be estimated using contemporaneous values of factors predictive of default and prepayment during each period a loan is outstanding. Although this type of ''panel'' data does not exist for historical Enterprise loan records, it was possible to reconstruct historical data on key determinants of default and prepayment, such as house prices and interest rates, and add this information to the individual loan event histories. Using these histories, OFHEO was able to estimate dynamic models for default and prepayment. The models are ''dynamic'' in the sense that OFHEO can estimate and simulate mortgage performance in response to actual or hypothetical (e.g., stress test) changes in economic circumstances over time.

4. Specification of the Statistical Model

The proposed regulation employs a monthly cash flow model of Enterprise performance over a ten-year stress period. The simulation of mortgage cash flows requires conditional rates of default and prepayment to be applied to outstanding mortgage balances during each month of the stress test. The purpose of the models described in this technical supplement is to provide a means of generating the required termination rates in a manner that is reasonable for Enterprise loans under the circumstances of the stress period.

Conditional rates of default and prepayment vary depending on a variety of factors, both random and systematic, some of which are fixed at origination and others that vary over time. Characteristics of loans and borrowers at origination can affect the level and timing of mortgage default and prepayment throughout the life of the loan. For example, conditional default and prepayment rates exhibit characteristic age-profiles that increase during the first years following origination, peak sometime between the fourth and seventh years, and decline gradually over the remaining years.[203] Default and prepayment rates also vary systematically in response to economic circumstances and other factors over time, such as changes in house prices and interest rates that affect the value to the borrower of embedded options.

Like other time-or age-dependent processes, mortgage terminations are highly amenable to analysis using statistical survival-time models specified in terms of conditional probabilities of prepayment and default. Default and prepayment are ''competing risks,'' which means that the occurrence of one type of event precludes the chance to observe when the other event might have occurred, and vice versa. In such a case it is necessary to account for the joint mathematical and statistical dependence of the conditional probabilities of default and prepayment on each other. Failure to account for the competing-risks nature of the events can lead to projections of total termination

[200] The process of data normalization involved confirming the consistency of mortgage product types and loan characteristics and defining standardized data fields.

[201] At the time that data bases were constructed for this analysis, information was not available from Freddie Mac on last-paid-installment dates. Therefore, OFHEO used the ''closing date'' for Freddie Mac's defaulted loans. This is the date of disposition of a foreclosed property. The last-paid-installment date was used for Fannie Mae defaults.

[202] Note that for some loans the last-paid-installment will occur prior to the end of the sample, with no corresponding change in loan status from active to defaulted. These ''censored'' events were treated in the same manner as loans that remained active through the end of the sample period. That is, they are viewed as active up to and including the last quarter in the sample period. Note that these censored default events do not occur in sufficient numbers to have a material impact on the statistical estimates. One reason is that during those time periods and places in which the incidence of default was greatest, such as, for example, in the historical benchmark experience, foreclosure and changes in loan status occurred within several months of the last payment by the borrower. In addition, relatively complete loan histories are available for those loan origination cohorts among which the majority of default events occurred on Enterprise loans. While more recent cohorts with shorter event histories have greater potential for censoring of default events, the impact of censoring on the statistical estimates is negligible because default rates have been so low in recent years.

[203] *See* discussion in Schwartz and Torous, at 379 (1989).

rates (default plus prepayment) that are mathematically inconsistent and that would preclude their application in the type of actuarial calculations of cash flows required for the stress test.

As outlined above, mortgage default and prepayment result in an observed last-paid-installment, after which no further payments are forthcoming. Thus, for loans outstanding at the beginning of each time period, three mutually exclusive outcomes are possible in the model: (1) the borrower defaults; (2) the borrower prepays the loan in full; or (3) the borrower makes the scheduled loan payment, and the loan remains active and part of the event history sample for the next time period. For the purposes of the statistical analysis, each of these outcomes is interpreted as an ''event.'' This approach implies that each loan contributes potentially many observations to the event history sample, depending on how long it remains active before experiencing one of the terminal events or reaching the end of the sample period.

a. Multinomial Logit Models

OFHEO has estimated multinomial logit models for quarterly conditional probabilities of default and prepayment.[204] Several empirical studies have applied some form of the logit or similar qualitative response models to analyze mortgage prepayment and default behavior.[205] The corresponding mathematical expressions for the conditional probabilities of default ($\pi_D(t)$), prepayment ($\pi_p(t)$), or remaining active ($\pi_A(t)$) over the time interval from t to $t + 1$ are given by:

$$\pi_D(t) = \frac{e^{\alpha_D + X_D(t)\beta_D}}{1 + e^{\alpha_D + X_D(t)\beta_D} + e^{\alpha_P + X_P(t)\beta_P}} \qquad (Eq.\ 1)$$

$$\pi_P(t) = \frac{e^{\alpha_P + X_P(t)\beta_P}}{1 + e^{\alpha_D + X_D(t)\beta_D} + e^{\alpha_P + X_P(t)\beta_P}} \qquad (Eq.\ 2)$$

$$\pi_A(t) = \frac{1}{1 + e^{\alpha_D + X_D(t)\beta_D} + e^{\alpha_P + X_P(t)\beta_P}} \qquad (Eq.\ 3)$$

Constant terms α_D and α_p, and coefficient vectors β_D and β_p, are the unknown parameters that must be estimated. $X_D(t)$ is a vector of mostly time dependent explanatory variables that are assumed to influence directly the conditional probability of defaulting (versus remaining active), and $X_p(t)$ is a vector of mostly time dependent explanatory variables assumed to influence directly the conditional probability of prepaying (versus remaining active).[206] The probability of remaining active ($\pi_A(t)$) is equal to 1 minus the other two probabilities, so that the three probabilities sum to 1.

The probabilities and coefficient vectors have a convenient interpretation when expressed in terms of odds ratios:

$$\ln\left[\frac{\pi_D(t)}{\pi_A(t)}\right] = \alpha_D + X_D(t)\beta_D \qquad (Eq.\ 4)$$

$$\ln\left[\frac{\pi_P(t)}{\pi_A(t)}\right] = \alpha_P + X_P(t)\beta_P \qquad (Eq.\ 5)$$

These expressions imply that the percentage impact of a one-unit change in an element of $X_D(t)$ on the relative probability or odds of defaulting versus remaining active is given by the corresponding element of the coefficient vector, β_D. A similar result holds for prepayment. Note also, that while changes in variables that affect the probability of prepayment affect the absolute level of the probability of default, and vice versa, such changes affect the probability of remaining active in a symmetric manner, so that the ''odds'' of defaulting versus remaining active are not affected.[207]

[204] The decision to model default and prepayment as quarterly events was consistent with the application of quarterly house price indexes in computing the underlying distributions of borrower equity. The resulting quarterly default and prepayment probabilities were converted to monthly factors for input to the monthly cash flow calculations required for application in the stress test.

[205] Examples of previous applications of the logit model are Campbell and Dietrich (1983), Zorn and Lea (1989), and Cunningham and Capone (1990).

[206] Some elements of $X_D(t)$ and $X_p(t)$ are constant over the life of the loan and are not functions of t.

[207] The multinomial logit model is widely applied in the analysis of consumer choice among discrete alternatives, where this feature has been called the

Continued

b. Estimation of Multinomial Logit Coefficients

The multinomial logit specification given by equations (1)–(3) is a purely mathematical representation of the underlying probabilities. How the unknown parameter coefficients of the logit model are estimated statistically depends on whether the model is applied to individual or aggregate data. Under some circumstances, the two approaches are mathematically equivalent. However, in some situations, the use of aggregate data may entail considerable loss of information.[208]

If only aggregate data were used, the proportions of loans defaulting, prepaying, and remaining active would be used to estimate the unknown coefficients α_D, α_p, β_D, and β_p directly by replacing the probabilities in equations (4) and (5) with the corresponding observed sample proportions and applying ordinary least squares. In this case the explanatory variables $X_D(t)$ and $X_p(t)$ correspond to the characteristics of the groups or classes of loans used in tabulating the observed sample proportions.

When loan-level data are available, it is possible to use equations (1)–(3) as an exact mathematical representation of the probabilities of individual loan events. In this case, estimation of unknown coefficients is achieved by the method of maximum likelihood. This approach chooses the values of α_D, β_D, α_p, and β_p that maximize the joint likelihood or probability of the entire event-history sample having actually occurred. For example, the joint sample likelihood is the product of the probabilities of each of the independent loan event observations:

$$\textit{Sample Likelihood (Joint Probability)} = \prod_{i=1}^{N} P_i \qquad \textit{(Eq. 6)}$$

where for each observation $i = 1,2. . ., N$, P_i is the estimated probability that the event that is actually observed would have occurred. These probabilities are obtained by substituting the appropriate expression from equations (1)–(3) for P_i in equation (6). The solution is found by varying the values of the elements of α_D, β_D, α_p, and β_p until the joint probability reaches its maximum value. The final values of α_D, β_D, α_p, and β_p are the maximum likelihood estimates. Numerous statistical software packages exist for this purpose.

The approach adopted by OFHEO is based on loan-level data, which has the significant advantage of preserving as much detail as possible on individual loan circumstances. This approach results in a flexible description of loan behavior, which can be used to project mortgage performance under the abnormal scenarios of the proposed regulation.

5. Explanatory Variables for Default and Prepayment

OFHEO estimated three separate sets of multinomial logit probability equations. The primary default and prepayment equations are for single family, 30-year FRMs. These loans comprise about 80 percent of all single family loans in the historical data obtained from the Enterprises. A second set of equations was estimated solely on data for ARMs. All loan types with any potential payment adjustments throughout the life of the loan were included as ARMs for purposes of the statistical estimation. A third set of default and prepayment equations was estimated to project the performance of less-prevalent single family loan types relative to 30-year fixed-rate mortgages. This estimation was performed using data on 30-year FRMs and all other fixed-rate loan types (including balloons). These loan types were grouped as: 20-year FRM, 15-year FRM, balloon, FHA/VA, and second liens. Data on 30-year FRMs are included in the estimation sample because the number of observations on other, less popular fixed-rate mortgage types was insufficient for estimating product-specific default and prepayment equations. However, the resulting default and prepayment equations are only used to project performance of the alternative product types, and not 30-year FRMs.

All three statistical estimations use the same conceptual underpinnings and empirical specifications, and only vary based on the data samples used in estimation. Thus, the basic definitions of the variables are the same across all three sets of equations, although the way some of the interest rate variable values change over time will differ, for example, for FRM loans and ARM loans, because of differences in their contractual terms.

For convenience, we refer to the three separate data sets and statistical estimations as model 1 (30-year FRMs), model 2 (ARMs), and model 3 (all fixed-rate products). In addition to the basic set of explanatory variables included in all three models, model 3 includes product-specific adjustment constants. The adjustment constants act like multipliers to the baseline default (hazard) rates of 30-year FRMs. The impacts of all other explanatory variables are presumed constant across product type, so there are no product-type adjustments to their coefficients. Because ARMs are believed to perform differently than FRMs, due to changing payments over time, they are treated in a separate estimation (model 2) so that variable coefficients can be uniquely identified for ARM versus FRM loans.

The explanatory variables $X_D(t)$ and $X_p(t)$ used to estimate the unknown coefficients of the multinomial logit models are listed in Table 31. All of the variables except mortgage age (*AGE*) were coded as categorical variables. Categorical variables are advantageous for several reasons. For instance, assigning the various explanatory variable outcomes to categories allows one to estimate effects that may be non-linear without having to experiment with many different functional forms. Because each categorical explanatory variable has minimum and maximum categories (determined through observation of the historical data), the

''independence of irrelevant alternatives.'' In the context of consumer choice theory this independence can result in apparent anomalies when close substitutes to existing choices are introduced. See, for example, McFadden (1976). This issue does not arise in the present context.

[208] For example, if the data are aggregated by taking average values of the explanatory variables within broad product groupings, then particular combinations of explanatory variables that exist for individual loans and which are associated with significant differences in probabilities of default and prepayment, will not be represented in the data. While this may not matter under ''normal'' circumstances, it could limit the usefulness of the model in projecting rates of default and prepayment within high risk categories under circumstances different than those embodied in the original aggregation scheme, such as those of the stress test.

impact of particular variables on rates of default or prepayment projected from the model is constrained to be within previous historical experience.[209] This helps to avoid unreasonable extrapolations when projecting mortgage performance under stress test conditions. Another advantage of using categorical outcomes for the explanatory variables is that it anticipates the need to apply the models to aggregated loan groups in the stress test.[210] The benefit of starting with loan-level data is that it allowed OFHEO to develop both the explanatory variables and stress test loan groups in a consistent manner, thus minimizing the loss of information due to data aggregation.

The summary of explanatory variables starts with descriptions of the two key options-related predictors of mortgage default and prepayment-respectively, the probability of negative borrower equity and the mortgage premium value. A review of additional interest rate variables and loan characteristics that are used as explanatory variables follows.

a. Probability of Negative Equity

The put option has value to the borrower when the property is worth less than the outstanding balance on the mortgage. In that case, the borrower is in a negative equity position. Thus, the equity position of the borrower is determined by the difference between the market value of the property securing the loan, $P(t)$, and the unpaid mortgage balance, $UPB(t)$:

$$EQ(t) = P(t) - UPB(t) \quad \textit{(Eq. 7)}$$

Ideally, periodic observations on the values of individual properties would be used to update individual house values and borrower equity at the same frequency (monthly) at which the decision to prepay or default can be exercised. However, because individual housing values are not updated continuously it is not possible to compute updated values of $EQ(t)$ for individual borrowers with sufficient accuracy for this measure to be used directly at the loan level.[211]

It remains possible, however, to characterize the equity positions of individual borrowers in terms of ex ante probabilities of negative equity.[212] The probability of negative equity is a function of the scheduled current loan balance and the likelihood of individual house price outcomes that lie below this value. Projected distributions of individual housing values relative to the value at mortgage origination were calculated by applying estimates of house price drift and volatility obtained from independent estimates based on the OFHEO House Price Index (HPI).[213]

The required estimates of house price drift and volatility are direct by-products of the estimation of the OFHEO HPI. The OFHEO HPI is based on a modified version of the weighted-repeat-sales (WRS) methodology (Case and Shiller, 1987, 1989), and is consistent with the assumption that housing values are generated by a log-normal diffusion process. This means that over time individual housing values will appreciate at different rates, distributed randomly around the average rate of appreciation. Over time, the cumulative rates of appreciation for individual homes will become more and more dispersed or diffused, hence the reference to diffusion processes. Mathematically, individual house prices are assumed to obey a non-stationary log-normal diffusion process in which individual house price appreciation since mortgage origination is normally distributed with variance σ^2 (A) around the expected rate of appreciation from the HPI, $\beta(t)$, computed as:

$$\beta(t) = ln\left(\frac{HPI(t)}{HPI(0)}\right) \quad \textit{(Eq. 8)}$$

Where A is loan age (in quarters), and HPI(0) is the value of the HPI at time of loan origination.[214] For the individual borrower with original house price $P(0)$ at time 0, the probability of negative equity at time t, PNEQ(t) is given by:

[209] This constraint applies specifically to the marginal contribution of particular explanatory variable outcomes, not to the overall level of the default and prepayment probabilities projected by the model. For example, if several explanatory variables simultaneously take on values that have not been previously observed in combination, then it is possible that the projected probabilities of default or prepayment would exceed those observed in the historical data. This type of outcome is anticipated by the 1992 Act, which requires regional adverse credit conditions to apply nationally to all loans at the same time.

[210] The loan groups used in the stress test were developed in conjunction with the classification of explanatory variable outcomes in the statistical analysis of mortgage default and prepayment. Aggregation of mortgage assets in the stress test recognizes the need to classify assets within broad product categories for financial accounting. Within the context of the proposed regulation, the use of aggregate loan groupings also facilitates the assignment of new loan products to existing categories with known risk characteristics. Further explanation of the aggregate loan groups used in the stress test is in section III. A., Mortgage Performance of the preamble.

[211] As discussed above, given the measurement difficulties associated with borrower equity at the loan level, some researchers have used various means of simulating the distribution of borrower equity. For example, Foster and Van Order (1984, 1985) used a Monte Carlo simulation of a synthetic mortgage pool in conjunction with a house price diffusion process and actual default and prepayment rates to reconstruct a time-series for the number of borrowers in a negative equity position. Under additional restrictions on the model (i.e., that only borrowers with negative equity default, and only borrowers with positive equity prepay), the time-series for the number of borrowers with negative equity (various levels) was used in regressions for conditional default and prepayment probabilities.

[212] See the discussion of ex ante probabilities of negative equity in footnote 199.

[213] House price drift is defined here as the average rate of house price appreciation as determined by the appropriate market house price index, while volatility is defined as the variance in individual house price appreciation rates around the market average rate of appreciation.

[214] Estimates of expected appreciation or drift in house prices are obtained directly from the estimated values of the HPI for each of the nine U.S. Census divisions. Estimates of diffusion volatility, $\sigma^2(A)$, are computed using the estimated parameters for the error variance of individual log-differences in housing prices that are obtained from the second-stage of the WRS method for each division. See Calhoun (1996) for additional details. Deng, Quigley, and Van Order (1996) applied a similar approach using WRS indexes for 26 metropolitan areas estimated using Freddie Mac data.

$$PNEQ(t)=Pr\{EQ(t)<0\} \qquad (Eq.\ 9)$$

$$= \Phi\left\{\frac{ln(UPB(t))-ln\ (P(0)e^{\beta(t)})}{\sigma(A)}\right\} \qquad (Eq.\ 10)$$

where $\Phi(x)$ is the standard normal cumulative distribution function evaluated at *x*. This expression quantifies the relationship between changes in house prices on average, and the likelihood of negative appreciation on individual properties that places some fraction of borrowers in a negative equity position. The imputed share of borrowers with negative equity implied by equation 10 is used as a proxy for the probability of negative equity for an individual borrower.[215] The computed probabilities of negative equity are assigned to one of eight categorical outcomes, as summarized in Table 31.

b. Relative Spread

The theoretical value of the call (prepayment) option on a mortgage is a function of the difference between the present value of the future stream of mortgage payments discounted at the current market rate of interest, *R(t)*, and the present value of the mortgage evaluated at the current note rate, *C(t)*. The actual value of this call option to the borrower is unknown due to uncertainty over the future time path of mortgage payments associated with uncertain future probabilities of prepayment and default. Therefore, it is common to use other variables to capture the impact of the call option value on prepayment rates. Following recent work by Deng, Quigley and Van Order (1996), OFHEO approximated the call option value using the relative spread variable, RS(t):

$$RS(t) = \left\{\frac{C(t)-R(t)}{C(t)}\right\} \qquad (Eq.\ 11)$$

Positive values of the call option exist when the mortgage coupon exceeds the current market interest rate (positive spread), and the borrower can benefit financially by refinancing to obtain a lower interest rate. Outcomes for the relative spread variable are classified into seven categorical outcomes, as summarized in Table 31.

c. Prepayment Burnout

Recent studies of mortgage terminations have emphasized the importance of previous interest rate environments for distinguishing among borrowers more or less likely to exercise the prepayment option when the opportunity arises.[216] The tendency for the most responsive borrowers to prepay first, so that the remaining sample of borrowers are those with lower average conditional probabilities of prepayment, contributes to the observed seasoning or ''burnout'' of mortgage pools. The indicator variable *B*(*t*) is included to measure whether the borrower has missed a previous refinance opportunity.[217] *B*(*t*) is defined by whether the market rate of interest was 200 basis points or more below the coupon rate of the mortgage during two or more quarters over the past two years. Those who have missed previous refinance opportunities are predicted to have lower conditional probabilities of prepayment and higher conditional probabilities of default. Failing to refinance under favorable interest rate conditions may indicate the existence of other credit-related problems, such as failure to obtain an adequate property appraisal.[218]

d. Yield Curve Slope

Expectations about future interest rates and differences in short-term and long-term borrowing rates associated with the slope of the Treasury yield curve influence the choice between ARM and FRM loans and the timing of refinancings and prepayments. A high value for the slope of the yield curve indicates relatively favorable short-term rates, increasing the likelihood that a borrower refinances to an ARM to take advantage of the lower initial coupons that can be offered by lenders. The variable *YS*(*t*) is included to measure the current slope of the yield curve. This variable is computed as the ratio of the ten-year Constant Maturity Treasury yield (CMT) to the one-year CMT, and assigned to four categorical outcomes.

e. Mortgage Age

The existence of other demographic and economic processes that may ''trigger'' mortgage default or prepayment, and the inability to measure the diffusion of house prices and the distribution of borrower equity precisely, create a need to account directly for age-specific differences in conditional rates of default and prepayment.[219] The direct dependence of the conditional probabilities on mortgage age recognizes the existence of other borrower processes and unobserved heterogeneity that induce duration dependence in the conditional rates of termination and help to explain the typical age patterns of default and prepayment.[220] For this reason,

[215] Although the market level (regional) values of house price drift and volatility are used, the imputed probability of negative equity is still specific to the individual borrower's circumstances, since the loan-specific values of original LTV and loan amount are used in the calculations.

[216] For example, see the discussions of borrower heterogeneity and path dependence in Bartholomew, Berk, and Roll (1988), and the discussion of burnout in Richard and Roll (1989).

[217] The indicator variable equals one if the spread between the note rate on the mortgage and the quarterly average market rate of interest has been 200 basis points or greater during any two of the past eight quarters.

[218] See footnote 198.

[219] Under a pure options model, the typical age patterns of conditional default and prepayment rates might be attributed entirely to the diffusion of housing values and the introduction of unobserved differences (heterogeneity) in the equity positions of individual borrowers, resulting in differences in the rates of default and prepayment among particular subsets of individual borrowers. As these differences emerge following mortgage origination, the observed average conditional default and prepayment rates will initially increase. Eventually, as ''high risk'' borrowers depart the sample or mortgage pool, the average conditional rates of default and prepayment will decline.

[220] *See* Lancaster (1990) for a discussion of the impact of unobserved heterogeneity on estimates of

mortgage age (*AGE*) is included as an additional explanatory variable in the empirical model. The model utilizes a quadratic function of mortgage age, where age is defined as the number of quarters since origination. The use of a parametric function of age instead of categorical values is based on two considerations. First, the use of categorical age values for individual quarters would result in a large number of additional coefficients to estimate. Combining loans into broader age groupings to reduce the number of parameters can produce large differences in rates of default and prepayment with small increments in age for loans graduating from one age category to the next. Second, when individual age categories are used, they show that a quadratic age function is a reasonable assumption, at least for the first eight to ten years. At higher values of mortgage age, the samples are much smaller (most loans have terminated by these ages), with the result that the estimates for individual age categories are quite erratic due to sampling error. The use of a simple functional form like the quadratic helps to smooth the estimates of the age effects for the higher age groups.

f. Original LTV

The original LTV ratio, *LTV*(0), serves as an indicator of the income and net worth of the borrower at mortgage origination, and directly determines the initial equity position of the borrower. To the extent that income and wealth are negatively correlated with *LTV*(0), high LTV borrowers will have fewer economic resources to finance the transactions costs of prepayment or endure spells of unemployment or other trigger events that might otherwise cause them to exercise the default option in a sub-optimal manner. Finally, high LTV borrowers have already demonstrated a willingness to ''leverage'' the financing of the home purchase, which may portend a greater sophistication or ''ruthlessness'' in the exercise of the default option. Thus, one would expect higher rates of default and lower rates of prepayment as *LTV*(0) increases. The six *LTV*(0) categories used in the default/prepayment models are similar to those used by the Enterprises in their annual reports and information statements.

g. Season of the Year

The variable *SEASON*(*t*) was included to account for the current season (quarter) of the calendar year, in recognition of the potential impact of weather, school schedules, and seasonal employment patterns on residential mobility and default and prepayment probabilities.

h. Occupancy Status

O*S* is an indicator variable included to distinguish mortgages on owner-occupied units from investor loans. Owner occupants should be less likely than investors to exercise the default option given the direct benefits they receive from the consumption of housing services. Owner occupants should be more likely to prepay than investors for non-financial reasons such as residential mobility.

i. Relative Loan Size

The ability to bear the transactions costs of refinancing, or to weather economic stress and avoid default, will be correlated with the income level of the household. Given the lack of information in the historical data on household income at origination, a measure of relative loan size provided a proxy for the relative income level of the household. *LOANSIZE* was defined as the ratio of the original loan amount relative to the average-sized Enterprise loan originated in the same State during the same origination year.[221]

j. Product Type Indicators

Five product type indicators were created to account for the performance of non-standard loans relative to the standard 30-year FRM loans in model 3: 20-Year FRM, 15-Year FRM, balloon, FHA/VA, and seconds. These indicator variables provide the adjustment constants mentioned earlier.

k. ARM Coupon Rate Dynamics

To estimate the current values of both the probability of negative equity, *PNEQ*(*t*), and the relative spread, *RS*(*t*), variables for ARM loans, it was necessary to trace the path of current coupon rates over the active life of individual mortgages. For standard ARM products, the coupon rate resets periodically to a new level that depends on the underlying index, plus a fixed margin, subject to periodic and lifetime interest rate caps that specify the maximum and minimum amounts by which the coupon can change on any one adjustment and over the life of the loan.[222] ARM coupon rates are updated using the following formula:

$$C(t) = \max\{\min[Index(t-S) + Margin, C(t-1) + A(t)\cdot PeriodUpCap, \quad \text{(Eq. 12)}$$
$$C(0) + A(t)\cdot LifeUpCap], C(t-1) - A(t)\cdot PeriodDownCap(t),$$
$$C(0) - A(t)\cdot LifeDownCap\}$$

Where *Index (t*) is the underlying index value at time *t, S* is the ''lookback'' period, and *Margin* is the amount added to *Index* (*t—S*) to obtain the ''fully-indexed'' coupon rate. The periodic adjustment caps are given by *PeriodUpCap* and *PeriodDownCap,* and are multiplied by an indicator variable *A*(*t*) which equals zero except during scheduled adjustment periods. The maximum lifetime adjustments are determined by and *LifeUpCap* and *LifeDownCap*.[223]

duration dependence in econometric models of transition probabilities. Other borrower processes include residential mobility, employment mobility, involuntary unemployment, and demographic events related to household formation and dissolution, mortality, and fertility. Ideally, given suitable household-level data, these other processes would be modeled jointly with mortgage terminations.

[221] Price Waterhouse (1990) reported significant differences in claim rates for FHA mortgages stratified by loan size. Smaller loans were observed to fail at significantly higher rates than other loans.

[222] Detail on specific ARM contracts was obtained in some cases from loan-level information, and in other cases was obtained using plan-level detail for loans in certain ARM product categories. Any loan product with variable interest rates was classified as an ARM, and modeled according to product terms. This includes so-called two-step mortgages and mortgages with interest-rate buydowns. For simplicity, the margin was set at 2 percent for all ARMS.

[223] The majority of Enterprise ARM loans are indexed to the one-year Treasury rate, with smaller but significant numbers indexed to either the five-year or ten-year Treasury rate, the 11-District Cost of Funds Index (COFI), or the London Inter-Bank Offer Rate (LIBOR). A small percentage of ARM loans are indexed to the six-month or three-year Treasury rates. The majority of ARM loans had lifetime adjustment caps of five or six percent, and have no lifetime rate floors. Most have periodic rate adjustment caps of two percent, while some have periodic rate adjustment caps of one percent. The majority of ARM loans have adjustment frequencies of one year, while a significant minority are adjusted every six months.

6. Empirical Results

The three models were estimated by the method of maximum likelihood using the SAS® CATMOD procedure. The CATMOD procedure employs a design matrix that automatically converts all categorical variables to a series of indicator variables prior to estimation. As discussed above, all explanatory variables except mortgage age were converted to indicator variables. This allows one to reduce the data to a smaller number of loan records, each representing unique combinations of the categorical variables, to which a frequency count is assigned and applied as a sampling weight in subsequent statistical analyses. This approach avoids the need to undertake choice-based sampling (e.g., over-sampling of defaulted loans) in order to assure that sufficient numbers of rare events like mortgage default are obtained.[224] However, given the large number of loan level observations available to OFHEO, simple random samples were used to estimate the 30-Year FRM and Multiple Products models. All available data were used to estimate the ARM model.[225]

Table 32 contains the parameter estimates for the three models.[226] The constant and age parameters are listed first, as they provide a baseline function to which the effects of other variables can be added. There is a high level of consistency in the coefficient estimates across all three models, and all three models provide empirical support for the importance of the options-related variables.

The coefficient estimates for the probability of negative equity variable (*PNEQ*) vary on the same order of magnitude for default as the coefficient estimates for the original LTV variable. *PNEQ* is also important for prepayment, in the opposite direction, consistent with the expectation that those most likely to have negative equity will have the greatest difficulty selling their homes or refinancing their mortgages, and therefore be less likely to prepay their existing mortgages. Original LTV is relatively unimportant for prepayment, although those in the lowest LTV category are more likely to prepay.

The value of the call option measured by the relative spread (*RS*) shows quite large effects on prepayment in the hypothesized direction. The higher the coupon rate on the mortgage relative to the current market rate of interest the higher the likelihood of prepayment. Note the general similarities between the *RS* coefficient estimates for models one and two (30-year FRMs and ARMs). Because ARM coupon rates will adjust with changes in market rates, ARM borrowers are less likely than FRM borrowers to end up with large positive or negative *RS* values. However, the estimates in Table 32 imply that ARM and FRM borrowers behave in a similar manner under comparable values of the call option.

The prepayment burnout variable, *B,* is most important for default rates, and indicates that missed opportunities to prepay are associated with higher credit risk. This result reinforces the results discussed above for *PNEQ*, where higher values of *PNEQ* were associated with lower probabilities of prepayment. This result also reflects the lack of precision in measurements of borrower equity at the loan level.

The slope of the yield curve (*YS*) is important for the probability of prepayment for FRM borrowers, especially for steep positive values of the slope. This result is consistent with the tendency of borrowers to refinance to ARM mortgages when short-term rates are relatively low and lenders can offer very favorable initial coupons (''teaser'' rates). It is also consistent with the assumption that the expectation of higher interest rates in the future may cause some borrowers to refinance sooner to lock in lower rates. The yield curve slope variable has similar, but smaller, effects for ARM borrowers.

The *SEASON* variable has modest effects in the anticipated directions. For FRM borrowers, prepayment rates are lower than average in the Winter and higher in the Spring. Default rates are lower in the Winter and higher in the Fall. For ARMs, prepayments are also higher in the Fall, but defaults are lower in that season.

Occupancy status (*OS*) has much larger impacts on default probabilities for ARM borrowers than FRM borrowers. For both product types, investors are more likely to default than owner-occupants, and much more so for ARM borrowers than FRM borrowers. It is reasonable to expect that owner-occupants will be less ruthless in the exercise of the default option given the offsetting value they receive from living in the home. The prepayment effects are more similar across ARM and FRM borrowers.

The variable *LOANSIZE* was included as a proxy for borrower income at origination. The results in Table 32 indicate that relative loan size is not particularly important for default probabilities, at least after controlling for the other explanatory variables. *LOANSIZE* is much more important for prepayment, with smaller loans prepaying at lower rates than relatively large loans. This is consistent with the interpretation of *LOANSIZE* as a proxy for borrower income. Lower income borrowers may lack the resources to bear the transactions costs of refinancing, causing them to prepay at lower rates than higher income borrowers with relatively large loans. Lower income borrowers may also be less mobile than higher income borrowers. The results for prepayment are similar across FRM and ARM borrowers.

The results for the two fixed-rate models, models one and three, are generally quite consistent. The individual product type indicators in model 3 provide estimates of the relative rates of default and prepayment of various fixed-rate products in comparison to 30-Year FRMs, and in comparison to each other. Balloon mortgages have the highest rates of default and prepayment relative to 30-Year FRMs. Intermediate FRM products (15-Year and 20-Year) default at lower rates than 30-Year FRMs. This result is consistent with more rapid loan payoff and accumulation of borrower equity for these borrowers. Rates of prepayment on intermediate FRMs are comparable to those on 30-Year FRMs. FHA and VA loans have higher rates of default and lower rates of prepayment than 30-Year FRM loans. Results for the category of second loans is most similar to the FHA/VA loans.

7. Application of the Models in the Stress Test

The three product-based single family models provide the means to project the conditional default and prepayment probabilities required as inputs to the cash flow model of Enterprise financial

[224] It has been demonstrated for static logit models that choice-based sampling results in biased estimates of the coefficients of the logit constant terms, for which relatively simple corrections are available, based on the population distribution of the explanatory variables across groups defined by dependent variable outcomes (Costlett, 1981). It is not clear that the same form of correction applies to the retrospective event-history sample used in this analysis. Selection on the basis of default outcomes implies selection of an array of preceding ''non-events'' for each quarter the loan was active, so that the distributions of the explanatory variables for specific age categories depends on the timing of default events for individual loans.

[225] A ten-percent random sample was used for the 30-Year FRM model and the Multiple Products model. All data used for estimation were subject to a variety of data quality screens and available data for all the explanatory variables.

[226] Note that a particular feature of the SAS CATMOD procedure is that when it estimates the coefficients corresponding to a variable with N categories, the program estimates only the first N–1 coefficients. The final-category coefficient for each variable is computed as the additive inverse of the first N–1 category coefficients.

performance. The stress test aggregates single family loan-level data into loan groups based on the following characteristics: Enterprise, portfolio (securitized vs. retained), product type, origination year, original LTV ratio class, original coupon class, starting coupon class, and region (Census division). The information contained in characteristics data for each aggregated loan grouping is sufficient, when combined with data on house price growth rates and interest rates, to compute and update all of the explanatory variables needed for computing conditional default and prepayment probabilities during the stress period.

There are three exceptions to this general statement. The variables *SEASON* and *LOANSIZE* were not used to classify loans for the purpose of the stress test. The *SEASON* variable was excluded when applying the logit models to project default and prepayment probabilities over the stress period.[227] The *LOANSIZE* variable was retained, but all loans were categorized as being of average size. These two changes reduced by a factor of nine the number of loan groups that had to be processed when running the stress test. Accounting for seasonal effects and differences in default and prepayment rates by loan size was not considered essential for projecting mortgage performance in the stress test.[228] In addition, the variable *OCCUPANCY*, used to distinguish mortgages on owner-occupied units from investor loans, is replaced by the portfolio average percentages for each occupancy status. Thus, instead of creating separate loan groups for owner-occupied and investor loans, these loans are combined into a single group, and a weighted average of the logit coefficients for owners and investors is used when projecting default and prepayment probabilities. This procedure reduces the number of records that must be processed by a factor of 2, but still allows OFHEO to account for changes over time in the percentage of Enterprise mortgages that are investor loans.

The detail contained in the starting position loan group records is sufficient to treat each loan group as if it performs like a single loan, with the projected probability of default or prepayment from the model corresponding to the share of the loan group balance that will default or prepay in any given period (i.e., by the ''law-of-large-numbers''). Group-specific average values of original LTV and mortgage coupon are used in place of exact loan-specific values in computing explanatory variables requiring these as inputs (e.g., *PNEQ* and *RS*). Categorical values such as original LTV and region (Census division) are classified in the same way for both the loan-level data used for estimation and the loan groupings used in the stress test.

Another nuance of stress test implementation is that, for purposes of projecting default and prepayment rates, OFHEO treats all mortgages with variable payments as if they were standard one-year Treasury ARMs, with identical payment caps and interest rate margins. In contrast, in the statistical analysis, specific payment changes for each loan type were reflected in the creation of explanatory variables.

In the development of explanatory variables for both the statistical analysis and stress test implementation, a shortcut is used to amortize ARMs. At each payment adjustment date, the new mortgage payments are computed using updated interest rates but with the original UPB and loan term, rather than current UPB and remaining term. This is seen in the formula used for PMT_q, which is the same for both fixed- and adjustable-rate mortgages. (*See* section 3.5.2.3, Procedures of the Appendix.) This approach provides an approximation for actual payment changes on adjustable rate mortgages. It expedites calculations by reducing the code necessary to update payments and UPB in each quarter. The approximation here should have little effect on default rate results because of the use of categorical, rather than continuous explanatory variables. Differences in loan amortization arising from using this payment-calculation approximation only affect default or prepayment rates when those differences move the probability of negative equity variable from one (value) category to another. Loan amortization in the Cash Flow component of the stress test does not use this shortcut.

In the development of variables for both the statistical analysis and stress test implementation, the incorrect term is used to amortize balloon loans. Mortgage origination term (T_0), rather than mortgage amortization term (T_a), is used to amortize these loans. This is seen in the formula used for PMT_q, which does not distinguish between balloon loans and other loan products. See section 3.5.2.3, Procedures of the Appendix. Amortization of balloon loan products in the Cash Flow component of the stress test uses the mortgage amortization term.

8. Consistency With the Historical Benchmark Experience

Certain adjustments and assumptions to the models were made to assure consistency of the rates of default projected in the stress test with the BLE. Loan-level data from the benchmark was aggregated in the same way current Enterprise loan groups are formed in the stress test, and the 30-year FRM model was applied to these data to project conditional and cumulative default and prepayment rates for the ten years following origination.[229] A single set of house price appreciation rates from the OFHEO HPI, the ten-year sequence of appreciation rates from the West South Central Census division for the period from 1984 Q1 to 1993 Q4, was applied to every benchmark loan group.[230] Actual historical interest rates were used. The projected average ten-year cumulative default rate was compared to that observed for the BLE, and adjustments were made to the constant term α_D of the default function until the projected and observed default rates were equal.[231]

[227] The parameter estimates generated by the SAS CATMOD procedure are defined so that they sum to zero across all categories of a given explanatory variable. This implies that dropping them from the model is equivalent to assuming that the logit probabilities for default and prepayment include the average effect across all the possible categories of the excluded variable.

[228] Including the *SEASON* variable in estimation can be justified because it helps to isolate the statistical impact of changes in house prices on borrower equity from purely seasonal fluctuations in default and prepayment rates. Likewise, *LOANSIZE* and original LTV are both likely to be related to borrower income and wealth at mortgage origination. However, because *LOANSIZE* is defined relative to the average sized loan within a state in the year of origination it provides a somewhat different measure of relative income or wealth.

[229] Note that all loans of the BLE are newly originated loans.

[230] The West South Central Census Division does not exactly match the 4-State benchmark region, but its use here to represent benchmark economics is consistent with OFHEO's proposal to aggregate data based on Census divisions, and to apply historical Census division-level house price growth rates to season loans at the beginning of the stress test. What is most important is that the price series used to calibrate the statistical equations is the same series that will be used in the stress test itself. The actual ten-year house-price experience of the West South Central Division and the 4-State benchmark area, 1984–1993, are very similar.

[231] When computing the cumulative default rate projected by the model for comparison with that observed for the benchmark experience, the same calculations were used. The model was used to project the total defaulting UPB for benchmark loans over the ten-year period following origination for each monthly origination cohort. The total defaulting UPB for each Enterprise was obtained by summing up the total defaulting UPB for each origination cohort, which was divided by the total original UPB for that Enterprise to compute the ten-year cumulative default rate. The two Enterprise cumulative default rates were then averaged. As discussed in NPR1, because of missing data on defaulting loans, OFHEO used the original UPBs on default loans in place of UPB at the time of default.

Continued

The adjusted (calibrated) model is then applied in the stress test, along with the sequence of house price appreciation rates used in the calibration procedure.[232] Therefore, if newly originated loans with characteristics similar to those comprising the benchmark sample were subjected to the same economic circumstances as occurred in the benchmark experience, then the statistical model of mortgage performance would project ten-year cumulative default rates equal to those of the benchmark sample. Conversely, to the extent interest rates, property values, and loan characteristics are different from the benchmark sample, and to the extent adjustments are necessary to account for other statutory requirements (e.g., increased general inflation under large increases in the ten-year CMT), the stress test rates differ from the benchmark level.

The adjustment of the model is appropriate for use in the stress test because the statistical equations in the model were estimated using Enterprise data on loans from a broad range of times and places, in addition to those loans included in the benchmark sample. Because, by definition, the BLE reflects the highest rates of loss observed from among these other periods and places, the model would not be likely to replicate benchmark results on benchmark loans exactly without some type of adjustment.

The calibration procedure does not add an adjustment factor to match projected prepayment rates directly to the benchmark prepayment experience. Nevertheless, the stress test model is fully calibrated to the credit loss experience of the benchmark loans because the calibrated default equation, and the uncalibrated prepayment equation that was used to help calibrate the default equation, are used together to determine mortgage performance. Because the time paths of Treasury yields and mortgage rates used in the calibration were those corresponding to the individual benchmark origination cohorts, the conditions leading to prepayments in the calibration exercise are entirely consistent with the benchmark default experience.

This has little effect on the resulting historical loss rates, because the same values for defaulting UPBs were used when computing severity rates. In the calibration of default rates, the UPBs at the time of default projected from the model (which take into account normal amortization) were adjusted back to their origination values for consistency with the benchmark methodology.

[232] In the calibration, all loans of the BLE are assigned an HPI volatility parameter estimate based on the West South Central Census division. In the stress test, loans from each region retain their respective regional volatility values.

Table 31. Explanatory Variables for Default and Prepayment Models

Variable Name	Description	Categorical Ranges
	Options-Related Variables	
RS(t)	Relative spread between the note rate and the current average market rate. Entered as a (7x1)−vector of indicator variables for value categories. See text for explanation.	$RS \leq -0.20$ $-0.20 < RS \leq -0.10$ $-0.10 < RS \leq 0.0$ $0.20 < RS \leq 0.10$ $0.10 < RS \leq 0.20$ $0.20 < RS \leq 0.30$ $RS > 0.30$
PNEQ(t)	Probability of negative equity. Entered as an (8x1)−vector of indicator variables for probability of negative equity categories. See text for explanation.	$0.0 < PNEQ \leq 0.05$ $0.05 < PNEQ \leq 0.10$ $0.10 < PNEQ \leq 0.15$ $0.15 < PNEQ \leq 0.20$ $0.20 < PNEQ \leq 0.25$ $0.25 < PNEQ \leq 0.30$ $0.30 < PNEQ \leq 0.35$ $PNEQ > 0.35$
	Other Interest Rate Variables	
B(*t*)	Burnout factor. Defined as missed opportunity to refinance. This occurs if coupon on the mortgage was greater than 200 basis points above market rate during any two quarters over the past two years. Entered as an indicator variable for burnout effect.	No Chance to Refi Missed Chance to Refi
YS(*t*)	Yield curve slope. Entered as a (4x1)− vector of indicator variables for yield curve slope categories. Yield curve slope is defined as ratio of 10-year CMT to 1-year CMT.	$YS < 1.0$ $1.0 \leq YS < 1.2$ $1.2 \leq YS < 1.5$ $YS \geq 1.5$
	Variables for Other Loan Characteristics	
AGE(t)	Mortgage age function. This variable is computed as a quadratic function of the number of quarters since origination. When combined with the constant term, this determines the baseline hazard function.	
LTV(*0*)	Original LTV. Entered as a (6x1)−vector of indicator variables for original LTV categories	$LTV \leq 60$ $60 < LTV \leq 70$ $70 < LTV \leq 75$ $75 < LTV \leq 80$ $80 < LTV \leq 90$ $90 < LTV \leq 100$

Table 31. Explanatory Variables for Default and Prepayment Models (Continued)

Variable Name	Description	Categorical Ranges
SEASON(*t*)	Season of the year. Entered as a (4x1)– vector of indicator variables for seasonal categories.	Winter Spring Summer Fall
OS	Occupancy status. Indicator variable for owner-occupancy status.	Investor Owner-Occupant
LOANSIZE	Relative loan size. Entered as a (6x1)– vector of indicator variables for original loan size relative to the state average loan size in the same year.	*LOAN SIZE* ≤ 0.40 0.40 < *LOAN SIZE* ≤ 0.60 0.60 < *LOAN SIZE* ≤ 0.75 0.75 < *LOAN SIZE* ≤ 1.00 1.00 < *LOAN SIZE* ≤ 1.25 *LOAN SIZE* > 1.50
Loan Product-Type Indicators		
BALLOON	Balloon Mortgages	Balloon / Non-Balloon
15-Year FRM	15-Year Fixed-Rate Mortgages	15 YR / Non-15 YR
20-Year FRM	20-Year Fixed-Rate Mortgages	20 YR / Non-20 YR
30-Year FRM	30-Year Fixed-Rate Mortgages	30 YR / Non-30 YR
GOVERNMENT	FHA/VA Mortgages	Government / Non-Government
SECONDS	Second Liens	Second liens/ first liens

Table 32. Comparison of Multinomial Logit Parameter Estimates for Quarterly Conditional Prepayment and Default Probabilities[1]

Explanatory Variables	30-Year FRM		ARM		Other Fixed-Rate Products	
	Prepay	Default	Prepay	Default	Prepay	Default
CONSTANT	−4.514 (0.000)	−6.985 (0.000)	−4.630 (0.000)	−5.218 (0.000)	−4.511 (0.000)	−7.045 (0.000)
AGE	0.072 (0.000)	0.118 (0.000)	0.061 (0.000)	0.057 (0.000)	0.078 (0.000)	0.139 (0.000)
AGE * *AGE*	−0.002 (0.000)	−0.002 (0.000)	−0.001 (0.000)	−0.002 (0.000)	−0.002 (0.000)	−0.002 (0.000)
LTV(0) *LTV* ≤ 60	0.169 (0.000)	-1.465 (0.000)	0.097 (0.000)	−1.424 (0.000)	0.117 (0.000)	−1.491 (0.000)
60 < *LTV* ≤ 70	0.069 (0.000)	−0.219 (0.000)	−0.008* (0.134)	−0.348 (0.000)	0.041 (0.000)	−0.219 (0.000)
70 < *LTV* ≤ 75	−0.024 (0.000)	0.426 (0.000)	−0.080 (0.000)	0.121 (0.000)	−0.027 (0.000)	0.374 (0.000)
75 < *LTV* ≤ 80	0.013 (0.000)	0.272 (0.000)	−0.071 (0.000)	0.191 (0.000)	−0.004* (0.106)	0.220 (0.000)
80 < *LTV* ≤ 90	−0.070 (0.000)	0.399 (0.000)	0.081 (0.000)	0.322 (0.000)	−0.049 (0.000)	0.412 (0.000)
90 < *LTV* ≤ 100	−0.157	0.587	−0.019	1.138	−0.078	0.704
PNEQ(t) *PNEQ* ≤ 0.05	0.234 (0.000)	−1.269 (0.000)	0.603 (0.000)	−1.206 (0.000)	0.328 (0.000)	−1.198 (0.000)
0.05 < *PNEQ* ≤ 0.10	0.199 (0.000)	−0.559 (0.000)	0.239 (0.000)	−0.413 (0.000)	0.174 (0.000)	−0.344 (0.000)
0.10 < *PNEQ* ≤ 0.15	0.196 (0.000)	−0.263 (0.000)	0.060 (0.000)	−0.292 (0.000)	0.132 (0.000)	−0.062* (0.055)
0.15 < *PNEQ* ≤ 0.20	0.169 (0.000)	−0.135 (0.000)	0.027 (0.037)	−0.043* (0.109)	0.074 (0.000)	−0.080 (0.040)
0.20 < *PNEQ* ≤ 0.25	0.015 (0.002)	0.254 (0.000)	−0.005* (0.736)	0.177 (0.000)	−0.042 (0.001)	0.164 (0.000)
0.25 < *PNEQ* ≤ 0.30	−0.207 (0.000)	0.563 (0.000)	−0.155 (0.000)	0.398 (0.000)	−0.125 (0.000)	0.404 (0.000)
0.30 < *PNEQ* ≤ 0.35	−0.249 (0.000)	0.647 (0.000)	−0.242 (0.000)	0.607 (0.000)	−0.169 (0.000)	0.421 (0.000)

Table 32. Comparison of Multinomial Logit Parameter Estimates for Quarterly Conditional Prepayment and Default Probabilities[1] (Continued)

Explanatory Variables	30-Year FRM		ARM		Other Fixed-Rate Products	
	Prepay	Default	Prepay	Default	Prepay	Default
0.35 > *PNEQ*	−0.357	0.762	−0.527	0.772	−0.372	0.695
RS(t) *RS* ≤ −0.20	−1.160 (0.000)		−1.473 (0.000)		−1.027 (0.000)	
−0.20 < *RS* ≤ −0.10	−0.822 (0.000)		−0.524 (0.000)		−0.810 (0.000)	
−0.10 < *RS* ≤ 0.0	−0.680 (0.000)		−0.328 (0.000)		−0.710 (0.000)	
0.0 < *RS* ≤ 0.10	−0.432 (0.000)		−0.162 (0.000)		−0.343 (0.000)	
0.10 < *RS* ≤ 0.20	0.633 (0.000)		0.414 (0.000)		0.628 (0.000)	
0.20 < *RS* ≤ 0.30	1.182 (0.000)		1.066 (0.000)		1.098 (0.000)	
0.30 > *RS*	1.279		1.007		1.164	
BURNOUT (*B(t)*) (No Chance to Refi)	0.106 (0.000)	−0.619 (0.000)	0.027 (0.000)	−0.468 (0.000)	0.087 (0.000)	−0.566 (0.000)
(Missed Chance to Refi)	−0.106	0.619	−0.027	0.468	−0.087	0.566
YS(t) *YS* < 1.0	−0.215 (0.000)		0.042 (0.000)		−0.214 (0.000)	
1.0 ≤ *YS* < 1.2	−0.228 (0.000)		−0.156 (0.000)		−0.211 (0.000)	
1.2 ≤ *YS* < 1.5	0.022 (0.000)		−0.101 (0.000)		−0.004* (0.197)	
1.5 ≤ *YS*	0.421		0.215		0.429	
SEASON(t) Winter	−0.154 (0.000)	−0.145 (0.000)	−0.151 (0.000)	−0.031 (0.020)	−0.158 (0.000)	−0.126 (0.000)
Spring	0.161 (0.000)	0.025 (0.000)	0.065 0.044 (0.000)	0.037 (0.004)	0.148 (0.000)	−0.010* (0.575)
Summer	−0.010 (0.000)	−0.052 (0.000)	0.009 (0.012)	0.010* (0.440)	−0.002* (0.421)	−0.050 (0.004)

Table 32. Comparison of Multinomial Logit Parameter Estimates for Quarterly Conditional Prepayment and Default Probabilities[1] (Continued)

Explanatory Variables	30-Year FRM		ARM		Other Fixed-Rate Products	
	Prepay	Default	Prepay	Default	Prepay	Default
Fall	0.003	0.172	0.077	−0.016	0.012	0.186
OCCUPANCY (*OS*) Investor	−0.140 (0.000)	0.244 (0.000)	−0.228 (0.000)	0.891 (0.000)	−0.142 (0.000)	0.269 (0.000)
Owner-Occupant	0.140	−0.244	0.228	−0.891	0.142	−0.269
LOANSIZE *LOANSIZE* ≤ 0.40	−0.531 (0.000)	−0.029* (0.084)	−0.399 (0.000)	−0.215 (0.008)	−0.506 (0.000)	−0.073* (0.082)
0.40 < *LOANSIZE* ≤ 0.60	−0.337 (0.000)	−0.043 (0.000)	−0.288 (0.000)	0.111 (0.000)	−0.321 (0.000)	−0.008* (0.779)
0.60 < *LOANSIZE* ≤ 0.75	−0.130 (0.000)	−0.039 (0.000)	−0.126 (0.000)	0.119 (0.000)	−0.131 (0.000)	−0.045* (0.092)
0.75 < *LOANSIZE* ≤ 1.00	0.051 (0.000)	−0.040 (0.000)	0.014 (0.005)	0.055 (0.004)	0.038 (0.000)	−0.040* (0.054)
1.00 < *LOANSIZE* ≤ 1.25	0.200 (0.000)	0.010* (0.174)	0.169 (0.000)	0.012* (0.528)	0.188 (0.000)	−0.009* (0.684)
1.25 < *LOANSIZE* ≤ 1.50	0.313 (0.000)	0.059 (0.000)	0.276 (0.000)	−0.036* (0.108)	0.300 (0.000)	0.089 (0.000)
1.50 < *LOANSIZE*	0.434	0.082	0.354	−0.046	0.432	0.086
PRODUCT TYPE Balloon					0.522 (0.000)	1.175 (0.000)
15-Year FRM					−0.046 (0.000)	−1.328 (0.000)
20-Year FRM					−0.059 (0.000)	−0.407 (0.000)
30-Year FRM					−0.042 (0.000)	−0.264 (0.000)
FHA/VA					−0.226 (0.000)	0.429 (0.000)
Second Liens					−0.149	0.395

[1] Note: All models were estimated by the method of maximum likelihood using the SAS CATMOD procedure. Empirical p-values are shown in parentheses. P-values are not shown for the imputed coeffieints (last category for each variable). An asterisk indicates that the coefficient is not statistically significant from zero at the five percent level for an asymptotic-normal hypothesis test. The coefficients burnout, occupancy status, product types, and the constants were modified for use in the regulation to reflect differently structure dummy variables.

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C. Single Family Loss Severity

1. Introduction

This supplementary material provides information on the estimation and application of statistical models for the single family loss severity component of the proposed risk-based capital stress test and regulation. With one exception, all cost and revenue elements of loss severity are calculated as averages of historical Enterprise experience with foreclosed mortgages. The one exception is that a statistical regression model was developed to project the sale proceeds on foreclosed (real estate owned, or REO) properties. This regression model uses the same property valuation process that was used to create a probability of negative equity variable in the default/prepayment analysis. However, in projecting REO sales proceeds, the process is used to create a variable that measures the average equity of performing loans that have the same characteristics (other than equity) as defaulting loans. The regression then describes the relationship between average equity of performing loans and average (negative) equity of defaulting loans. One minus the projected negative equity on defaulting loans gives the projected REO sale proceeds. This regression analysis allows stress test loss severity rates to reflect economic conditions and provides an opportunity to reasonably relate loss severities on current Enterprise portfolios to the benchmark experience.

With the exception of government insured loans, OFHEO's loss severity analysis does not make explicit distinctions by loan product type. Differences by loan products are captured in the basic loan terms—coupon rate, LTV, and amortization term-that factor into loss severity equations.

The Enterprises rely upon various counterparties to provide credit enhancements that offset gross severity rates. An explanation of how credit enhancements are modeled in the stress test can be found in the appendix to the regulation.

The remainder of this supplementary material is organized as follows: section 2 provides the conceptual framework for single family loss severity analysis; section 3 describes the data used in the analysis; section 4 discusses the statistical analysis; section 5 examines adjustments made to the severity equations to reasonably relate the results to the historical benchmark experience identified in the first NPR; and section 6 explains how the results of the statistical analysis are applied in the stress test.

2. Conceptual Framework

In determining the approach to use in modeling loss severity rates, OFHEO reviewed four research studies. None of these attempted to analyze the various components of loss severity, but rather used simple regressions of some measure of a gross severity rate on original loan-to-value and loan age. These studies provide little guidance, as they do not provide frequency distributions of observed severity rates, nor do they provide averages y loan types.[233]

OFHEO chose to analyze defaulted loan severity rates in three parts: loss of loan principal, transaction costs, and

[233] These studies are: Clauretie (1990), Lekkas, Quigley, and Van Order (1993), Crawford and Rosenblatt (1995), and Berkovec, *et al.* (1997). The Berkovec, *et al.* study is not focused on loss severities, but rather analyzes them as part of a broader study of potential lending discrimination. These four studies are reviewed by Capone and Deng (1998), who themselves are interested in variations in loss severity rates across defaulted loans that can be explained by the tenets of option pricing theory. *See also* Kau and Keenan (1997) for the one example of severity analysis in a theoretical mortgage pricing model.

funding cost. This decomposition was used for three reasons. First, the loss of unpaid principal loan balance (UPB) is a function of the loss of property value before and during the default period, which can be statistically modeled as a function of economic conditions. The second reason for a decomposition analysis is to accommodate the timing of various cash flows during the period between initial default (month of first missed payment) and final property disposition. In the stress test, all default losses are accounted for in the month of default. The loss severity rate accounts for the timing of income and expenses after the default month. The timing of post-default cash flows is captured using present value discounting techniques. This method also captures funding costs of the nonearning assets-first the mortgage, and then the REO. Finally, the stress test calibrates the severity component related to loss of principal balance to the economic conditions of the BLE, as will be discussed in section 5. The stress test also uses BLE data for the elapsed time between default and foreclosure completion, and between foreclosure completion and property disposition.

Loss severity is most frequently expressed as a rate rather than a dollar amount. The most accurate representation of the magnitude of losses is to express loss severity as a percentage of the UPB at the time of default. Therefore, OFHEO has chosen to calculate all costs and revenues associated with loss severity as a percentage of the UPB. This will result in the computation of loss severity rates rather than dollar amounts, but they become dollar amounts when the stress test multiplies both default and loss severity rates against loan balances.

3. Data

Loan level data on Enterprise single family REO properties were used to analyze the components of single family loss severity rates. The data contain all defaulted mortgages on single family (1–4 unit) properties that were both originated and had a last-paid-installment date between January 1980 and December 1995. After removing incomplete records, over 116,500 valid records remained in the analysis database. These records consist of loan terms, event dates (default, foreclosure, disposition), and various expense and revenue fields.

A second analysis database was created consisting of only those loans in the historical REO analysis database that met benchmark criteria. Those criteria singled out conventional, 30-year fixed-rate loans on single family properties (single unit, owner-occupied, detached properties) that originated in 1983 and 1984 in the States of Arkansas, Louisiana, Mississippi, and Oklahoma, and defaulted within ten years of origination. This benchmark database (789 loans) was used to create an adjustment factor that provides consistency between the loss severity rates projected in the stress test and the benchmark loss rates. This process is discussed in section 5, Consistency with the Benchmark Loss Experience, below.

Other data used in the analysis of loss severity rates includes historical Census division level HPI indices and their associated volatility parameters, which come from the *OFHEO HPI Report,* 1996:3.

4. Statistical Analysis

The primary statistical analysis performed for single family loss severity rates measured the impact of market conditions on REO sale proceeds. This is the one dynamic element of loss severity in stress test application. It relies upon original LTV, loan amortization, and Census division level house price growth. OFHEO performed a statistical regression analysis to model negative equity for defaulted loans as a function of the average equity of similar, but performing, loans. All other statistical analyses involved calculating average historical experience by loss severity element. The two elements with values computed as historical averages are foreclosure expenses and a combination of REO expenses, revenues (other than disposition proceeds), and property selling expenses. In addition, average times to foreclosure and time in REO were computed for use in calculating the net present value of revenues and expenses in the month of default.

When averages were computed for loss elements, a two-step procedure was used. First, the average experience of each firm was calculated using UPB as a weighting factor. This weighted average provides a good measure of portfolio-wide performance, although the analysis is based on individual loans. The second step was to give equal weight to the experience of each firm by taking a simple average of the experience of the two Enterprises. This procedure is also consistent with the procedure used to find the benchmark loss severity rate reported in NPR1.[234]

The averages of the foreclosure and the REO expense/revenue elements are based on the entire national, historical sample of Enterprise experience. Benchmark experience was not used by itself because it was evident from an analysis of the data that there were significant numbers of records with missing expense components. The magnitudes of these expense items should not vary between the benchmark region and other areas of the country for two reasons. First, the benchmark region has a variety of foreclosure laws, by State, so that the average foreclosure expense rate for the benchmark region is similar to averages from other regions of the country, and to the average for the nation as a whole. Second, OFHEO computed these loss components as percentages of the outstanding loan balance, rather than as actual dollar amounts. Thus, the fact that the benchmark region may have had lower property values than the national average, and therefore lower dollar losses per loan, will not be material. Average loss rate components from other regions of the country should be comparable to what would be found in the benchmark loan data, if those records were complete.

OFHEO does, however, base time frames on benchmark experience. Because the benchmark region does have a variety of foreclosure laws, these time frames are actually very close to those of the entire national experience of the Enterprises.

a. Predicting REO Sale Proceeds

The REO sale proceeds, as a percentage of the defaulting UPB, measures the impact of erosion of property value over time, both prior to and after default. To begin the analysis of REO sale proceeds, OFHEO computed negative property equity, the difference between the defaulting UPB and the gross property sale proceeds, as a percentage of the UPB.[235] This amount was regressed against average equity for similar, but non-defaulting loans. The resulting regression coefficient provides the relationship between average equity of performing loans and average (negative) equity of defaulting loans. The nuance here is that average equity of performing loans is first transformed into a standardized normal distance, or what is commonly called a z-score, before being used in the regression. This is a widely used statistical technique for

[234] *See* 61 FR 29592, 29597, June 11, 1996. Procedures here differ from those of the first NPR by calculating loss severity as a percentage of the outstanding loan balance at time of default, rather than a percentage of the original loan balance.

[235] The one expense that OFHEO does net from sale proceeds here is property repairs undertaken by the Enterprises during the REO period. Because these expenses reflect part of the loss of property value that occurred prior to foreclosure completion, it is appropriate that they be included in the estimation of the loss of UPB due to property value deterioration.

creating a standard unit of measure for comparisons across many different variables and/or value levels.

To measure average (performing loan) equity, the property value underlying each defaulting mortgage was adjusted using the change in the (Census division) OFHEO HPI from origination to the last-paid-installment date, and using loan amortization schedules.[236] This adjustment provides average expected equity for each loan, if it were performing. But these loans are not performing, and rather than having average house price growth, they will generally have lower-than-average house price growth. In fact, defaulting loans come from the lower tail of the equity distribution, so the statistical analysis must capture just how far into the tail defaulting loan properties will be, on average. OFHEO analyzed several measures of the house price distribution to find which gave the best prediction of the difference between average performing loan equity and average non-performing loan equity. The best predictor was the z-score, identifying the distance between the expected (performing loan) house price and the (actual defaulting) loan balance. The z-score transforms the actual difference between (expected) house price and (actual) loan balance into the number of standard deviations there are between the two values, where the standard deviation is of house prices in the Census division. The z-score tells how far below the average property value growth in the Census division must the growth of any individual property value be, before all borrower equity is eliminated. The difference of actual growth of defaulting loans from average growth for performing loans will be larger than this, on average, because the z-score distance gives the minimal difference needed to eliminate borrower equity. The z-score equation is:

$$z = \frac{ln(HPI_{d,q,t}) - ln(B)}{\sigma_{d,t}} \quad \textit{(Eq. 13)}$$

where:

z = standardized distance of the loan balance from the average house price at the time of default

$HPI_{d,q,t}$ = House Price Index value for properties in Census division d, whose loans originated in quarter q and defaulted at age t (in quarters). This is created by dividing the HPI value for the calendar quarter of the last-paid-installment date by the HPI value in the calendar quarter of loan origination.

B = the ratio of outstanding loan balance at default to the original house price. This captures the equity generated from both the original downpayment and loan amortization over time.

$\sigma_{d,t}$ = standard deviation of HPI growth rates for properties in Census division d, after t quarters. This is the square root of $(\alpha t + \beta t^2)$, where α and β are the two volatility parameters for each HPI series (published in the *OFHEO HPI Report*).

In their continuous rate forms, the cumulative growth rate factors are found by taking the logarithm of the HPI, as is done here. The log of *HPI* gives average price appreciation, and the difference between that and the log of the loan balance, *B,* gives the expected loan equity due to price appreciation, downpayment, and amortization.[237]

These standardized distances, or z-scores, are the key values used to compute the expected negative property equity (as a percent of the outstanding loan balance) when a foreclosed property is sold. Larger z-scores reflect some combination of large downpayments, loan amortization, and high levels of (average) house price growth since loan origination. In these circumstances, loans that do default should have relatively good rates of property sale proceeds as a percent of the mortgage UPB (small rates of negative equity). In other environments, where z-scores are small, there are low rates of appreciation in the market, and/or low downpayments and a lack of significant amortization. The small z-score indicates that there is a wide range of property values in the market area that are below the loan balance. Therefore, REO sale proceeds will be low and the negative property equity will be high.

The statistical equation used to predict negative property equity (L) was estimated using ordinary least squares (OLS) regression of actual rates of UPB loss on the z-scores computed for each loan. The regression dataset was limited to historical REO observations where $(-0.50 \leq z_t \leq 4.0)$, because sample sizes outside this range were very thin.[238] Log-transformed values of negative property equity ($\ln(L) + 1$)) were used in the regression to account for a change in the relationship between negative equity and z-scores as those values change. The estimated regression equation is:

[236] The last-paid-installment (LPI) month is the month directly prior to the month of default, when the first payment is missed. Loan amortization ends at LPI, and because the HPI index is updated quarterly rather than monthly, the choice of LPI month or default month for loan seasoning is immaterial.

[237] Taking the logarithm of B transforms owner-invested equity (downpayment plus amortization) into an implied HPI growth rate factor. It is the cumulative (negative) growth of HPI necessary to eliminate all positive equity in the property. By transforming B into its continuous rate counterpart in this fashion, the z-score variable can measure the amount by which the growth of property value on loan properties must be less than the average growth rate of performing loans before default is a real possibility (the point of zero equity). The regression then measures the relationship between actual below-normal growth on REO properties and the minimumly required below-normal house price growth needed to trigger default.

[238] In stress test application, outliers are given predicted equity loss values measured at the boundary points of the z-score range employed in the regression.

$$ln(L + 1) = 0.241325 - 0.076959 \cdot z \quad (Eq.\ 14)$$

where:

t-statistic for z coefficient = -102

R^2 = 0.09

One-half the regression variance (0.029104) is added to the regression equation to provide the median-to-mean adjustment factor for log-normal models.[239] The result is:

$$\ln(L + 1) = 0.27043 - 0.076959 \cdot z \quad (Eq.\ 15)$$

so that:

$$L = \exp(0.27043 - 0.076959 \cdot z) - 1 \quad (Eq.\ 16)$$

The low R-squared value for the regression indicates a wide variance of actual loss rates around the average, predicted rates. OFHEO has analyzed this variance and believes that using the simple regression equation that captures average loss rates at each z-score value is more appropriate for the stress test than is a more complex model that would capture deviations around that average loss rate. Average rates provide an appropriate simplification because loss severity rates will be applied to groups of loans.

The boundary values of L are computed at the boundary points of z used in the regression sample, 4.0 and -0.5. When $z = 4.0$, $L = -0.04$. This suggests that, on average, REO sales prices are 4 percent higher than the mortgage UPB in areas with significant house price appreciation and/or for loans that have substantial amortization. That is, the average default (and there will be relatively few) will actually have a small amount of positive equity, though generally not enough to pay the costs of selling the property. At the other extreme, where $z = -0.5$, the predicted value of $L = 0.36$. This is a situation where average property values on performing loans are 36 percent below their associated mortgage balances. This extreme was reached in several areas of the country at various times during the study period. Such a loss of loan principal can cause the total loss severity to exceed 60 percent of UPB.

b. Foreclosure Expenses

Foreclosure expenses vary principally by property State and by the rate of bankruptcy filings among defaulted borrowers.[240] The average expense rate in the historical observation period is five percent of UPB. Unlike other loss components, this component is based solely on Fannie Mae experience because Freddie Mac did not break out foreclosure expenses from REO expenses in its data systems.

c. REO Holding and Disposition Expenses

Property (REO) holding costs include such items as property maintenance, utilities, property taxes, and hazard insurance. OFHEO calculated the average total REO holding expenses, plus selling costs (principally, realtor fees), less miscellaneous revenues to produce a final REO expense loss severity factor of 13.7 percent.[241]

d. Time Frames

There are two time frames of interest: time from default to foreclosure completion, and time from foreclosure completion to property disposition. A mean expected value for each of the time periods of interest was calculated from BLE data. The mean benchmark foreclosure time (period from default to foreclosure) was 13 months. The mean benchmark REO/property sale time was seven months. These time frames are used in the stress test to discount the various default-related cash flows to the month of default.

5. Consistency With the Benchmark Loss Experience

The equation for negative equity of defaulted loans (equation 14) was estimated on all historical REO experience of the Enterprises. Using this broad range of data assured that the equation would be appropriate for loans entering the stress test with a wide range of loan amortization and cumulative HPI experience. The equation used in the stress test includes an adjustment that calibrates the results to the BLE.

The procedure for calibrating equation 16 to the benchmark experience parallels the procedure used by OFHEO to calibrate the single family default equations to the BLE. A database of defaulted loans meeting benchmark criteria was input into the negative equity equation to compute the projected negative equity, by loan. The z-score variable values were computed by assuming that all loans originated in the first quarter of 1984, using the West South Central HPI series, for purposes of assigning house price appreciation rates. These predicted rates of negative equity were then averaged by Enterprise, using UPB as a weighting factor. Finally, a simple average of these Enterprise averages was computed to arrive at a mean expected value for the benchmark REO database.

[239] The logarithmic equation used in the regression implies a lognormal distribution of potential negative equity values around predicted values. The point estimates from the regression, therefore, produce median rather than mean value estimates of loss of principal balance. The adjustment to arrive at the mean is the additive constant (0.029104), one-half the variance of the regression residuals.

[240] To process foreclosures when defaulting borrowers file for Bankruptcy Court protection requires further legal expenses to gain release from the bankruptcy ''stay'' on debt collection actions.

[241] As noted earlier, the Freddie Mac foreclosure expense rate is imputed from the Fannie Mae experience (five percent). Therefore, the REO holding costs used to create the average rate shown here use total expense for Freddie Mac less imputed foreclosure expense for Fannie Mae.

This final mean rate of negative equity on defaulted loans was then compared with the actual, historical mean rate across the two firms' benchmark experience. The average projected rate of negative equity using equation 16 and this averaging method was 21.30 percent. The actual historical experience average was 31.64 percent. The difference, 10.34 percent, reflects the nature of the benchmark experience: that defaulting benchmark loans tended to have larger losses, on average, than did loans from other regions of the country that experienced the same housing market conditions. The adjusted negative equity equation is:

$$L = (\exp(0.27043 - 0.076959 \cdot z) - 1) + 0.1034 \qquad \textit{(Eq. 17)}$$

Proceeds from REO sale are then computed as one minus the projected negative property equity for the defaulting loans in each loan group.

6. Application to the Stress Test

Stress test application of loss severities begins with the results of the statistical analysis of severity components discussed here, but then adds components for loss of loan principal, servicer claim payments, mortgage insurance, and seller/servicer recourse. OFHEO's approach is to account for all default related cash flows at one of three points in time: 120 days delinquency, foreclosure, and property disposition. The stress test then calculates the effective loss severity rate as a net present value of all cash flows, in the month of loan default. The month of default is one month after the last paid installment (LPI) date, the month of the first missed payment.

There is a difference in the treatment of sold and retained loans when computing stress test loss severity rates. For retained loans, defaulting UPB is not a cash outlay and, therefore, is not discounted. For sold loans, however, the defaulting UPB represents the current expense of repurchasing a defaulted loan from a security pool. It is, therefore, a cash-flow element that should be discounted.[242] This expense is normally incurred in the fourth month of default. Sold loans in default also involve four months of interest passthroughs to the investors while the loans remain in the security pools. The interest passthroughs are not immediate expenses of the Enterprises because they are initially matched by passthroughs made by the seller/servicers to the Enterprises. However, all post-default interest payments received by the Enterprises are reimbursed to servicers in the post-foreclosure claim filing. Therefore, all interest passthroughs between seller/servicers and Enterprises are ignored. Only the passthrough by the Enterprise to security holders is counted as an expense in the stress test, and it is included with the seller/servicer claim payment at time of foreclosure.

The stress test provides that, at the time of foreclosure, the Enterprises make servicers whole for expenses incurred on the loan and property, including foreclosure costs, and receive proceeds from any available mortgage insurance. When mortgage insurance is present, mortgage insurance payments will generally be larger than the servicer claim payment and provide net inflows of funds to the Enterprises at foreclosure.

Also, any available seller/servicer recourse is applied to reduce the final loss severity rate. There are some smaller sources of credit enhancements that further reduce Enterprise losses, and these are added once dollar losses are computed in the cash flow component of the stress test.[243]

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D. Multifamily Default/Prepayment

1. Introduction and Conceptual Framework

This section describes how OFHEO developed its model of multifamily default and prepayment rates for use in the risk-based capital stress test. The same theory that underlies the single family default/prepayment models, financial options theory, also underlies OFHEO's modeling of mortgage performance for multifamily loans. However, the single family approach is modified to account for the importance of property cash flows in the default decisions of investors. This theoretical framework treats mortgage terminations as a function of their financial value to the borrower. Both the single family and multifamily default/prepayment models also use a multinomial logistic specification to estimate the impact of explanatory variables on default and prepayment rates. Beyond these similarities in general approach, however, there are significant differences in the specifics of model construction and estimation.

Many of these differences reflect special features of multifamily mortgages. For these loans, the borrowers are all investors, and that affects the determinants of credit risk. Two key financial ratios are used in commercial mortgage underwriting: the DCR and the LTV. DCR is a property's net operating income (NOI) divided by the mortgage payment.[244] DCR indicates how much cash there is available for loan repayment after operating expenses are paid. LTV is the ratio of the UPB to the value of the property; it measures

[242] Such loans become part of the Enterprise retained portfolios once they are bought out of the security pools.

[243] These lesser sources of credit enhancements are items where the amount of recourse available to the Enterprises is not a function of per loan losses, but rather it is available in total dollar amounts for pools of loans.

[244] NOI is a measure of the differernce between full potential rent at market prices and operating expenses (including vacancy losses).

borrower equity.[245] Lenders concentrate on these two ratios at loan underwriting, and all major credit rating agencies start their analysis of the credit support levels needed to receive various rating grades with the DCR and LTV values of the loan collateral.

Multifamily mortgage modeling should also recognize the special features that differentiate commercial loans from single family residential loans. Commercial loans have prepayment restrictions, usually in the form of yield maintenance clauses, that severely reduce the value of refinancing during the early years of a mortgage. Commercial loans are also dominated not by fully amortizing 30-year loans, but by balloon mortgages with maturities of up to 15 years. These two product distinctions—yield maintenance and balloon terms—create different borrower incentives and different mortgage performance patterns for multifamily mortgages.

Previous research on multifamily mortgage performance has generally made simplifying assumptions to avoid having to deal with all of these issues in one model. First, research has tended to ignore DCR and only concentrate on LTV. Even then, without readily available property value indexes, researchers have not updated LTV over time to capture local market conditions.[246] Some studies have captured property cash flows, but they omitted LTV and had no mechanism for updating property cash flows for projection purposes.[247] One study that recognized the need for both DCR and LTV for predicting default rates, defined them to be perfectly correlated so that only one financial variable needed to be included in the model.[248] Another shortcoming of past research has been that default and prepayment have not been analyzed together.[249] Either defaults are assumed not to matter because of agency guarantees, or else prepayments are ignored because of yield maintenance terms. Most studies model defaults without prepayments, but prepayment studies are starting to appear, with three in 1997 and one in 1998.[250] In both default and prepayment studies, little work has been done to understand the dynamics of yield maintenance and balloon terms.[251] But even with all of these limitations in current research, the greatest concern is that researchers most often resort to pooling multifamily mortgages with loans on other commercial property types in order to have sufficient sample sizes.[252]

The broad conceptual framework chosen by OFHEO corresponds to the dominant paradigm in mortgage research, financial options theory. Studies that apply financial options theory to commercial mortgage performance have generally emphasized the role of borrower equity (LTV) in default rate estimation, but have not seriously modeled the role of cash flows (DCR).[253] However, because both DCR and LTV are critical credit risk dimensions, an appropriate multifamily mortgage performance model should also treat cash flows and equity as essential elements.[254]

For the default option to be in the money, the property must have both negative equity (LTV>1) and negative cash flow (DCR<1). The two sources of income for an investment property owner are rental (current) income and capital gains. Rental income can be thought of as dividend payouts from the property. Capital gains result when the property is sold. The owner holds the property until the expected annual rate of return from both dividends and capital gains becomes less than the return that could be earned by selling the property and investing the proceeds into another investment. However, if the rental market declines, and property equity becomes negative, then default becomes a viable option. This option will not be exercised as long as the dividend payout is positive. If property owners/borrowers were to default in the presence of positive cash flows, they would give up valuable cash flow streams. Therefore, default is only optimal if both equity and cash flow are negative. This implies that the dual condition, LTV> 1 and DCR<1, is required for default to occur.[255]

Prepayment options are in some ways simpler and in others more complex than default options. The simplicity arises because the financial value of prepaying a mortgage is directly measured by the mortgage premium value, the difference between the present value of future mortgage payments discounted at the current note rate, and present value of those same payments discounted at the current market rate. When interest rates fall, there is negative value to holding onto the existing mortgage, measured by a negative mortgage premium value. However, measuring the premium value itself is complex because of yield maintenance and balloon terms. When a

[245] Commercial loan underwriting also includes examinations of borrower credit, servicing capability, site and engineering reviews, and cost certifications for new construction. Market condition reports are part of the appraisal process used to estimate LTV at loan origination.

[246] Vandell (1992) and Vandell, et al. (1993) develop models of commercial mortgage default that update LTV over time using a national property-value index, along with the property-value diffusion process introduced by Foster and Van Order (1984) for single family mortgages.

[247] *See* ICF (1991) and Pedone (1991). These studies adapt the work of Edward Altman (1981, 1983) to predict corporate bankruptcy to model multifamily defaults. Capone (1991) discusses the application of bankruptcy models to multifamily mortgages, and provides a review of this literature. A related line of literature discusses the relationship between lender and borrower in the default/bankruptcy process. Kahn (1991) and Mahue (1991) study the impact of foreclosure laws on the balance of borrower and lender bargaining strength at these crucial junctures. Riddiough and Wyatt (1994a, 1994b) explore the power of lender signals of intent to pursue debt collections on distressed-loan foreclosure.

[248] Abraham (1993b).

[249] The first known attempt outside of OFHEO to model default and prepayment rates simultaneously was by Boyer, Follain, Ondrich, and Piccirillo (1997), who studied FHA insured mortgages.

[250] Abraham and Theobald (1997), Elmer and Haidorfer (1997), Follain, *et al.* (1997), and Capone and Goldberg (1998).

[251] In a theoretical pricing model, Kau, *et al.* (1990) do attempt to show how prepayment restrictions impact both default and prepayment options with balloon mortgages.

[252] The lack of historical data has often been cited as a major obstacle to research on multifamily and commercial loan credit risk (DiPasquale & Cummings, 1992; Standard & Poors, 1993; and Vandell, *et al.,* 1993). Studies that combine multifamily with other commercial mortgage types include Vandell (1992), Vandell, *et al.* (1993), Barnes and Gilberto (1994). Studies that use only multifamily data tend to model FHA-insured loans (Goldberg, 1994; ICF, 1991; Follain, *et al.,* 1997). Exceptions to this include Abraham (1993a, 1993b), who used multifamily loan data from Freddie Mac to study defaults, and Abraham and Theobald (1997), who use Freddie Mac data to model multifamily prepayment rates. Elmer and Haidorfer (1997) use Resolution Trust Corporation data to study multifamily prepayment rates. Researchers at OFHEO have published a default study based on Enterprise data (Goldberg and Capone, 1998).

[253] Even theoretical ''pricing'' models that simulate default rates on a pool of newly originated mortgages make simple assumptions that cash flow to the property owner is a fixed percentage of property value (Titman and Torous, 1989; Kau, Keenan, Epperson, and Muller, 1987 and 1990). They also treat cash flow as something negative (detracts from potential future property value) rather than something positive to the investor/owner/borrower.

[254] Abraham (1993b), Goldberg (1994), and Quercia (1995) have all questioned the sufficiency of net equity as a default trigger.

[255] The wealth-maximizing borrower should default if the property expects to have negative equity and negative cash flow from this point on. If there are negative cash flows, delaying default would lower wealth. If negative equity and negative cash flow were expected to be only temporary conditions, default would not be optimal. In principle one should incorporate expectations regarding rental markets and interest rates, simulate wealth over time, and have the borrower default only if it maximizes wealth over some long-run investment horizon. This was viewed as an overly complex, expensive, and therefore unfeasible approach. Theory notwithstanding, researchers typically construct the default option value variable using just current year information. This is also the approach taken by OFHEO. For relevant theoretical studies, *See* Kau *et al.* (1987, 1990), Brennan and Schwartz (1985), Dyl and Long (1969), Joy (1976), and Robichek and VanHorne (1967).

fixed-rate loan is under yield maintenance, it may refinance, but it will not accrue any value from the transaction until the yield maintenance period expires.[256] With balloon loans, there is the added uncertainty surrounding the contractual requirement to find new funding at loan maturity. Risk averse borrowers, therefore, may desire to refinance in the pre-balloon period even if the call option is not in the money.

An additional consideration for modeling prepayment speeds is that investors desire to leverage their investments to maximize return on equity. Interest rate spreads do not, therefore, provide the only incentive for refinancing a mortgage. To maximize leverage requires maximizing LTV ratios, within bounds set by lenders. Over time, investors will engage in cash-out refinancings in order to rebalance the ratio of debt to equity in the property. This second prepayment incentive can be captured by the LTV of the mortgage.

In modeling multifamily mortgage default rates, OFHEO distinguishes among the various programs of the Enterprises. Conventional multifamily loan purchases by the Enterprises began in 1983, and include ''cash'' and ''negotiated'' programs. Under the cash programs, the Enterprises purchased newly originated individual loans underwritten according to their own guidelines. Historically, most of these loans were retained in the portfolios of the Enterprises. Some ''cash'' loans were swapped for MBS, and this type of transaction is becoming more common. In a negotiated transaction, an Enterprise swaps pools of seasoned (i.e., aged and performing) loans for securities. These loans need not meet the underwriting guidelines of cash programs, and they are priced according to the risk of the loans in the pool. In negotiated transactions, unlike cash purchases, an Enterprise often requires credit enhancement from the seller/servicer to cover expected credit losses.

The initial cash programs exposed the Enterprises to significant credit risk in the late 1980s and into the 1990s. This exposure was due to generous appraisal practices used in the 1980s and to other significant weaknesses in those programs that do not exist today. Fannie Mae changed its cash program in 1988. Freddie Mac continued to build a portfolio of less-than-investment-grade mortgages through 1990. The poor performance of this portfolio led to a three-year moratorium on Freddie Mac's new purchases of multifamily loans, and a complete overhaul of the multifamily operations of the Enterprise.

Prepayment rates were modeled by loan characteristics product type rather than program type. This breakdown captures the differences in financial incentives to prepay that exist when yield maintenance penalties are or are not in effect, and the impact on defaults of balloon mortgage maturity. Balloon maturity is a significant multifamily modeling issue for the stress test because, in an up-rate interest rate environment, balloon loan borrowers are often required to pay off the existing mortgage and refinance, at much higher interest rates than property financials are currently supporting. In order to refinance at the balloon point in the up-rate scenario, property income must be higher than the minimum necessary to qualify for a new loan under the original interest rates. Therefore, it is important to model both the expected default and payoff rates of loans at balloon maturity for the stress test.

Section 2 of this supplementary material on multifamily default/prepayment provides a review of the historical data used to estimate the statistical models, and section 3 reviews the statistical procedures employed. Section 4 completes the description of the statistical model with explanations of the development of the explanatory variables. Section 5 presents and reviews the results of statistical estimations, and section 6 concludes with a discussion of how the estimated statistical equations are applied in the stress test.

2. Historical Data

a. Enterprise Loan Records

OFHEO used the combined historical experience of the Enterprises, 1983–1995, to estimate the statistical model of default and prepayment rates. This experience provided a large and rich data base that encompasses three different programs: the initial cash purchase programs that had high default rates; negotiated purchase (or transactions) programs where securities were swapped for pools of seasoned and performing mortgages; and new cash purchase programs that corrected flaws in the original programs and have experienced low default rates.

The historical data includes 35,759 conventional multifamily loans.[257] After eliminating missing or erroneous records, the sample includes observations on 21,994 loans: 12,845 from Freddie Mac and 9,149 from Fannie Mae. Of these, 61 percent are cash purchases and 39 percent are negotiated purchases. The final cash purchase sample is more complete than the negotiated purchase sample because, in negotiated programs, the Enterprises have relied more on buying seasoned portfolios with (limited) credit risk recourse to the seller/servicer, rather than on gathering enough property financial characteristics to re-underwrite the loans.[258]

The database was expanded by creating annual observations from loan acquisition to the termination year, or to 1995 if no termination occurred. The loan-year file includes 89,577 loan-year observations for cash purchases, and 59,415 observations for negotiated purchases. Cash purchases appear in the database with origination years from 1983 to 1995. The negotiated loans, however, have origination years as early as 1970 because they were often highly seasoned at time of acquisition. Annual observations are used, rather than monthly or quarterly observations, because of the relatively small number of multifamily termination events. If quarterly or monthly event histories were used, there would be significant numbers of time periods in which there were no terminations.

To avoid any possible statistical bias resulting from not having records of loan terminations prior to 1983, negotiated purchase loans enter the database starting in the acquisition year, rather than the origination year. But they enter at their proper age and are not treated as new originations at the time of acquisition. The same issue of potential ''left censoring'' bias also appears for certain cash purchase programs, where the Enterprises did not begin to maintain systematic records of loan terminations until 1991. For such programs, the loans do not enter the statistical estimation sample until 1991.[259]

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[256] ARM loans have minimal penalties, and they have prepaid much more often in the early years after loan origination.

[257] Fannie Mae has maintained a portfolio of FHA-insured multifamily mortgages over time. OFHEO chose not to model performance of these loans, but rather to assign default and prepayment rates according to conventional loans with similar features. Because FHA pays for nearly 100 percent of default losses, the stress test imposes no credit losses on FHA-insured mortgages on the stress test.

[258] Ninety percent of cash purchases are retained in the final sample, while only 41 percent of negotiated purchases had enough loan characteristics data to be kept in the sample. For the 41 percent of negotiated purchase loans in the sample, DCR values at time of acquisition were estimated by OFHEO by first estimating net operating income (NOI) as NOI=value at origination divided by an estimate of the average CAP rate multiplier for the year, divided by the mortgage payment amount.

[259] The left-censoring bias would result if the statistical model used complete loan-history records

For cash loans, the default outcome of record is a foreclosure or foreclosure alternative that still provides for the property to be liquidated.[260] For most Fannie Mae negotiated purchase loans, however, the default event of record is a 90-day delinquency. This is because, for Fannie Mae negotiated transactions, the loan is repurchased by the seller/servicer if it becomes 90-days delinquent. The seller/servicer then bills Fannie Mae for resolution costs, and these are deducted from a limited recourse pool originally established with funds from the seller/servicer at time of acquisition. OFHEO recognizes that 90-day delinquencies cannot be treated as full default events, and makes adjustments in the statistical model.

b. Rents and Vacancies

OFHEO uses a unique approach to property valuation that uses local market indexes of rent growth rates and vacancy rates to update net operating income, and through that, update DCR and LTV over time. Rent growth rates came from the residential rent component of the CPI for each of the four Census regions, and for the 29 MSAs covered by Bureau of Labor Statistics (BLS) surveys. Most MSA level CPI series produced by BLS start in 1970, but some do not begin until the 1980s. The regional CPI series are available beginning in 1978, so percent changes for these can only be computed starting in 1979. To capture rent growth rates for each year, partial MSA series were completed with regional series starting in 1979 and national series before that. The regional series themselves were also filled in for the pre-1979 period with percent changes in the national CPI residential rent series.

Vacancy rates were obtained from the Bureau of the Census H–111 series. These are available for the same MSAs as is the CPI residential rent series (back to 1970), and for Census regions, and, beginning in 1986, for the 50 States plus the District of Columbia.[261] As with rent growth rates, the most disaggregated index available was used for each loan, in each calendar year.

c. Tax RatesOFHEO required tax rate data for calculating the present value of depreciation writeoffs (see discussion of the explanatory variable, *DW,* below). In order to compute weighted average tax rates, OFHEO used Internal Revenue Service (IRS) data on the income distribution of taxpayers with net capital gains. For 1983–90, data on adjusted gross income for taxpayers with net capital gains were obtained from the IRS publication, *Individual Income Tax Returns* (annuals). For 1991–95, data were obtained from IRS, *Statistics of Income Bulletin* (quarterly). These income-class weights were used to compute weighted average tax rates for both capital gains and ordinary income.

The marginal tax rate on ordinary income used here is for Married Filing Jointly taxpayers (Schedule Y–1). Five percent was added to the Federal tax rate for State income taxes. Schedule Y–1's for 1983–95 were obtained from Internal Revenue Service, *Package X* (annual publications 1983–95). Data on capital gains tax rates were obtained from IRS's *Package X,* for 1983–95. No adjustment was made for State taxes on capital gains.

Data on depreciation schedules is for newly constructed residential rental property, from the IRS publication, *Depreciation 1992,* Publication 534. This publication includes accelerated schedules for years 1983–92. Accelerated depreciation was assumed in years in which it was an option. Because there were no changes in the tax code affecting depreciation after 1992, the schedule for 1992 was used for 1993–95.

3. Statistical Estimation

The statistical estimation involves binomial logistic regressions of subsets of the data. There are two separate regressions for default rates and five separate regressions for prepayment rates. This breakdown accommodates programmatic differences between cash and negotiated purchases in the default equations, and the changing nature of prepayment incentives across various products and loan terms. The results are matched together so that the end result is trinomial logistic probability equations that provide the same result as if defaults and prepayments were estimated simultaneously for each loan program and product.[262]

The logistic model is founded on assumptions that the utility of each borrower payment choice—make payment, prepay, or default—is a function of its contribution to wealth and that, each observation period, borrowers make the choice that maximizes wealth. The regressions compute weights (coefficients) that estimate the influence of each explanatory variable on the net wealth effect of one choice over another. These models estimate the log-odds of choosing a mortgage termination over continuing to make loan payments as a function of the explanatory variables. In particular,

$$ln\left(\frac{\text{probability of default}}{\text{probability of continuing payments}}\right) = X\beta \quad \textit{(Eq. 18)}$$

and

$$ln\left(\frac{\text{probability of prepayment}}{\text{probability of continuing payments}}\right) = Y\Gamma \quad \textit{(Eq. 19)}$$

for all loans, when some groups of loans only enter the sample if they survive to a certain point (e.g., time of acquisition by the Enterprise). If the sample were not censored at the acquisition point, the model could severely underestimate the rates of loan termination in the early years of a mortgage.

[260] Foreclosure alternatives include third party sales where a ''third party'' purchases the property at the foreclosure auction; short sales, where the Enterprise finds a buyer for the property prior to completion of foreclosure; and note sales, where the mortgage itself is sold to another investor.

[261] Census also added more MSAs starting in 1986. These were not used in OFHEO's statistical analysis.

[262] This is the three-choice logit model, though the more generic model is known as the multinomial logit, or MNL.

where:

ln = natural logarithm

X = matrix of explanatory variables (columns) by loan record (rows)

β = (column) vector of coefficients (weights) to be estimated

Y = matrix of explanatory variables (columns) by loan record (rows)

Γ = (column) vector of coefficients (weights) to be estimated

And the resulting equations for calculating probabilities are transformations of these equations:

$$\text{Probability (default } X, Y) = \frac{e^{X\beta}}{1 + e^{X\beta} + e^{Y\Gamma}} \qquad \textit{(Eq. 20)}$$

and

$$\text{Probability (prepayment } X, Y) = \frac{e^{Y\Gamma}}{1 + e^{X\beta} + e^{Y\Gamma}} \qquad \textit{(Eq. 21)}$$

If X and Y are matrices of all event-history records, then the resulting probabilities will be (column) vectors of estimated probabilities for each of these records, for each observed time period. Because of the relatively small number of loan defaults in the data, OFHEO used annual observations to estimate the equations. Economic variables are averages for each calendar year, and the logistic equations estimate probabilities of default and prepayment for all loans surviving to the beginning of the next year.

The probabilities of default and prepayment are interdependent, and normally the equations would be estimated using simultaneous equations methods. However, because there are two default equations and five prepayment equations, doing so would be quite complex. Following Begg and Gray, OFHEO estimated the system using single equation methods in which separate binomial log-odds equations are estimates for default and prepayment.[263]

4. Explanatory Variables

The multifamily mortgage performance model has separate sets of explanatory variables for default and prepayment analysis. They are described separately here.

a. Default Equations

OFHEO estimated two separate logit default equations, one for cash purchases and one for negotiated purchases. This decomposition serves three purposes. First, significant numbers of negotiated purchase loans did not enter the Enterprise portfolios until after the Tax Reform Act of 1986. That statute greatly changed the value of depreciation allowances to new purchasers of investment real estate. OFHEO desired to model the effects of tax law changes on default rates, but could only do this with the cash purchase loans, where there are significant numbers of observations both before and after tax reform. The second reason for separating cash from negotiated purchase loans is that negotiated loans did not undergo the same change of quality as did cash purchases. It is easier to separate the effects of movements by the Enterprises from original to new cash-purchase programs if these are isolated from the negotiated purchases for default analysis. A third reason for separating the two programs into two separate default equations is that the majority of negotiated purchase loans have seller/servicer repurchase provisions, which required use of 90-day delinquency as the default event of record. OFHEO decided that capturing the difference between 90-day delinquencies and full defaults was best achieved through an estimation that involved only negotiated purchases.

Table 33 provides a list of the explanatory variables used in each default equation. Each variable listed in the Table will be described and developed more fully below.

[263] *See* Begg and Gray (1984). To do this, one must be sure to censor competing termination events from the regression samples. That is, for default rate log-odds estimation, all prepayment observations must be censored in the period of the prepayment (and vice versa). This censoring assures that the estimation is of the log-odds of defaulting (or prepaying) versus remaining current on the mortgage. The underlying principle of logistic regression analysis that allows for this approach to modeling the competing risks of default and prepayment is called the independence of irrelevant alternatives. This principle means that logistic analysis assumes that the log-odds of default versus remaining current are not influenced by the log-odds of prepaying versus remaining current.

Table 33. Explanatory Variables in the Multifamily Default Equations

Variable	Description	Cash Purchase Equation	Negotiated Purchase Equation
JP_t	The joint probability of negative equity and negative cash flow (*LTV*>1.00 and *DCR*<1.00) in year *t*.	Yes	Yes
BJP_t	For balloon loans, JP_t times a dummy variable equal to 1 if the loan is in the balloon year, 0 otherwise.	Yes	No
DW_t	Present value of depreciation tax write-offs per $100 of property value. Value to a new owner over 20 years.	Yes	No
DD	Dummy variable equal to 1 if the loan was originated under an original cash purchase program (Fannie Mae, 1983-1987, Freddie Mac, 1983-1991), 0 otherwise.	Yes	No
RA	For ARM loans, dummy variable equal to 1 if the default type is a 90-day delinquency, 0 if it is a property loss event such as a foreclosure.	No	Yes
RF	For fixed-rate loans, dummy variable equal to 1 if the default type is a 90-day delinquency, 0 if it is a property loss event such as a foreclosure.	No	Yes
AY_t	The age of the mortgage in years.	Yes	Yes
AY_t^2	Loan age squared.	Yes	Yes

(i) Joint Probability of Negative Equity and Negative Cash Flow

The key explanatory variable in the default equations is the joint probability of negative equity and negative cash flow, which is defined as:

$$JP = \text{Prob}(LTV > 1 \text{ and } DCR < 1) \quad \textit{(Eq. 22)}$$

A probabilistic measure is used because the exact financial condition of each mortgaged property, over time, is unknown. However, the equity and cash flow positions of the property at time of loan acquisition, and how local rents and vacancy rates changed over time are known. With this information, and reasonable assumptions regarding the dispersion of rent growth rates and vacancy rates across properties, the joint probability, *JP*, can be constructed. This variable is similar to the probability of negative equity variable used in the single family mortgage performance model, only here the variable begins with an index of growth rates of property net operating income (NOI), rather than an index of the growth rates of property value directly. OFHEO developed this approach for multifamily modeling because there are no property value indexes available, and it was not feasible to develop one with Enterprise data.

Ideally, *JP* would capture all of the numerous factors affecting LTV and DCR, including rents, expenses, vacancies, special underwriting provisions (e.g., maintenance reserves), interest rates, and tax laws. OFHEO incorporated three important factors into the *JP* variable: rents, vacancies and interest rates. Because the actual property purchase year for current investors is unknown, the actual tax code affecting depreciation writeoffs is also unknown for each property. Therefore, OFHEO constructed a separate variable that captures changes in the value of tax benefits from property ownership to a new purchaser. Changes in property expenses are incorporated into *JP* by specifying that expenses are a constant ratio of rents.

(a) Creating Time Series for DCR and LTV

The construction of *JP* first involves creating time series variables for *DCR* and *LTV*. Each of these can be shown to be a function of property *NOI* in each time period, *t*:

$$DCR_t = \frac{NOI_t}{PMT_t} \quad \textit{(Eq. 23)}$$

where:

PMT_t = mortgage payment in period *t*

NOI_t = net operating income in period *t*

and

$$LTV_t = \frac{UPB_t}{V_t} = \frac{UPB_t}{NOI_t \cdot M_t} \qquad (Eq.\ 24)$$

where:

UPB_t = unpaid principal loan balance in time period *t*

V_t = property value in time period *t*

M_t = capitalization (cap) rate multiplier in time period *t*

For commercial properties, appraisers use capitalization (''cap'') rate factors for estimating the present value of a future stream of property NOI.[264] The cap rate multiplier for each loan at origination, M_0, can be derived given three other variables: LTV_0, UPB_0, and NOI_0. Because the cap rate multiplier is a function of interest rates, changes in interest rates over time will affect M_t and, through that, affect V_t and LTV_t also. OFHEO collected data on cap rate multipliers at origination on Enterprise loans and the mortgage coupon rates on those loans.[265] These data were used to estimate the elasticity of the cap rate multiplier with respect to interest rates, so that property values can be updated in response to interest rate changes. The estimated regression equation is:

$$\ln(M_0) = 3.01 - 0.27 \cdot (\ln r_{c,0}) \qquad (Eq.\ 25)$$
$$(t=13.3)$$

where:

$r_{c,0}$ = mortgage coupon rate at time zero (origination)

N = 8535 (sample size)

R^2 = 0.0525

M = 10.7 (mean cap rate multiplier across sample)

By estimating a double-log equation, the coefficient on the interest rate variable, $r_{c,0}$, is the elasticity of the cap rate multiplier with respect to interest rate changes. This elasticity is used to project changes in M_t over time (since loan origination) as follows:

$$\frac{M_t - M_0}{M_0} = -0.27 \cdot \left(\frac{r_t - r_{c,0}}{r_{c,0}} \right) \qquad (Eq.\ 26)$$

where:

r_t = market interest rate for multifamily mortgages in time *t* (OFHEO generated a time series of rates from Enterprise purchases of fixed-rate loans.)

and the factor used to update LTV^t over time is then,

$$\frac{M_t}{M_0} = 1 - 0.27 \cdot \left(\frac{r_t - r_{c,0}}{r_{c,0}} \right) \qquad (Eq.\ 27)$$

[264] While the cap rate multiplier is used here to project property value from NOI, the cap rate itself is the reciprocal of the multiplier. So if, for example, a cap rate multiplier of 10 is implied from the property value (and the underlying NOI), the actual cap rate is 0.10. The cap rate on each individual property begins, like other appraisal techniques, with cap rates found on recent sales of comparable properties. Appraisers then incorporate an assessment of the duration and risk of the earnings on the particular property into the final cap rate used to project property value; a risky earnings stream will be penalized with a higher cap rate (lower multiplier).

[265] The choice of an interest rate series to use here was one of convenience, and does not materially affect the results.

distribution of property level *DCR* and *LTV* values, it is convenient to use a logarithmic transformation of equation (31):

$$ln(NOI_t/NOI_0) = ln(RPI_t) + ln(Z_t) \qquad (Eq.\ 34)$$

where $Z_t = [1 - 2.15\ (\mu_t - 0.0623)]$ and RPI_t is a rent index that equals one plus the growth of rents since loan origination. Z_t can be interpreted as the percentage change in NOI_t due to changes in the vacancy rate since loan origination, and RPI_t is the percentage change in NOI_t due to rent growth. If $ln(Z)$ and $\ln(RPI)$ are normally distributed across properties, at any given point in time, then their sum has a bivariate normal distribution. This implies a bivariate normal distribution for $ln(DCR)$ and $ln(LTV)$, which provides the distributional form used to estimate the joint probability that $DCR < 1$ and $LTV_t > 1$ for any given property, JP_t.

Normality for $ln(RPI)$ follows from the standard assumption that growth rates follow a lognormal diffusion process over time. Such a process is also foundational to the OFHEO HPI, which is used for single family mortgage performance analysis. With lognormal diffusion, the distribution of $ln(RPI_{j,t})$, where j is a property index, is:

$$ln(RPI_{j,t}) \sim N(ln(RPI_t), t \cdot \sigma_t^2) \qquad (Eq.\ 35)$$

where:

$RPI_{j,t}$ = RPI for individual property, j, in time t

RPI_t = market rent index measuring cumulative growth of rents from time of loan origination through time t

σ_t^2 = variance in individual property rent growth rates (diffusion parameter) within each time period (year), t (assumed constant over time and place)

If all apartment units can be assumed to have the same probability of being vacant, the distribution of vacancy rates across properties, within a geographic area, can be assumed to be binomial, with mean and variance parameters:

$$\nu_{j,t} \sim BN(\nu_t, \nu_t \cdot (1 - \nu_t)) \qquad (Eq.\ 36)$$

where:

$\nu_{j,t}$ = vacancy rate for property, j, in time period t

ν_t = market area vacancy rate index in time period t

The binomial distribution for apartment vacancies at the project level is bounded below by zero and skewed to the right, and because it can be approximated by a lognormal distribution with the same parameters. Thus, $Z_{j,t}$, which is a linear transformation of $\nu_{j,t}$, can be modeled with a lognormal distribution:

$$Z_{j,t} \sim LN(Z_t, 2.15^2 \cdot \nu_t \cdot (1 - \nu_t)) \qquad (Eq.\ 37)$$

This allows $ln(Z_{j,t})$ to be modeled with a normal distribution. Rewriting the parameters of $Z_{j,t}$ as:

$$Z_{j,t} \sim LN(\mu_{Z_t}, \sigma_{Z_t}^2) \qquad (Eq.\ 38)$$

we can write the parameters of the (normal) distribution of $ln(Z_{j,t})$ as:

$$\mu_{lnz} = ln\mu_{z_t} - 0.50\sigma_{lnz_t}^2 \text{ and}$$
$$\sigma_{lnz}^2 = ln(1 + \sigma_{z_t}^2/\mu_{z_t}^2) \qquad (Eq.\ 39)$$

where the t subscripts for these parameters are dropped here and subsequently for clarity. Because both $ln(DCR_{j,t})$ and $ln(LTV_{j,t})$ are linear functions of the normally distributed random variables, $ln(Z_{j,t})$ and $ln(RPI_{j,t})$, $ln(DCR_{j,t})$ and $ln(LTV_{j,t})$ have a bivariate normal distribution, $BV(\mu_1,\mu_2,\sigma_1,\sigma_2,\rho)$, where,

$$\mu_{1,t} = \ln DCR_t - 0.50 \cdot \sigma^2_{lnZ}$$

$$\mu_{2,t} = \ln LTV_t + 0.50 \cdot \sigma^2_{lnZ}$$

$$\sigma^2_{1,t} = t \cdot \sigma^2_r + \sigma^2_{lnZ} \qquad \textit{(Eq. 40)}$$

$$\sigma^2_{2,t} = t \cdot \sigma^2_r + \sigma^2_{lnZ}$$

$$\rho = \mathrm{corr}(ln(DCR_{j,t}), ln(LTV_{j,t}))$$

The correlation between $ln(LTV_{j,t})$ and $ln(DCR_{j,t})$ in the historical Enterprise data is used as an estimate of π (-0.5975). Unpublished data from the Bureau of Labor Statistics (BLS) suggests a value for σ^{2t} of 7.5 percent. Alternative values between 5 and 15 percent were also considered, but the statistical model results (default rate equations) were insensitive to the value used for this variance.[266]

The bivariate normal distribution defined by the parameters in equation 40 can be used to calculate the joint probability of negative equity and negative cash flow, *JP*. The joint probability is the bivariate (standard) normal distribution evaluated at particular boundary (cutoff) values for $ln(DCR)$ and $ln(LTV)$. The definition of $JP_{j,t}$ can be restated as:

$$JP_{j,t} = \mathrm{Prob}\,(ln(DCR_{j,t}) < 0 \text{ and } ln(LTV_{j,t}) > 0) \qquad \textit{(Eq. 41)}$$

which can be calculated using the bivarate normal distribution:

$$JP_{j,t} = \frac{1}{2\pi \cdot \sqrt{1-\rho^2}} \int_{-\infty}^{a} \int_{b}^{\infty} exp\left(\frac{x^2 - 2\rho xy + y^2}{2(1-\rho^2)}\right) dy\, dx \qquad \textit{(Eq. 42)}$$

where *x* and *y* are two standard normal random variates, each representing the possible values of the logs of *DCR* and *LTV* values on all apartment properties in a given geographic area, at a given point in time. The *x* and *y* values are standardized, which for *DCR* and *LTV* is accomplished by subtracting from them the log of the expected values for each property, $\mu_{1,t}$ and $\mu_{2,t}$, and then dividing by the respective standard deviations, $\sigma_{1,t}$ and $\sigma_{2,t}$. The two limits of integration, *a* and *b*, are the standardized differences between the expected values for each property and the boundary conditions, which are the log of 1.00 for each. So, from equation 40 they are just:

$$a = \frac{-\mu_{1,t}}{\sigma_{1,t}} \qquad \textit{(Eq. 43)}$$

and

$$b = \frac{-\mu_{2,t}}{\sigma_{1,t}} \qquad \textit{(Eq. 44)}$$

(iii) Updating DCR_t for Balloon and ARM Payment Shocks

The joint probability variable, JP_t, is given additional weight for balloon loans in the maturity year. Weaker loans will be unable to qualify for refinancing in the balloon year, especially if there is an increase in rates, which leads to more defaults at that point, for any given level of DCR_t and LTV_t. This effect should be a function of JP_t. Balloon year shock is added using a composite variable BJP_t:

[266] This is because the variance of *lnDCR* and *lnLTV* is much more heavily influenced by the variance of the vacancy rate than the variance of the growth rate of *RPI*.

$$BJP_t = BYR_t \cdot JP_t \qquad (Eq.\ 45)$$

where BYR_t is a dummy variable equal to 1 if the observation is the balloon year, and 0 otherwise, and JP_t is the joint probability of negative equity and negative cash flow. (The loan specific subscript, j, is dropped here for ease of exposition.) Due to the small number of balloon loans in negotiated purchase portfolios, this variable is only estimated in the default rate equation for cash purchase loans. In stress test application, the estimated coefficient for cash purchases is also used to predict default rates of negotiated purchase balloon loans in the maturity year.

The Enterprises tend to extend balloon loans beyond maturity when properties cannot meet minimum qualification standards for a new loan, provided the borrower continues to make the monthly payment on the original mortgage. This possibility of what is called ''extension risk,'' the risk of loans not leaving the portfolio at the balloon point, has been documented by Elmer and Haidorfer (1997) and by Abraham and Theobald (1997). OFHEO also finds that in the Enterprise database a large percentage of loans are extended beyond balloon maturity. This model imposes payment shock for extended loans by updating the DCR to reflect what the borrower would be paying if the borrower refinanced the property. DCR_t is updated after the balloon point by adjusting PMT_t to reflect a new payment level commensurate with market interest rates for fixed-rate (fully amortizing) loans in the balloon year.

ARMs are treated with similar DCR adjustments, except that the payment adjustment occurs annually.[267] Fannie Mae and Freddie Mac purchased very few ARM loans through their cash programs, however there are significant numbers of negotiated transactions that are ARMs.

(iv) The Present Value of Depreciation Write-offs for Multifamily Properties

The value of depreciation write-offs to a new property owner is calculated with the present value formula used by Goldberg and Capone (1998):[268]

$$DW_t = \sum_{s=t}^{t+19} \left(\frac{\theta_s DEP_s}{(1+r_t)^s} \right) - \varphi_s \left(\frac{\sum_{s=1}^{20} DEP_s}{(1+r_t)^{20}} \right) \qquad (Eq.\ 46)$$

DW_t is the present value of depreciation write-offs for each $100 of investment in rental housing, and can be thought of as the percentage of the investment tax basis that is returned to the investor through depreciation write-offs. The tax rate data used to calculate this variable are described above in section IV.D.2., Historical Data.

In addition to tax rates, an estimate of a required rate of return is needed to calculate the present value of depreciation write-offs. For this OFHEO used an estimate of the weighted average cost of capital, with 20 percent equity and 80 percent debt financing. The cost of debt financing is measured with data from the Enterprises on the average coupon rate of multifamily fixed-rate mortgages in each year, 1983–95 ($r_{f,t}$). The cost of equity is calculated with data from the Enterprises and the Bureau of Labor Statistics. In particular, if property NOI is expected to increase annually at the rate *g*, then the cap rate, *CAP*, can be thought of as equaling the required return on equity (r_e) minus the growth rate, g_t. This implies that the required return on equity equals:

$$r_{e,t} = CAP_{0,t} + g_t \qquad (Eq.\ 47)$$

$CAP_{0,t}$ is estimated using cap rate values for all Enterprise loans originated in year, *t*, and the relationships estimated in equation 27. Values for g_t are three-year average growth rates of rents, using the Bureau of Labor Statistics CPI residential rent series, national average (for years *t*–2, *t*–1, and *t*).

The weighted average discount rate for all loans in year, *t*, is then:

$$r_t = 0.2 \cdot r_{e,t} + 0.8 \cdot r_{f,t} \qquad (Eq.\ 48)$$

Table 34 shows values of DW_t in the study period, 1983–95.

[267] Nearly all ARMs in Enterprise portfolios are indexed to the 11th District FHLB Cost of Funds, with monthly rate adjustments, semi-annual payment adjustments, and negative amortization provisions. The payment adjustment calculations here proxy for the full stress of partial payment adjustments and negative amortization by treating ARM loans as 5/1 products where annual payment changes are only limited by the lifetime and annual rate caps (5 and 1 percent, respectively). This allows for larger potential payment shock than would normally be allowed on these loans to compensate for the lack of negative amortization provisions in this model.

[268] The variable in the Goldberg and Capone (1998) article is called *PVTAX*, but it is the same as the *DW* variable shown here. Weights for Θ and Φ are the percent of taxpayers in adjusted gross income groups.

Table 34. Trends in the Present Value of Depreciation Write-offs, 1983-95

Year	DW_t
1983	12.94
1984	12.91
1985	13.52
1986	14.33
1987	9.50
1988	7.87
1989	7.73
1990	8.03
1991	7.06
1992	7.46
1993	8.29
1994	8.57
1995	9.27

(v) Program Restructuring

The original cash purchase programs of the Enterprises were implemented in an overheated lending environment in which appraisal practices allowed for inflation adjustments to rents when calculating property value. Such adjustments resulted in understatements of LTV_0 and overstatements of DCR_0, leading to the purchase of loans with understated credit risk and, eventually, to severe credit losses. In addition to the overstatement of anticipated rents, original multifamily cash-purchase programs at the Enterprises had other significant weaknesses. For these reasons, on loans purchased under original cash programs (Fannie Mae, 1983–1987, Freddie Mac, 1983–1991) the stress test accounts for increased risk in two ways. The first method is to adjust LTV_0 and DCR_0 on original cash program loans to extract the average inflation factors. Internal research at OFHEO has concluded that reasonable adjustment multipliers are 0.85 for DCR_0 and 1.27 for LTV_0.

The second method used to account for increased default risk in original cash programs is to include a dummy variable (*PR*) in the default equation. This measures the behavioral difference of loans purchased prior to program restructuring (1 = original cash purchase loan).

(vi) Default Type

For most loans acquired through negotiated transactions, the loan event used to estimate defaults is a 90-day delinquency, rather than a foreclosure. A different event was chosen for these loans because the seller/servicer typically has a contractual obligation to repurchase delinquent loans from security pools and resolve the default. As a result, the Enterprises' data do not reflect which of these loans were cured or renegotiated and which resulted in property loss events. These loans will have more observed ''defaults'' because they include cures and loan modifications as well as property loss events. To adjust for this discrepancy, two dummy variables are included in the negotiated purchase default equation: one to flag ARM loans under repurchase contracts (*RA*), and one to flag fixed-rate loans under repurchase contracts (*RF*).

(vii) Loan Age

Default risk is greatest in the years just after loan origination. Apartment projects are then most vulnerable to economic shocks because DCR_t may be low, LTV_t may be high, and it may take several years to create a viable market niche for the property. However, a financially troubled project will not default immediately. First, valuable depreciation write-offs may be available in the early years to counterbalance negative property cash flow. Second, working-capital reserves may forestall default. And third, the owner may ''bleed the project'' by deferring maintenance and other expenditures prior to delinquency.[269] Age denotes the loan year of an observation. Thus, if a loan was originated in 1985, its age is 1 in 1985, 2 in 1986, and so on.

Other studies of commercial mortgage defaults confirm that defaults tend to rise in the first years after loan origination and then, once the weakest loans exit, the conditional default rate declines.[270] Preliminary analysis of Enterprise data indicated that the peak default period is about four years after loan origination. To capture this underlying trend, a quadratic age function is included in the default equations.

b. Prepayment Equations

The explanatory variables chosen for the prepayment equations are designed to capture multiple refinancing incentives: exercising the ''call'' option (normal refinance); rebalancing debt and equity in the property (cash-out refinance); risk aversity with respect to

[269] This final reason is discussed by Quercia (1995) and by Riddiough and Thompson (1993).

[270] *See* Snyderman (1994).

pending balloon expirations (early payoffs); and balloon payoffs. The overall model is separated into five equations in order to best capture the differing prepayment incentives by product and product-life stage. For ease of exposition, these five equations are referred to here as ''models.''

The first model is for fixed-rate loans in the initial yield maintenance period, when refinancing has no immediate value. Beyond the yield maintenance period, fully amortizing and balloon loans with fixed interest rates are analyzed separately in two additional models. This approach is used because, after yield maintenance ends, balloon loans prepay more quickly than self-amortizing loans, reflecting borrower uncertainty surrounding interest rate movements leading up to the time of loan maturity, when a payoff is required. At maturity, balloon loans are viewed as having payoffs rather than prepayments. The dynamics of required payoffs are much different from those of voluntary prepayments prior to maturity. Therefore, a fourth equation is estimated for balloons during and after the maturity year. This fourth model includes both fixed-and adjustable-rate balloons. The fifth and final model is for adjustable-rate mortgages other than those that may have reached a balloon maturity point. Adjustable rate mortgages do not have yield maintenance terms, and their refinancing incentives are different from those of fixed-rate mortgages.

In prepayment model 4, for balloon payoffs, OFHEO recognizes that while there is a contractual obligation to find new sources of financing at the balloon point, those with weak financials may not qualify for new funding. The Enterprises, like all lenders, however, are often unwilling to initiate foreclosure if loan payments are being made under the current (but now expired) contract. OFHEO's approach to these extended loans is, therefore, to continue to model payoff rates at and beyond the balloon point.

Table 35 sets forth the structure of the explanatory variables used in the five prepayment equation/models, as follows:

Table 35. Explanatory Variables Used in Multifamily Prepayment Equation/Models

Variables	Definitions	Prepayment Equation/Models				
		1[1]	2[2]	3[3]	4[4]	5[5]
RSD_t	Relative interest rate spread if current rates are less than the coupon rate. Zero if current interest rates in year t are higher than the coupon rate.	Yes	Yes	Yes	No	No
RSU_t	Relative interest rate spread if current rates are greater than the coupon rate. Zero if current interest rates in year t are lower than the coupon rate.	Yes	No[6]	Yes	No	No
$RDS1_t$	RSD_t times dummy variable equal to 1 if year t is one year prior to balloon year; 0 otherwise.	No	Yes	No	No	No
$RSD2_t$	RSD_t times dummy variable equal to 1 if year *t* is two years prior to balloon year; 0 otherwise.	No	Yes	No	No	No
RS_t	Relative interest rate spread between ARM and FRM multifamily conventional loans in year *t*.	No	No	No	No	Yes
$r_{f,t}$	Average market interest rate for conventional multifamily fixed-rate loans in year *t*.	No	No	No	No	Yes
AY_t	Loan age in years.	Yes	Yes	Yes	No	Yes
AY_t^2	Loan age squared.	Yes	Yes	Yes	No	Yes
LTV_t	LTV ratio in year *t*.	Yes	Yes	Yes	No	Yes
PQ_t	Probability of qualification for a new loan in year *t* (*LTV*<=0.8 and *DCR*>=1.2).[7]	No	No	No	Yes	No
YTG_t	Years remaining ("to go") in the yield maintenance period.	Yes	No	No	No	No

[1] All fixed-rate loans, under yield maintenance.

[2] Fixed-rate balloon loans in pre-balloon period (post-yield maintenance, pre-balloon).

[3] Fixed-rate, fully amortizing loans, out of yield maintenance.

[4] All balloon loans at and beyond maturity year.

[5] All ARMs, except for balloon-ARMs at and beyond maturity year.

[6] This variable is not included in this equation/model because of lack of variability in the historical data series.

[7] This variable is only included in the balloon maturity equation/model because of collinearity with the *LTV* variable used in other equations.

(i) Relative Spreads in Interest Rates

The relative difference between coupon and market interest rates is the primary call option variable used in the prepayment equations. For fixed-rate loans (prepayment models 1–3), OFHEO includes spread variables when market rates are lower ($RSD_{j,t}$) and when market rates are higher than coupon rates

($RSU_{j,t}$). Asymmetry of effects is allowed for because drops in rates affect refinancings with different motivations than rises in rates do. Rate declines stimulate refinancings designed to lower interest costs, while rate increases discourage cash-out refinancings.

$$RSD_{j,t} = \begin{cases} \dfrac{r_{j,t} - r_{f,t}}{r_{j,t}} & \text{when } r_{j,t} > r_{f,t} \\ 0 & \text{otherwise} \end{cases} \qquad \textit{(Eq. 49)}$$

$$RSU_{j,t} = \begin{cases} \left| \dfrac{r_{j,t} - r_{f,t}}{r_{j,t}} \right| & \text{when } r_{j,t} < r_{f,t} \\ 0 & \text{otherwise} \end{cases} \qquad \textit{(Eq. 50)}$$

where:

$r_{j,t}$ = coupon interest rate on mortgage *j* in year *t*

$r_{f,t}$ = market rate, fixed-rate loans, in year *t*

The down-rate spread variable, $RSD_{j,t}$, is given added weight in the years preceding balloon maturity (model 2) in order to capture the risk aversity of borrowers with respect to interest rate movements leading up the balloon point. This weight is added through two interactive variables. First, $RSD1_{j,t}$, is $RSD_{j,t}$ multiplied by a 0/1 dummy variable that is turned on during the year immediately preceding the balloon year (13–24 months prior to the maturity month). The second, $RSD2_{j,t}$, is $RSD_{j,t}$ multiplied by a 0/1 dummy variable that is turned on during the second year preceding the balloon year (months 25–36 prior to the maturity month).

For adjustable rate mortgages (model 5), the spread variable is not separated into positive and negative components, but is allowed to have one effect for both increases and decreases in interest rates.[271] Because ARM coupon rates change every year, the relative spread variable is used to capture the slope of the yield curve, which indicates whether it is more valuable to retain the ARM or to refinance into a fixed-rate loan.

$$RS_{j,t} = \frac{r_{j,t} - r_{f,t}}{r_{j,t}} \qquad \textit{(Eq. 51)}$$

(ii) Market Interest Rate

An additional interest rate variable is added to the ARM equation (model 5). This is the fixed-rate mortgage rate, $r_{f,t}$, and it captures incentives to refinance into fixed-rate products when the level of rates is low.

(iii) Years-To-Go in the Yield Maintenance Period

Yield maintenance fees are a function of the remaining time until the end of the prepayment restriction period. As the yield maintenance period draws to a close, the prepayment penalties decline and the value of refinancing increases. To capture this change, prepayment model 1 has a variable that measures the years-to-go until the end of the yield maintenance period (YTG_t).[272]

A small number of older Enterprise loans had prepayment lockouts for a period of years, rather than financial prepayment fees. For these loans, we set YTG_t equal to 10 (its maximum value) throughout the restriction period.

(iv) Loan-to-Value Ratio

Investors in multifamily properties will engage in cash-out refinancings to increase returns on invested equity. This refinance motivation as *LTV* falls over time is captured by including LTV_t as an explanatory variable.

(v) Loan Age

The baseline prepayment hazard is a function of the desired holding period of investors. The holding period is heavily influenced by tax laws: accelerated writeoffs and shorter depreciation schedules encourage shorter holding periods. It is also affected by exogenous factors, e.g., investor retirement. Lacking data to measure the expected holding periods of investors, we assume that the distribution of expected holding periods, and their effect on baseline prepayment rates, can be captured through a quadratic function of mortgage age.[273]

[271] Also, a lack of observations on high interest rate environments made it difficult to estimate separate effects for rate rises (*RSU*).

[272] OFHEO experimented with variables that attempted to capture the impact of yield maintenance fees on refinancing incentives, but the fixed effects (years-to-go) proved to be a better predictor of historical mortgage performance.

[273] Follain, *et al.* (1997) attempt a fourth-order function of age to provide a more flexible baseline hazard function, but the third and fourth order terms are not statistically significant. Therefore, OFHEO accepts a second-order age function as sufficient for capturing the distribution of expected investor holding periods.

(vi) Probability of Qualifying To Refinance

An important obstacle to call option exercise is qualifying for a new loan. Because information on property financials after loan origination is not available, it is not known which properties can, at any point in time, meet minimum standards, *DCR*=1.20 and *LTV*=0.80. Instead, the model uses the same approach employed for default analysis, calculating the joint probability that *DCR* and *LTV* will meet minimum qualification standards (PQ_t). PQ_t is measured by evaluating the bivariate normal distribution shown in equation 42 with new integration limits:

$$PQ_{j,t} = \frac{1}{2\pi \cdot \sqrt{1-\rho^2}} \int_{c}^{\infty} \int_{-\infty}^{d} exp\left(\frac{x^2 - 2\rho xy + y^2}{2(1-\rho^2)}\right)(dy\,dx) \qquad (Eq.\ 52)$$

where, for any given loan (j) in any given time period (t):

$$c = \frac{ln(1.20) - ln\left(DCR_t \cdot \frac{PMT_0}{RPMT_t}\right) - 0.50 \cdot \sigma^2_{lnZ}}{\sigma^2_{1,t}} \qquad (Eq.\ 53)$$

$$d = \frac{ln(0.80) - \mu_{2,t}}{\sigma^2_{2,t}} \qquad (Eq.\ 54)$$

where:

$RPMT_t$ = mortgage payment if the loan were refinanced at time *t*, at current market interest rates

This effectively estimates the probability:

$$PQ_{j,t} = \text{Probability}\,(lnDCR_{j,t} > ln(1.20)\ and\ lnLTV_{j,t} < ln(0.80)) \qquad (Eq.\ 55)$$

(vii) Summary of Prepayment Models

In summary, the five prepayment models (equations) are organized as follows:

1. Model 1: All Fixed-Rate Mortgages-Fully Amortizing and Balloon-in the Yield Maintenance Period

Includes explanatory variables to capture investor holding horizons (AY_t, AY_t^2), normal refinancings (RSD_t), cash out refinancings (LTV_t), adverse interest rate effects on cash-out refinancings (RSU_t), and effects on normal refinancings due to yield maintenance (YTG_t).

2. Model 2: Balloon Loans After Yield Maintenance, but Prior to the Maturity Year

Includes explanatory variables for normal refinancings (RSD_t), cash-out refinancings (LTV_t), preballoon incentives to refinance and avoid the uncertainty of interest rates at maturity ($RSD1_t$ and $RSD2_t$), and the various investment horizons of borrower/owners (AY^t, AY_{t2}). The variable for adverse interest rate offsets to cash-out refinancings (RSU_t) is not included in this equation because of a lack of positive observations in the historical data series.[274] The coefficient from model 3 is used for this variable in this equation in stress test application.

3. Model 3: Self-Amortizing Fixed-Rate Loans After Yield Maintenance

Includes explanatory variables for investment horizons (AY_t, AY_t^2), normal refinancings (RSD_t), cash-out refinancings (LTV_t), and adverse interest-rate effects on cash-out refinancings (RSU_t).

4. Model 4: Balloon payoff

Includes an explanatory variable for the ability of the property to qualify for new financing (PQ_t). This is the only variable because at the balloon point there are no longer prepayments, only payoffs.

5. Model 5: Prepayments of Adjustable Rate Mortgages

Includes explanatory variables for the expected investment horizons of borrower/owners (AY_t, AY_t^2), cash-out refinance incentives (LTV_t), and incentives to refinance out of ARMs and into fixed-rate products (RS_t and $r_{f,t}$).

5. Results of the Statistical Estimation of Default and Prepayment Equations

Table 36 provides maximum likelihood estimates of coefficients in the two default equations.

[274] Estimating the regression equation with both *RSD* and *RSU* does not significantly change the coefficient on *RSD*. The *RSU* coefficient is negligible and without statistical significance.

Table 36. Binary Logistic Default Equations for Multifamily Loans

	Cash Purchases		Negotiated Purchases	
Variable	**Coefficient Estimate**	**Wald Chi-Square**	**Coefficient Estimate**	**Wald Chi-Square**
Constant	-10.0191	414.3	-9.6418	1065.4
AY_t	1.2687	229.9	1.0596	213.5
AY_t^2	-0.0790	127.5	-0.0633	144.9
BJP_t	2.6446	10.8	NA	NA
PR	0.6203	17.4	NA	NA
DW_t	-0.0829	4.9	NA	NA
JP_t	7.8230	979.4	12.1660	290.8
RA	NA	NA	0.6751	20.6
RF	NA	NA	0.2627	1.8
Model χ-squared	1693.8	DF=6	787.8	DF=5

All coefficient signs are as expected in both default equations, and all variables have significant effects, both statistically and practically. The age patterns in each equation (including the constant term) are similar, but the joint probability (JP_t) has a larger effect on negotiated purchase default rates than on cash-purchase default rates. This finding may result from the fact that most negotiated loan defaults were 90-day delinquency rather than foreclosures, and delinquencies may be more sensitive to changes in variables, such as vacancy rates, that underlie JP_t.

The dummy variable for program restructuring (*PR*) has a coefficient of 0.6203. That implies that annual default rates on original cash-purchase loans are roughly 1.6 times those of new-cash purchase loans.[275] The value of the depreciation write-off coefficient indicates that the decrease in depreciation allowances that were part of the 1986 tax reform increased default rates roughly 40 percent.[276]

Table 37 provides maximum likelihood estimates of the five prepayment models (equations). All of the coefficient estimates have the expected signs and provide consistent results. While the coefficient of the negative spread variable (RSD_t) is larger during the yield maintenance than it is out of yield maintenance, it actually has a much smaller effect on the probability of prepayment. In this functional form, the coefficient represents (approximately) the percentage change in prepayments per unit change in rates. Because prepayment rates are much greater for loans out of yield maintenance, the larger proportional effect for loans in yield maintenance is still much smaller in absolute terms.

[275] The marginal probability of binary logit coefficients is $\beta \bullet P(1-P)$, where β is the coefficient and P is the probability estimated with the coefficient set to zero. So, if P=1 percent, then the increase in probability for original cash program loans is equal to 0.61 percent, and the original-program probability is 1.61 percent. If P=0.5 percent, then the probability for an original-program cash loan is 0.8 percent (marginal probability is 0.30 percent).

[276] This finding is explored in greater depth in Goldberg and Capone (1998).

Table 37. Binary Logistic Prepayment Models for Multifamily Loans

Variable	Coefficients, by Model (Wald Chi-squared statistics in parentheses)				
	Model 1: fixed-rate in yield maintenance	Model 2: balloon out of yield maintenance	Model 3: fixed-rate, non-balloon, out of yield maintenance	Model 4: balloon maturity payoffs	Model 5: adjustable rate mortgages
Constant	−4.7854 (152.7)	−7.3368 (172.0)	0.7129 (1.1)	−1.0021 (2.0)	−0.9037 (1.6)
AY_t	0.4393 (17.6)	1.5412 (121.2)	−0.2091 (8.6)	NA	1.7119 (304.1)
AY_t^2	−0.0263 (8.3)	−0.0952 (119.2)	0.0044 (4.8)	NA	−0.1231 (289.6)
RSD_t	11.0790 (280.6)	5.1700 (321.4)	3.9940 (61.3)	NA	NA
RSU_t	−7.1300 (1.9)	NA	−0.7960 (11.0)	NA	NA
$RSD1_t$	NA	1.9200 (12.0)	NA	NA	NA
$RSD2_t$	NA	1.6200 (15.6)	NA	NA	NA
RS_t	NA	NA	NA	NA	4.8140 (789.1)
$r_{f,t}$	NA	NA	NA	NA	−51.3100 (74.4)
LTV_t	−0.9499 (7.4)	−2.2591 (171.0)	−3.8166 (30.2)	NA	−3.2223 (63.5)
PQ_t	NA	NA	NA	1.8013 (3.4)	NA
YTG_t	−0.2656 (413.5)	NA	NA	NA	NA
Model χ-squared	1655.7 DF=6	1002.4 DF=6	135.7 DF=5	3.4 DF=1	1474.4 DF=5
Sample size (Loan-years)	59,272	26,341	14,269	360	37,728

As expected, balloon loans in the post-yield maintenance period have higher refinance incentives than do fully-amortizing loans, and, therefore, there is a higher coefficient on RSD_t in prepayment (model 2) than in prepayment (model 3), with even greater effects as balloon maturity approaches ($RSD1_t$ and $RSD2_t$).

Cash-out refinancings (LTV_t), are much stronger in the post-yield maintenance period, than during yield maintenance, as expected. ARM loan prepayments (model 5) are sensitive to all of the factors in the model. The balloon payoff (model 4) shows that the probability of qualifying for a refinancing is a valuable predictor of annual payoff rates in the balloon and post-balloon years.

6. Application to the Stress Test

The risk-based-capital stress test matches default and prepayment models for each loan group by loan characteristics and age. Because the stress test uses loan aggregates (groups), the probabilities that result from use of the statistical equations can be thought of as rates of default and prepayment on the outstanding balances in each loan group, in each month of the stress period. But the default and prepayment models generated here produce annual rates of default and prepayment. Monthly rates are derived by first calculating annual equivalent rates in each month, given the explanatory variable values in that month, and then converting the annual rates to their monthly equivalents.

The stress tests selects the appropriate default equation used for each loan group based solely on the value of the Program Type data field in the Enterprises' loan characteristics data. The stress test chooses among prepayment equations based upon Product Type and loan Origination Term fields in the loan characteristics data, and also upon a computed mortgage age variable. Balloon loans use three separate prepayment models throughout loan life: in yield maintenance (model 1), post-yield maintenance (model 2), and payoff period (model 4). Fully amortizing ARMs will use just one equation (model 5), balloon ARMs will use two equations (model 5, and then model 4 at balloon term). Fully amortizing fixed-rate loans will use two prepayment equations, model 1 during yield maintenance and model 3 afterward. The estimated default and prepayment equations are used not in binary logistic equations, but rather in trinomial equations, as shown in equations 20 and 21, above. Use of the trinomial or, more generally, multinomial probability equations assures that prepayments and defaults are treated as competing risks in stress test application.

Use of the statistical equations in the stress test also involves some cross-equation grafting of coefficients. This is because the historical data on post-yield maintenance balloon loans (model 2) do not have sufficient observations where market interest rates are higher than coupon rates to compute a reliable coefficient for *RSU.* Instead, the coefficient for the variable RSU_t in model 3 is added into model 2 so that the effect of the up-rate stress test can be captured. An additional cross-equation grafting is performed for the added balloon-year effect for the joint probability variable in the default equations (*BJP*). There are insufficient loans with balloon maturity in the negotiated purchase data set to estimate a coefficient. Therefore, the coefficient estimate from the cash purchase default equation is used in the negotiated purchase default equation in the stress test.

The cap rate multiplier used to update property value from NOI (equation 27) is updated in the stress test using ten-year constant maturity Treasury yields, rather than mortgage coupon rates. Which interest rate is used to capture percent changes in interest rates is not important, and the ten-year constant maturity Treasury Yield series is the fundamental interest rate series used in the stress test. The stress test also uses a simplifying assumption for the depreciation writeoff variable, DW_{jt}. Rather than predict the value of this variable into the future, OFHEO chose to use the 1995 value (9.27) for the entire stress period, in both up- and down-rate scenarios.

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E. Multifamily Loss Severity

1. Introduction

Owing primarily to limited available data, OFHEO's approach to modeling multifamily loss severity rates for stress test application is simpler than approaches chosen for other elements of mortgage performance. The number of multifamily loans in Enterprise portfolios is a fraction of the number of single family loans. Therefore, the number of defaulted multifamily loans is relatively small. Further, only one Enterprise, Freddie Mac, has reliable historical records of multifamily loss severity rates. Until the mid-1990s, Fannie Mae's multifamily default resolutions were handled by the various field offices, and there were no standard protocols for tracking and maintaining data elements on a loan-by-loan basis. The result is that OFHEO analysis of Enterprise experience is exclusively focused on that of Freddie Mac.

Even so, the Freddie Mac program provides sufficient data to understand the various components of loss severity rates. They represent the worst historical experience of the Enterprises, and some of the worst experience on record for industry-wide multifamily mortgage loss severities. The Freddie Mac data are not extensive enough to allow a multivariate statistical analysis. The analysis outlined here is univariate: each element is examined individually, without explanatory variables. The result is that OFHEO chose for its stress test to use simple averages of various components of multifamily loss severity.

Section 2 of this supplementary material on multifamily loss severity gives an outline of the conceptual framework, the plan OFHEO used in approaching multifamily loss severity rates; section 3 provides a discussion of the source data; section 4 is a summary of the data analysis; and section 5 concludes with an examination of how the loss severity components are applied in the stress test.

2. Conceptual Framework

Loss severity is the net cost of resolving a mortgage default. It is most typically measured as a percentage of the unpaid principal balance (UPB) at the time of default.[277] OFHEO measures severity in this way and then applies any available credit enhancements against the loss to arrive at a net loss to the Enterprises. Credit enhancements are not discussed in this supplement. A description of how the stress test applies credit enhancements can be found in the Appendix to this regulation.

OFHEO's general approach is to model only those loss severity rates associated with full foreclosure events. The one exception is for programs where the default event of record is a 90-day delinquency. This exception will be discussed below, under Data Analysis. Foreclosure results in the Enterprise taking title to the property, managing and rehabilitating it, and then marketing and selling the property. OFHEO also models the timing of events and cost elements associated with foreclosure and property management. As with single family loss severity rates, OFHEO recognizes three time frames in capturing costs and revenues associated with mortgage foreclosure: the first four months of delinquency, the time from default to foreclosure completion (which includes the first four months), and time of property inventory (from foreclosure completion to property disposition).

After analyzing Enterprise data, and reviewing available research on multifamily loss severity, OFHEO chose to use simple averages of Enterprise experience, by loss component, and not to perform multivariate statistical analysis. Component analysis permits the use of discounting techniques to create effective loss severity rates at the time of default (one month after last-

[277] All references to UPB in this part of the supplement indicate UPB at time of default.

paid-installment). OFHEO found no basis in the existing literature for multivariate statistical analysis of multifamily loss severities.

OFHEO identified seven studies of loss severity, each of which relies upon data from a broad range of commercial property types, and each of which defines and measures severity rates somewhat differently.[278] These studies primarily provide simple averages of loan-level loss severity rates, though some do attempt some statistical analysis of severity rates. Curry, et al (1990) model loss severities as a function of the type of organization managing the foreclosed property (public or private). Haidorfer (1997) performs a multivariate statistical analysis that looks at the type of property sale process (open auction, sealed-bid auction, or broker sales). He finds that the type of selling process does not influence severity rates. A third study by Ciochetti and Riddiough (1998) models expected property recovery rates as a function of mortgage terms, and a list of property type and region dummies.[279] They find no statistical significance of original LTV, debt coverage ratio (DCR), loan age, or the mortgage interest rate.

3. Sources of Data

OFHEO obtained loss severity data on multifamily loans from both Enterprises, but only Freddie Mac maintained a complete historical data base of all relevant revenue and expense components that was useful for this analysis.[280] The analysis of foreclosure loss severities is then limited to 705 multifamily loans purchased by Freddie Mac, that subsequently defaulted between 1987 and 1995 and ended in foreclosure. Over 83 percent of these loans defaulted between 1990 and 1993, in what is considered the worst period in modern history for the commercial mortgage market. These data are supplemented by Freddie Mac data on other default resolutions. These additional data are used for projecting potential losses on negotiated purchase loans for which seller/servicers must repurchase and resolve all 90-day delinquencies. Once delinquencies are resolved, the seller/servicers bill the Enterprise for the net costs.[281] Fannie Mae has a large portfolio of sold loans with these repurchase provisions and has maintained data on the claims for losses submitted by the seller/servicers. However, many of the claim records are incomplete and OFHEO therefore, relied on information on Freddie Mac default resolutions, and on information from other available studies, to determine a loss rate to charge against 90-day delinquencies. Freddie Mac provided OFHEO with information on the chargeoffs associated with 160 non-foreclosure resolutions that occurred from 1990 to 1995.

These data represent the worst historical experience of the Enterprises, which began purchasing conventional multifamily mortgages in 1983.[282] The Freddie Mac data is among the largest and richest sets of information available to any researchers who have studied multifamily loss severities.

4. Data Analysis

a. Foreclosure Severity Rates

Table 38 provides average values for loss severity components in the Freddie Mac foreclosure database. The cost components are each measured as a percent of the UPB at the time of default. These average rates are also computed using UPB as a weighting factor on each loan. This weighting provides a more accurate measure of portfolio severity rates than would a simple average.[283] The operating loss per month is the difference between monthly property income (rents) and expenses, where expenses include property repairs. It is not surprising that this element is a net cost rather than a net revenue because defaulting properties will have high vacancy rates and significant needs for repairs. The net proceeds of property sale is arrived at by subtracting selling expenses and other prorated expenses (taxes and rents) due at settlement from the actual sales price of each property. The two time dimensions reported here are important for discounting the associated cash flows to arrive at an effective loss severity rate at time of default (one month after last-paid-installment). One cost element not shown in Table 38 is the interest passthroughs to security holders during the initial months of delinquency. In general, loans are repurchased from security pools by the 120th day of delinquency, so that four months of passthrough interest must be added to severity calculations in stress test application.

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[278] The seven studies are: Curry, Blalock, and Cole (1990); Snyderman (1994); Fitch Investors Service (1996); Ciochetti (1997); Haidorfer (1997); Barnes, Gilberto and Peyton (1998); and Ciochetti and Riddiough (1998).

[279] The Ciochetti and Riddiough study looks at expected recoveries immediately following foreclosure, where property value is appraised value, and no property management or disposition costs are included in the calculations.

[280] Until the mid 1990s, Fannie Mae's foreclosed property inventory was managed by the individual field offices. There were no standard protocols for recording or retaining expense and revenue components of loss severity on a loan-by-loan basis. Fannie Mae could only provide OFHEO with consistent data on event times (foreclosure and property disposition).

[281] When these loans are purchased by the Enterprises, the seller/servicers must establish resource accounts. These credit enhancements drawn on as first-lost protection before the Enterprises actually incur any costs from loan defaults in these mortgage pools.

[282] Goldberg and Capone (1997) detail the problems that led to high default rates among multifamily mortgages in the late 1980s and early 1990s. These same factors led to high severity rates. In addition to market factors, Freddie Mac attributes its particularly bad performance to fraud by lenders that underwrote loans that were not of investment quality. An analysis of data shown in Investor Analyst Reports shows that in 1991, Freddie Mac's chargeoff for bad multifamily loans was more than its total chargeoff for bad single family loans, even though its multifamily portfolio of $10 billion was only three percent as large as the single family portfolio. This high rate of chargeoffs lasted from 1989 through 1992.

[283] UPB weighting is also used in the OFHEO single family loss severity analysis.

Table 38. Multifamily Loss Severity Components Freddie Mac Foreclosure Experience, 1987-1995

Component	Average value
Foreclosure costs	9.01%
Operating loss, per month, during property holding period	0.332%
Net proceeds of property sale	58.88%
Time from default to foreclosure	18 months
Time in property inventory	13 months

Adding the cost components here produces a 54 percent loss severity. This sum is comparable to what is reported by Fitch (1996) in its study of commercial mortgage foreclosures. Fitch reports a 56 percent average loss severity rate on foreclosures.[284] The Fitch study had an (undefined) interest passthrough component. If added to the Freddie Mac severity components, a four-month passthrough at eight percent interest would increase their sum from 54 percent to roughly 58 percent.

b. 90-Day Delinquency Severities

Deriving a loss rate to use for 90-day delinquency events involves making inferences on the rate of foreclosure and other costly resolutions versus non-costly resolutions. Snyderman (1994) found that 46 percent of 90-day delinquencies in life insurance company portfolios, 1972–1986, ended in foreclosure. Freddie Mac data are consistent with this finding. Freddie Mac data indicate that foreclosures plus other costly resolutions are 56 percent of total 90-day delinquencies. Using 56 percent as the rate of costly loan resolutions, and applying a 70 percent foreclosure loss severity to them, produces a severity rate on 90-day delinquencies of just over 39 percent.[285]

5. Application to the Stress Test

The loss severity components just described enter the stress test as cash flows at various points in the default time frame. These cash flows are discounted by a cost-of-debt interest rate to produce a net-present-value loss severity rate in the month of default. The use of discounting provides an implicit funding cost. It reduces the value of final proceeds by an amount equal to the cost of funding the non-performing assets (first the loan, and then the property), and it reduces the value of various expenditures to reflect the fact that cash is not actually expended in the month of loan default but could be invested at some rate-of-return for a number of additional months.What discounting does not include is the cost of funding that portion of the loan balance that is not recovered in the sale of the foreclosed property. That portion of funding cost is captured elsewhere in the stress test by ongoing interest expenses on debt that is in excess of what can be retired by the property sale proceeds.[286] The ongoing interest expenses are captured in other parts of the stress test beyond the loss severity calculations.

a. Foreclosure Loss Severity Rate Application

The basic loss severity equation for foreclosure costs has five elements, as shown in this equation:

$$L_t = \frac{1}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{4}{6}}} + \frac{(r_p/12)\cdot 4}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{2}{6}}} + \frac{F}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}} + \frac{O\cdot t_i}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{(t_f+t_i/2)}{6}}} - \frac{P}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{t_f+t_i}{6}}}$$

[284] It is not clear exactly how many foreclosures there are in the Fitch data set. Fitch reports 547 costly default resolutions of 60-day delinquencies, of which it appears from other data given in the report (loss severity rates on foreclosure and non-foreclosure resolutions) that 147 are foreclosure events.

[285] The 70 percent loss rate on foreclosures comes from the 54 to 58 percent reported earlier, with asset holding costs added.

[286] For retained loans, the debt supporting the mortgage UPB will already be on the Enterprise balance sheets at the time of default. For sold loans, however, asset funding occurs when the Enterprise buys the defaulting loan out of its security pool.

where:

L_t = net loss severity rate (as a fraction of the unpaid loan balance) for loans that default in month t

F = foreclosure costs (0.0901 of the unpaid loan balance)

O = operating loss, per month (0.0033 of the unpaid loan balance)

P = net property sale proceeds (0.5888 of the unpaid loan balance)

t_f = time from default to foreclosure (18 months). This is divided by 6 to accommodate the use of semi-annual discounting.

t_i = property inventory time (13 months), the time between foreclosure and property disposition. This is divided by 6 to accommodate semi-annual discounting.

$r_{d,t}$ = discount rate (6-month agency cost of funds) in month *t*. This is divided by 2 to represent semi-annual discounting.

r_p = passthrough interest rate on the underlying mortgage(s)

The first loss element is the UPB of the defaulted loan. It is set here equal to '1' or 100 percent. For sold loans, it is discounted for four months, which represents the timing of repurchasing the loan from the security pool. For retained loans, the UPB is not discounted because the economic loss occurs at the time of default. The second loss element is the passthrough interest expense for four months. This expense is discounted for two months as an approximation to discounting each month's pass through individually. This element only appears for sold loans.

The third element of loss severity is the expense incurred to obtain a foreclosure judgment on the property. This cost includes all legal expenses for foreclosure and, when necessary, to release a bankruptcy stay, and other charges that may be incurred to obtain clean title to the property (e.g., property taxes due). The fourth element is the cost of operating and maintaining the foreclosured property while it is REO. And the fifth element is the net proceeds at final property disposition.

The formula can be applied very simply. Using the cost elements in Table 38, along with a discount rate, $r_{d,t} = .06$, and a passthrough rate, $r_p = .08$:

$$L_t = \frac{1}{\left(1+\frac{0.06}{2}\right)^{\frac{4}{6}}} + \frac{(0.08/12)\cdot 4}{\left(1+\frac{0.06}{2}\right)^{\frac{2}{6}}} + \frac{0.0901}{\left(1+\frac{0.06}{2}\right)^{\frac{18}{6}}} + \frac{0.0033\cdot 13}{\left(1+\frac{0.06}{2}\right)^{\frac{(25.5)}{6}}} - \frac{0.5888}{\left(1+\frac{0.06}{2}\right)^{\frac{31}{6}}}$$

This reduces to 0.622 for sold loans and 0.615 for retained loans. If we increase the discount rate to 12 percent, the results change to 0.661 for sold loans and 0.673 for retained loans. If the discount rate were reduced to three percent, the net present value severity rates would be 0.598 for sold loans and 0.581 for retained loans.

b. 90-Day Delinquencies

For negotiated purchase loans with seller/servicer repurchase provisions, the stress test discounts to reflect a time lag between the initial delinquency and the claim payment. In the stress test, seller/servicer claims on 90-day delinquencies are settled 12 months after default. Starting with the 39 percent severity rate for foreclosure alternatives reported above, and discounting for one year, yields a rate of around 34 to 37 percent, depending on the actual discount rate.

6. References

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F. Property Valuation

1. Introduction

The stress test simulates mortgage performance under housing market

conditions that reflect stresses comparable to those of the time and place of the benchmark loss experience (BLE). This section describes the data used to define and create variables that comprise the housing market conditions of the stress test.

Three housing market condition variables are used in the stress test: house price growth rates, rent growth rates, and rental vacancy rates. House price growth rates are used to project single family mortgage performance, both default/prepayment rates and loss severity rates. Rent growth rates and vacancy rates are used to project multifamily default and prepayment rates.

Section 2 of this part of the Technical Supplement describes the conceptual framework OFHEO used to determine the housing market condition variables in the stress test. Section 3 lists the sources of data used to develop these variables. Section 4 then describes the statistical analysis performed to transform source data into housing market condition variables.

2. Conceptual Framework

The BLE is based upon the performance of 30-year, fixed-rate single family mortgages in four States—Arkansas, Louisiana, Mississippi, and Oklahoma—originated in 1983 and 1984, during the ten years following origination, as defined in the first NPR. The actual BLE covered twelve calendar years because benchmark loans could originate any time between January 1983 and December 1984, and the ten-year experience of the last loans originated during the benchmark time period lasted through December of 1994. For house prices, rent growth rates, and vacancy rates in the stress test, OFHEO defined the BLE as the years 1984 through 1993—the middle ten years of the twelve-year period marking the BLE. OFHEO then identified sources of data that reflect the housing market conditions of the benchmark time and place, and that are compatible with historical data used to estimate statistical (econometric) models of mortgage default, prepayment, and loss severity.

a. Single Family House Price Appreciation Rates

OFHEO sought publicly available data with geographic coverage that reflect stresses similar to those of the BLE. For house price growth rates, the stress test uses OFHEO HPI data from the West South Central (WSC) Census Division. Because the 1984–1993 WSC HPI series was used to calibrate the single family default- and severity-rate equations to the actual four-State benchmark loan performance,[287] the same series also was used to define housing market conditions in the stress test. The WSC Census Division is similar geographically to the actual four-State BLE. The difference is that the WSC includes Texas, but not Mississippi. For the ten-year period, 1984–1993, the cumulative house price appreciation rate for the WSC Census Division is very similar to that of the four-State benchmark region. For the stress test, the OFHEO HPI is converted from index form into quarterly appreciation rates.

b. Vacancy Rates and Rent Growth Rates

Rental market data—vacancy rates and rent growth rates—used in the statistical analysis of historical multifamily default and prepayment rates are also from government sources. Rent growth rates are from the residential rent component of the consumer price index (CPI), produced by the Bureau of Labor Statistics. Vacancy rates are from the rental vacancy rate series (H–111) produced by the Bureau of the Census. However, these data series are not used directly to reflect multifamily housing market conditions during the stress period because the available geographic aggregations and time periods do not closely match the four-State benchmark. The CPI residential rent index is not available for the appropriate geographic areas, and the H–111 state vacancy rate series is not available for 1984 and 1985.[288]

In light of these shortcomings, OFHEO identified a non-government source of data published by the Institute for Real Estate Management (IREM). However, the IREM data do not represent the same properties as the government data. IREM surveys include only apartments, while the government surveys (both rents and vacancies), include apartments and single family rental units. To assure consistency with the government series, statistical regression equations were estimated to use in adjusting the IREM data. The adjusted data can be thought of as answering the question, ''What would CPI and H–111 data look like if they were available in the benchmark area?'' The statistical regressions (detailed in section 4, Statistical Analysis) use data from all metropolitan statistical areas (MSAs) for which both IREM and CPI or H–111 data are available, to estimate statistically valid relationships. These equations are then applied to IREM data from the four-State area to assure that variables used in the stress test are compatible with the variables used to develop the statistical models.

3. Data Sources

The sources of data used to develop the housing market condition variables for stress test application are as follows:

- *OFHEO HPI Report, 1996:3,* West South Central Census Division Series, 1983:4–1993:4.
- Bureau of Labor Statistics, Consumer Price Index, Residential Rent Component, MSA series, 1970–1995, annual index values.
- Bureau of the Census, H–111 Housing Vacancy Survey, rental unit vacancies, MSA series, 1981–1995, annual average vacancy rates.
- Institute for Real Estate Management. Conventional Apartments. Chicago, IL: IREM. Annual publications, 1981–1995, MSA level (median) dollar rents per square foot, (median) dollar vacancy losses per square foot, and number of apartments in survey.

4. Statistical Analysis

a. House Prices Appreciation Rates

The use of the OFHEO HPI in the stress test requires no statistical analysis. Monthly house price appreciation rates are derived from the OFHEO HPI index in three steps. First, monthly appreciation rate indexes are created for each quarter by dividing that quarter's index value by the index value for the preceding quarter. Second, the logarithm of this new index is used as the growth rate factor for that quarter. Finally, the quarterly rate is divided by three to produce at monthly growth rate factors for each month in the quarter. In this manner, the 120 months of stress test HPI growth rate factors ($g_{q,t}$) are produced from the 41 quarterly HPI values (HPI_q), 1983:4–1993:4:

[287] Benchmark loss experience calibration is discussed in both the Single Family Default/Prepayment and the Single Family Severity sections of this Technical Supplement.

[288] The residential rent series includes MSA level data for New Orleans, beginning in 1986. The New Orleans data alone, however, were insufficient for use in representing the BLE.

$$g_{q,t} = \frac{ln\left(\frac{HPI_q}{HPI_{q-1}}\right)}{3} \qquad (Eq.\ 56)$$

where:

$g_{q,t}$ = house price growth rate factor in month t={1,2,3} in calendar quarter q = {1984:1,...,1993:4}

The $g_{q,t}$ are called growth rate ''factors'' because they are the continuous growth rate equivalents to actual, discrete growth as measured across each month and quarter.[289] Stress test applications convert these factors to actual appreciation rates. This baseline series of monthly growth rates applies in both the up- and down-rate scenarios, but may be adjusted for inflation in the up-rate scenario.

b. Rent Growth Rates

The statistical analysis underlying the rent growth rate variable used in the stress test uses MSA level data from both IREM and the CPI for the 26 cities for which the CPI residential rent index is available.[290] Annual growth rates for 1970–1995 were computed from both the IREM and CPI rent data, and the following pooled, time series, cross-sectional, weighted least squares regression was estimated:

$$\dot{RR}_{j,y} = 0.027 + 0.295 \cdot \dot{IR}_{j,y} \qquad (Eq.\ 57)$$

where:

$\dot{RR}_{j,y}$ = annual growth rate of the CPI residential rent index in MSA, j, and calendar year y

$\dot{IR}_{j,y}$ = annual growth rate of the IREM rent growth rate series in MSA, j, and calendar year y

The regression was weighted by the number of apartments that IREM surveyed in each MSA. The coefficient for $IR_{j,y}$ is significant at the 99 percent confidence level.

IREM data are available for one city in each of the four benchmark States—Jackson, Little Rock, New Orleans, and Oklahoma City. A benchmark region rent growth rate series was computed from equation 57, using a simple average of annual IREM rent growth rates in each of these cities (1984–1993) to populate $IR_{j,y}$. Monthly rent growth rates were then computed using the following compounding formula.

$$g_{y,t} = \sqrt[12]{1 + \hat{CR}_y} - 1 \qquad (Eq.\ 58)$$

where:

$\hat{CR}_y$ = the ''fitted value'' annual government-equivalent rent growth rate from equation 57, for year, y = {1984,...,1993}, using the four-city average IREM rent growth rates in place of $\dot{IR}_{j,y}$

$g_{y,t}$ = monthly rent growth rates for each month t = {1,...,12} in year y

Equation 58 produces final rent growth rates in discrete form, rather than continuous form, because the process used to create the original series was discrete. As with the house price growth rate factors, inflation adjustments may be applied in the up-rate scenario.

c. Vacancy Rates

Because Census vacancy rate data are available at the State level starting in 1986, OFHEO uses the average of rates

[289] Continuous growth rates refer to a process whereby house price appreciation is a continuous process, throughout each month or quarter. The actual house price index that shows total appreciation across a month or quarter is just the exponential of the growth rate factor for that time period.

[290] Statistical analysis was based upon what the Bureau of Labor Statistics calls its ''old series.'' The new series covers 29 MSAs.

in the four benchmark States, from 1986–1993 for the latter eight years of the stress test. For the first two years, OFHEO employs a statistical analysis similar to that for rent growth rates to create government-equivalent vacancy rates for 1984 and 1985, the first two years needed for the stress test. The weighted-least-squares regression matches MSA-level Census vacancy rates to IREM vacancy rates in the same cities. Matching data is available for 51 MSAs; 23 with Census data that begin in 1981, and another 28 for which Census data become available in 1986. The pooled cross-section, time series regression is:

$$\dot{CV}_{j,\,y} = 0.001 + 0.29 \cdot \dot{IV}_{j,\,y} \qquad \textit{(Eq. 59)}$$

where:

$\dot{CV}_{j,\,y}$ = annual change in Census vacancy rate between years (y-1) and y, for MSA j

$\dot{IV}_{j,\,y}$ = Annual change in IREM vacancy series between years (y-1) and y, for MSA j

The coefficient on $IV_{j,y}$ is statistically significant at the 99 percent level, but the constant term is not statistically significant. This lack of significance is not surprising, given that the regression is relating rates of change and not levels of vacancy rates. In application, the constant term is dropped from the equation.

To compute vacancy rates for 1984 and 1985, equation 59 is applied using average IREM vacancy rates for the four benchmark cities to compute rates of change for the four-State average Census vacancy rate. The resulting rate of change from 1986 to 1985 is first applied to the four-State average Census vacancy rate for 1986 to compute a government-equivalent vacancy rate for 1985. The procedure is repeated to compute the vacancy value for 1984. Finally, each annual vacancy rate in the ten-year series is applied to each month in the year to extend the series to cover the 120 months of the stress period.

V. Regulatory Impact

A. Executive Order 12612, Federalism

Executive Order 12612 requires that Executive departments and agencies identify regulatory actions that have significant Federalism implications. ''Federalism implications'' is defined as regulations or actions that have substantial direct effects on the States, on the relationship or distribution of power between the national government and the States, or on the distribution of power and responsibilities between the Federal and State government. This proposed regulation has no Federalism implications that warrant the preparation of a Federalism Assessment in accordance with Executive Order 12612.

B. Executive Order 12866, Regulatory Planning and Review

This regulation has been reviewed by the Office of Management and Budget (OMB) in accordance with Executive Order 12866. OMB has determined that this is an economically significant rule. Included in the preamble to the proposed rule is an economic analysis of the proposal's impact on the regulated entities, and in particular on mortgage credit, of various alternatives. It contains a technical supplement providing detail on the specifications and estimations of econometric models for mortgage performance, and how those statistical models are applied in the proposed risk-based capital stress test.

The proposed regulation implements the 1992 Act's requirement that OFHEO establish a risk-based capital requirement for the Enterprises. Along with the existing minimum capital leverage ratios and the examination function, the stress test is designed to ensure that the Enterprises have adequate capital and operate in a safe and sound manner.

It is difficult to estimate precisely the particular benefits and costs associated with the risk-based capital requirement. Where possible, section II. C., Implications of the Proposed Rule discusses and quantifies the potential benefits and potential costs in more detail. Otherwise, that section characterizes the benefits and costs qualitatively. The analysis indicates that the anticipated benefits from implementing the risk-based capital regulation outweigh the anticipated costs. It further indicates that the proposed regulation ensures that risk is held at an appropriate level, while imposing the least burden on the Enterprises.

By carrying out Congress' intent to implement the risk-based capital requirement, OFHEO would reduce the potential for Enterprise insolvency by protecting against interest rate, credit, and management and operations risk. By ensuring their safety and soundness, the regulation allows the Enterprises to continue to carry out their public purposes.[291] These include providing stability in the secondary market for residential mortgages and providing access to mortgage credit in central cities, rural areas, and underserved areas. In addition, the regulation will also ensure that the Enterprises will continue to provide benefits to the primary mortgage market such as standardizing business practices.[292]

Other benefits of the risk-based capital requirement are (1) making the Enterprises' capital requirement more sensitive to differences in risk exposures, (2) discouraging the Enterprises from taking excessive risks by making riskier behavior more costly, and (3) ensuring that the Enterprises maintain adequate capital in stressful credit and interest rate environments. Implementing a risk-based capital requirement with credit risk and interest rate risk components will help ensure that the Enterprises' capital requirement is more closely related to the risks that they incur. Adopting the proposed rule will result in a capital requirement that corresponds more closely to capital levels that the marketplace would demand in the absence of the benefits afforded by the government sponsorship of the Enterprises, and will lead to gains in overall economic efficiency.

[291] 1992 Act, section 1302(2) (12 U.S.C. 4501(2)).

[292] *Managing Risk in Housing Finance Markets: Perspectives from the Experiences of the United States of America and Mexico,* OFHEO and the Mortgage Bankers Association of America (June 11, 1998).

Moreover, by evaluating risk in a forward-looking, dynamic manner, the stress test identifies potential problems before they become significant.

As detailed in the Implications section, the Proposed Rule may impose some costs on the Enterprises. Nevertheless, any such costs are the necessary and reasonable costs of carrying out Congress' intent that the Enterprises remain financially solvent, which will enable them to out their important public purposes.

Changes to comply with the risk-based capital requirement can be accomplished at relatively low costs. Both Enterprises can employ various practices and procedures to manage credit risk and interest rate risk by adjusting their holdings or operations. For example, one method to reduce credit risk exposure is to increase use of credit enhancements with highly-rated counterparties. One method to reduce interest risk exposure is to purchase derivative contracts.

By complying with an effective risk-based capital requirement, the Proposed rule may in fact reduce Enterprise costs by enhancing investor confidence. This is consistent with a study by Standard & Poor's (S&P) that provided risk-to-the-government credit ratings for the Enterprises.[293] While S&P had rated Fannie Mae A − and Freddie Mac A+ in 1991, the 1997 report upgraded the ratings of both Enterprises to AA-. S&P cited increased governmental oversight by OFHEO as an important factor in these higher ratings. It further noted that ''OFHEO's regulatory oversight [of Freddie Mac] also gives comfort that appropriate interest rate risk mitigation steps would be taken as needed.'' [294]

C. Executive Order 12988, Civil Justice Reform

Executive Order 12988 sets forth guidelines to promote the just and efficient resolution of civil claims and to reduce the risk of litigation to the government. The proposed regulation meets the applicable standards of sections 3(a) and (b) of Executive Order 12988.

D. Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires that a proposed regulation that has a significant economic impact on a substantial number of small entities must include an initial regulatory flexibility analysis describing the rule's impact on small entities. Such an analysis need not be undertaken if the agency head certifies that the rule will not have a significant economic impact on a substantial number of small entities. 5 U.S.C. 605(b).

OFHEO has considered the impacts of the proposed risk-based capital regulation under the Regulatory Flexibility Act. The proposed regulation does not have a significant effect on a substantial number of small entities.

This proposed regulation would not have a significant economic impact on a substantial number of small entities since it is applicable only to the Enterprises, which are not small entities for purposes of the Regulatory Flexibility Act. Therefore, the General Counsel of OFHEO acting under delegated authority has certified that the proposed regulation would not have a significant economic impact on a substantial number of small entities.

E. Paperwork Reduction Act

The Paperwork Reduction Act of 1995, 44 U.S.C. Chapter 35 requires that regulations involving the collection of information receive clearance from the Office of Management and Budget (OMB). The risk-based capital proposal contains no such collection of information requiring OMB approval under the Paperwork Reduction Act.

List of Subjects in 12 CFR Part 1750

Capital classification, Mortgages, Risk-based capital.

Accordingly, for reasons set forth in the preamble, the Office of Federal Housing Enterprise Oversight proposes to amend 12 CFR part 1750 as follows:

PART 1750—CAPITAL

1. The authority citation for part 1750 as published at 61 FR 29619, June 11, 1996, continues to read as follows:

Authority: 12 U.S.C. 4513, 4514, 4611, 4612, 4614, 4618.

§ 1750.5 [Removed]

2. Remove § 1750.5.

3. Amend § 1750.12 of part 1750 as published at 61 FR 29620, June 11, 1996, by revising paragraph (a) to read as follows:

§ 1750.12 Procedures and Timing.

(a) Each Enterprise shall file with the Director a risk-based capital report each quarter, or at such other times as the Director requires. The report shall contain information identified by OFHEO in written instructions to each Enterprise.

* * * * *

4. Revise the Appendix to subpart B of part 1750 as published at 61 FR 29621, June 11, 1996, to read as follows:

Appendix to Subpart B of Part 1750—Risk-Based Capital Test Methodology and Specifications

[293] *Final Report of Standard & Poors to OFHEO,* Contract No. HE09602C (February 3, 1997).

[294] Contract No. HE09602C, p. 10.

1.0 Identification of the Benchmark Loss Experience

OFHEO will use the definitions, data, and methodology described below to identify the benchmark loss experience.

1.1 Definitions

The terms defined at § 1750.11 shall apply for this Appendix. In addition, the term *Origination year* means the year in which a loan is originated.

1.2 Data

[a] OFHEO identifies the benchmark loss experience using historical loan-level data required to be submitted by each of the two Enterprises. OFHEO's analysis is based entirely on the most current data available on conventional, 30-year, fixed-rate loans secured by first liens on single-unit, owner-occupied, detached properties. Detached properties are defined as single family properties excluding condominiums, planned urban developments, and cooperatives. The data includes only loans that were purchased by an Enterprise within 12 months after loan origination and loans for which the Enterprise has no recourse to the lender.

[b] OFHEO organizes the data from each Enterprise to create two substantially consistent data sets. OFHEO separately analyzes default and severity data from each Enterprise. Default rates are calculated from loan records meeting the criteria specified above. Severity rates are calculated from the subset of defaulted loans for which loss data are available.

1.3 Procedures

1.3.1 Cumulative 10-year default rates for each combination of states and origination years (state/year combination) that OFHEO examines are calculated for each Enterprise by grouping all of the Enterprise's loans originated in that combination of states and years. For origination years with less than 10 years of loss experience, cumulative-to-date default rates are used. The two Enterprise default rates are averaged, yielding an ''average default rate'' for that state/year combination.

1.3.2 An ''average severity rate'' for each state/year combination is determined in the same manner as the average default rate. For each Enterprise, the aggregate severity rate is calculated for all loans in the relevant state/year combination and the two Enterprise severity rates are averaged.

1.3.3 The ''loss rate'' for any state/year combination examined is calculated by multiplying the average default rate for that state/year combination by the average severity rate for that combination.

1.3.4 The default and severity behavior of loans in the state/year combination containing at least 2 consecutive origination years and contiguous areas with a total population equal to or greater than 5 percent of the population of the United States with the highest loss rate constitutes the benchmark loss experience.

2.0 Identification of a New Benchmark Loss Experience

OFHEO will periodically monitor available data and reevaluate the benchmark loss experience using the methodology set forth in this Appendix. Using this methodology, OFHEO may identify a new benchmark loss experience that has a higher rate of loss than the benchmark experience identified at the time of the issuance of this regulation. In the event such a benchmark is identified, OFHEO may incorporate the resulting higher loss rates in the stress test.

3.0 Computation of Risk-Based Capital Level

3.1 Enterprise Data

3.1.1 Overview

[a] The stress test requires data on all of an Enterprise's assets, liabilities, stockholders equity, and off-balance sheet obligations, as well as the factors that affect them: interest rates, house prices, rent growth rates, and vacancy rates. This section characterizes proprietary data of the Enterprises (as opposed to publicly available data) that are necessary for the stress test, which are primarily data on Enterprise portfolios of financial instruments and guarantees as of the start of the stress test. Data available from public sources that are also necessary for the stress test—e.g., historical interest rates, house price growth rates, and public securities data [1]—are described in the sections of this Appendix that describe the related components of the stress test (e.g., the Interest Rate component). The stress test uses proprietary and public data directly, and also uses values derived from such data. The derivation of these additional values are also explained in sections of this Appendix. All data as of the start of the stress test, proprietary data of the Enterprises and public data, are ''starting position data.''

[b] Starting position data include, for all the loans owned or guaranteed by an Enterprise, as well as securities and derivative contracts, the dollar balances of these instruments and obligations, as well as all characteristics that bear on their behavior under stress test conditions. Data are required for the following categories of instruments and obligations:

- Mortgages owned by or underlying mortgage-backed securities issued by the Enterprises (''whole loans'')
- Mortgage-related securities

[1] Data elements listed below for non-mortgage financial instruments are available from public sources for publicly traded securities, but are proprietary for privately placed instruments, in particular, derivative contracts.

• Non-mortgage-related securities, whether issued by an Enterprise, e.g., debt, or held as investments
• Derivative contracts
• Other off-balance sheet guarantees (e.g., guarantees of private-issue securities)

[c] The stress test also requires starting position data for ''non-cash'' balance sheet items, such as premiums and discounts, that affect pro forma financial statements through the ten-year stress period.

3.1.2 Whole Loans

[a] Whole loans are individual single family or multifamily mortgage loans. The stress test distinguishes between whole loans that the Enterprises hold in their investment portfolios (retained loans) and those that underlie mortgage-backed securities (sold loans). Data are aggregated for loans with similar portfolio (retained or sold), risk, and product characteristics. The characteristics of these ''loan groups'' determine mortgage default, prepayment, and loss severity rates, and cash flows.

[b] The characteristics that are the basis for loan groupings are called ''classification variables'' and reflect categories, e.g., fixed interest rate versus floating interest rate, or identify a value range, e.g., original loan-to-value ratio greater than 80 percent and less than or equal to 90 percent. After the loans are grouped, weighted average values for characteristics of the loan group are calculated, e.g., weighted average loan coupon (WAC) and weighted average remaining maturity (WAM). Loan group characteristics are used as inputs in section 3.5, Mortgage Performance, of this Appendix to determine mortgage performance (default, prepayment, and loss severity) and mortgage cash flows.

3.1.2.1 Characteristics Used to Create Loan Groups

[a] Loan groups are formed based on the values, as of the start of the stress test, of the relevant loan classification variables shown in Table 3–1.

Table 3-1. Classification Variables Determining Loan Groups

Classification Variable	Description	Values
Business Type	Whether the loan finances a single family or multifamily property	Single Family Multifamily
Portfolio	Whether the loan is in the retained or the sold portfolio	Retained Portfolio Sold Portfolio
Program Type[1] (multifamily only)	Whether the loan is purchased individually (cash) or as part of a pool (negotiated), whether seller is responsible for any losses (recourse), and whether seller repurchases 90-day delinquent loans from securitized pools	Cash with recourse Cash without recourse Negotiated with repurchase Negotiated without repurchase FHA-insured
Product Type	Defines loan terms FHA = loans insured by the Federal Housing Administration VA = loans guaranteed by the Veterans Administration "COFI" = Federal Home Loan Bank 11th District Cost of Funds Index "TPM" = Tiered Payment Mortgage "GPM" = Graduated Payment Mortgage	Single Family FHA/VA Long Term FHA/VA Intermediate Term 30-YR Fixed-Rate 20-YR Fixed-Rate 15-YR Fixed-Rate Fixed Other Intermediate Adjustable Rate, Treas < =1 YR Adjustable Rate 1-3 YR Adjustable Rate > 3 YR Adjustable Rate COFI 1 MO Adjustable Rate COFI 2-6 MO Adjustable Rate COFI > 6 MO Adjustable Rate Other Bi-Weekly 30 YR Bi-Weekly 20 YR Bi-Weekly 15 YR Balloons 5 YR Balloons 7 YR Balloons Other Second Lien Long Second Intermediate Steps/TPM/GPM Long Steps/TPM/GPM Intermediate Multifamily: FHA-insured 30-YR Fixed-Rate 20-YR Fixed-Rate 15-YR Fixed-Rate Adjustable Rate Balloons 5 Year Balloons 7 Year Balloons 10 Year Balloons 15 year Balloons, Adjustable Rate, 15 Year All Other Products

Table 3-1. Classification Variables Determining Loan Groups (Continued)

Classification Variable	Description	Values
Origination Year	The year the loan was originated.	
Delivery Month (for loans purchased during the stress period)	The month during the stress test when an Enterprise purchases loans fulfilling commitments	Stress period months 1-6
Original Loan-to-Value Ratio (LTV) Class	Ratio of the original loan amount to the original property value (for multifamily negotiated program loans, this is the LTV at the time of loan acquisition)	0<LTV<=60 60<LTV<=70 70<LTV<=75 75<LTV<=80 80<LTV<=90 90<LTV<=95 95<LTV<=100 100<LTV
Original Coupon Class	Original loan rate	0.0<=RATE<1.0 1.0<=RATE<2.0 2.0<=RATE<3.0 3.0<=RATE<4.0 4.0<=RATE<5.0 5.0<=RATE<6.0 6.0<=RATE<7.0 7.0<=RATE<8.0 8.0<=RATE<9.0 9.0<=RATE<10.0 10.0<=RATE<11.0 11.0<=RATE<12.0 12.0<=RATE<13.0 13.0<=RATE<14.0 14.0<=RATE<15.0 15.0<=RATE<16.0 16.0<=RATE<17.0 17.0<=RATE<18.0 18.0<=RATE<19.0 19.0<=RATE<20.0 20.0<=RATE<21.0 21.0<=RATE<22.0 22.0<=RATE<23.0 23.0<=RATE<24.0 24.0<=RATE

Table 3-1. Classification Variables Determining Loan Groups (Continued)

Classification Variable	Description	Values
Starting Coupon Class	The loan rate at the start of the stress test (original loan rate for loans fulfilling commitments)	0.0<=RATE<1.0 1.0<=RATE<2.0 2.0<=RATE<3.0 3.0<=RATE<4.0 4.0<=RATE<5.0 5.0<=RATE<6.0 6.0<=RATE<7.0 7.0<=RATE<8.0 8.0<=RATE<9.0 9.0<=RATE<10.0 10.0<=RATE<11.0 11.0<=RATE<12.0 12.0<=RATE<13.0 13.0<=RATE<14.0 14.0<=RATE<15.0 15.0<=RATE<16.0 16.0<=RATE<17.0 17.0<=RATE<18.0 18.0<=RATE<19.0 19.0<=RATE<20.0 20.0<=RATE<21.0 21.0<=RATE<22.0 22.0<=RATE<23.0 23.0<=RATE<24.0 24.0<=RATE
Debt Coverage Ratio (DCR) Class (multifamily only)	The ratio of property net income to debt service as of the date of loan acquisition for negotiated program loans; as of the date of loan origination for all cash program loans	1.00 to 1.09 1.10 to 1.19 1.20 to 1.29 1.30 to 1.39 1.40 to 1.49 1.50 to 1.59 1.60 to 1.69 1.70 to 1.79 1.80 to 1.89 1.90 to 1.99 2.00 to 2.49 2.50 to 3.99
Metropolitan Statistical Area (multifamily only)	The 4-digit Metropolitan Statistical Area (MSA) or Consolidated Metropolitan Statistical Area (CMSA) code as defined by the Office of Management and Budget; used to calculate Rental Rate Index	All MSA and CMSA codes outside of MSA

Table 3-1. Classification Variables Determining Loan Groups (Continued)

Classification Variable	Description	Values
Census Region or Division	The Census division (single family) or Region (multifamily) in which the property is located	Divisions (Single Family) East North Central East South Central Middle Atlantic Mountain New England Pacific South Atlantic West North Central West South Central Regions (Multifamily) North Central North East South West
Remittance Cycle	The remittance cycle that applies to a loan and governs when payments are remitted by the servicer to the Enterprise and by the Enterprise to the investor Values reflect average number of days an Enterprise holds scheduled principal and interest payments (see Cash Flows: Whole Loans for further details)	7 days -3 days 57 days

[1] The values shown reflect aggregation of similar Enterprise programs. Individual Enterprise programs (subgroups of the values shown) are distinguished in the creation of loan groups; they are not listed here because most of them are Enterprise-specific.

[b] All loans with the same values for each of the relevant characteristics included in Table 3–1 above comprise a single loan group; for example, one loan group would include all loans with the following characteristics:

- Single family
- Sold portfolio
- 30-year fixed-rate conventional
- Originated in 1997
- LTV greater than 75 percent and less than or equal to 80 percent
- Original coupon greater than or equal to six percent and less than seven percent
- Starting coupon (coupon at the start of the stress period) greater than or equal to six percent and less than seven percent
- Secured by property located in the East North Central Census division
- Subject to a remittance cycle where scheduled principal and interest payments are held for an average of seven days

3.1.2.2 Loan Group Characteristics

In addition to the classification variables used for grouping loans, the stress test requires values for characteristics calculated for the loans within each group. All values are as of the start of the stress test. Except as indicated in the ''Description'' column, values are averages for the loans comprising a loan group, weighted by their unpaid principal balances (UPB).

Table 3-2. Loan Group Characteristics

Loan Group Characteristic	Description
Original Coupon	Mortgage coupon at loan origination
Starting Coupon	Mortgage coupon at loan origination for loans fulfilling commitments
Margin (ARMs only)	Amount added to an ARM interest rate index value to establish the fully adjusted rate
Servicing Fee	The amount paid to a seller/servicer for servicing a loan, calculated as a percentage of the principal balance, expressed in basis points
Net Yield	The interest rate passed to an Enterprise by the lender (mortgage coupon less servicing fee)
Guarantee Fee (sold loans only)	Interest rate spread (in basis points) retained by Enterprise as payment for guarantee of mortgage-backed security (included in Net Yield)
Passthrough Rate (Sold loans only)	Mortgage coupon less servicing fee and guarantee fee; the rate of interest passed through to mortgage-backed security investors
Starting UPB	The aggregate unpaid principal balance of a loan group
Original LTV	Ratio of the original loan amount to the original property value (for multifamily negotiated program loans, this is the LTV at the time of acquisition)
Original Term	Original term to maturity in months; e.g., 360 months for 30 year fully amortizing loan or 84 months for a seven-year balloon loan
Amortization Term	Original term, in months, used to calculate scheduled payments for balloon loans
Starting Remaining Term	Months remaining until loan maturity date
Starting Mortgage Age	Months since loan origination
Debt coverage ratio (DCR) at Acquisition or Loan Origination (multifamily only)	Ratio of property net operating income to debt service (as of loan origination for cash program loans; as of date of acquisition for negotiated program loans)
Credit Enhancement (C.E.) Coverage Type 1[1] (single family only)	PMI coverage rate, as a percent of the gross claim amount
C.E. Coverage Type 2[1]	Loss coverage provided under unlimited recourse/repurchase agreements, as a percent of the net loss amount
C.E. Coverage Type 3[1]	Loss coverage provided by all other types of credit enhancements, in dollars
Percent of UPB Under Dollar-Denominated Coverage[1]	Percent of loan group starting UPB covered by dollar-denominated credit enhancements

Table 3-2. Loan Group Characteristics (Continued)

Loan Group Characteristic	Description
Percent of UPB under AAA[2] coverage[1]	Percent of loan group starting UPB covered by counterparties rated AAA
Percent of UPB under AA[2] coverage[1]	Percent of loan group starting UPB covered by counterparties rated AA
Percent of UPB under A[2] coverage[1]	Percent of loan group starting UPB covered by counterparties rated A
Percent of UPB under BBB[2] coverage[1]	Percent of loan group starting UPB covered by counterparties rated BBB

[1] Required computations are described in section 3.7, Mortgage Credit Enhancements, of this Appendix.
[2] Rating categories are described in section 3.6, Other Credit Factors, of this Appendix.

3.1.2.3 Individual Loan Data

The stress test requires data for individual loans in an Enterprise's portfolio in order to determine the characteristics of loans that (for purposes of the stress test) fulfill commitments that are outstanding at the start of the stress period, and to compute loss coverage provided by credit enhancements such as private mortgage insurance. These data requirements are listed below.

3.1.2.3.1 Commitments Data

[a] To establish the characteristics of loans that fulfill commitments so that they are consistent with the characteristics of loans securitized by an Enterprise that were recently originated, data are required for loans that meet the following criteria:

- Single family
- Originated within six months of the start date of the stress test
- Securitized
- One of the following product types:

1. 30-year fixed-rate
2. 15-year fixed-rate
3. One-year CMT ARM
4. Seven-year balloon

[b] For these loans, the following data are required:

- Loan balance as of the beginning of the stress period
- Original LTV
- Census division
- Guarantee fee
- Servicing fee
- Margin (for ARM loans)
- Credit enhancement data described in section 3.1.2.3.2, Credit Enhancement Data, below

[c] The dollar amount of commitments outstanding at the start of the stress test is also required.

3.1.2.3.2 Credit Enhancement Data

[a] To facilitate calculation of the reductions in mortgage credit losses due to credit enhancements, the following data are required for all credit-enhanced loans, if any, in a loan group:

1. Type of mortgage credit enhancement:
a. Private mortgage insurance
b. Recourse
- Limited
- Unlimited

c. Indemnification
- Limited
- Unlimited

d. Pool insurance
e. Spread account
f. Collateral posted under collateral pledge agreement
g. Cash account
2. Private mortgage insurance coverage percent
3. Loan balance as of the beginning of the stress period
4. Public rating of mortgage insurer
5. Public rating of pool insurer
6. Public rating of seller or servicer

[b] The following additional information is needed for each loan delivery contract involving a spread account, collateral account, cash, limited recourse or indemnification, or pool insurance account (e.g., a particular contract for the delivery of $100 million of loans may specify the establishment of a spread account as credit enhancement):

- Coverage remaining, as of the beginning of the stress period
- Account balance(s) at the start of the stress period
- Coverage expiration date

3.1.2.4 Single Family Mortgage Portfolio-Wide Information

To reflect the differential performance of single family mortgages on investor-owned and owner-occupied properties, the stress test also requires data on the percentage of first lien mortgages in the combined retained and sold portfolios financing investor-owned properties.

3.1.3 Mortgage-Related Securities

[a] The Enterprises hold mortgage-related securities as assets. These securities include single class and derivative mortgage-backed securities (multi-class and strip securities) issued by Fannie Mae, Freddie Mac, and Ginnie Mae; mortgage revenue bonds issued by State and local governments and their instrumentalities; and single class and derivative mortgage-backed securities issued by private entities. Most mortgage-related securities are collateralized by single family mortgages, others by multifamily mortgages, and, for the purposes of the stress test, still others by housing-related assets such as manufactured housing loans.

[b] The stress test models the cash flows of these securities individually. Enterprise data required for this purpose are described below.

3.1.3.1 Single Class MBS Issued by the Enterprises and Ginnie Mae

[a] Table 3–3 provides Enterprise data regarding each MBS held in their portfolios. This information is necessary for simulating cash flows in the stress test.

Table 3-3. MBS Input Variables

Variable	Description
Pool Number	A unique six-digit number assigned by the issuing Enterprise to identify an individual MBS
Original Principal Balance	The pool balance at the time of security issuance multiplied by the Enterprise's percentage ownership
Starting Principal Balance	The pool balance as of the start of the stress test multiplied by the Enterprise's percentage ownership

[b] The Enterprises and Ginnie Mae make available to the public monthly pool data that provide investors with information on principal payments, as well as extensive data characterizing individual MBS and their underlying mortgage pools. These data, which are necessary to simulate MBS cash flows, are listed in section 3.9.2, Mortgage-Related Securities, of this Appendix.

3.1.3.2 Derivative Mortgage Securities Issued by the Enterprises and Ginnie Mae

[a] Table 3–4 provides Enterprise data regarding REMICs and Strips issued by the Enterprises or Ginnie Mae. This information is necessary for determining associated cash flows.

Table 3-4. Derivative Mortgage Securities Input Variables

Variable	Description
Series Identification	Unique identifier assigned by the issuing Enterprise that identifies a mortgage derivative security transaction (e.g., FHR 1980 for a Freddie Mac REMIC)
CUSIP Number	Unique identification number assigned to debt securities assigned by the Committee on Uniform Security Identification Procedures
Original Principal (Notional) Balance	The security principal balance at issuance multiplied by the Enterprise's percentage ownership (may be notional balance for interest-only security)
Starting Principal Balance	The security principal balance at the start of the stress test, multiplied by the Enterprise's percentage ownership (may be notional balance for interest-only security)

[b] The data in Table 3–4 identify individual securities that are held by the Enterprises in their portfolios, as well as the REMIC or Strip transaction associated with individual securities. Public securities disclosure information is the source of data on the collateral underlying the securities (e.g., pool numbers of securities comprising collateral for a series of securities) and the rules governing security cash flows. (*See* section 3.9.2, Mortgage-Related Securities, of this Appendix.)

3.1.3.3 Mortgage Revenue Bonds and Miscellaneous Mortgage-Related Securities

[a] Table 3–5 provides Enterprise data regarding mortgage revenue bonds and private-issue, mortgage-related securities (MRS). This information is necessary for determining associated cash flows.

Table 3-5. Mortgage Revenue Bond and Other MRS Input Variables

Variable	Description
CUSIP Number	Unique identification number assigned to debt securities
Original Principal Balance	The principal balance at the time of purchase by the Enterprise multiplied by the Enterprise's percentage ownership
Starting Principal Balance	The principal balance at the start of the stress test multiplies by the Enterprise's percentage ownership

[b] The data in Table 3–5 are supplemented with public securities disclosure data, as described in section 3.9.2, Mortgage-Related Securities, of this Appendix.

3.1.4 Non-Mortgage Financial Instruments

[a] Non-mortgage financial instruments include debt securities issued to fund assets, debt securities and preferred stock held as assets, derivatives contracts (interest rate swaps, caps, and floors), and preferred stock issued by an Enterprise. Cash flows for non-mortgage financial instruments are simulated based on their characteristics. Although information for publicly traded securities, including most of the Enterprises' debt securities and non-mortgage investments, is available from public securities disclosure documents, information on other derivative contracts and non-publicly traded instruments must be obtained from the Enterprises. Data categories listed here apply to both publicly traded and privately placed instruments. All data are instrument specific; the pay- and receive-sides of swap contracts are treated as separate instruments. Table 3–6 provides basic information about non-mortgage financial instruments input variables, as follows:

Table 3-6. Non-Mortgage Financial Instruments Input Variables

Variable	Description
Issue Date	First settlement date for this instrument
Face/Notional Amount	The face amount of a security or notional amount of a derivative contract
Principal/Notional Factor	Factor representing proportion of original principal or notional amount that is outstanding at start of stress test
Coupon	Current interest rate
Index	Interest rate index to which interest payments are tied
Spread	The amount that is added or subtracted from an interest rate index to calculate the coupon rate for floating rate instruments
Index Multiplier	A constant multiplier used in variable interest rate formula
Payment Frequency	Frequency with which payments are made
Accrual Method	The convention used for calculating interest
Maturity Date	The date on which the instrument matures
Remaining Term	Number of months until an instrument matures
Call (Cancellation)/Put Date	The first date on which the instrument may be called (cancelled) or put
Call/Put Strike Price	The price at which the call or put option may be exercised
Floor Rate	The minimum coupon for a variable rate security
Cap Rate	The maximum allowable coupon rate for a variable rate security
Cap/Floor Strike Price	Used for cap and floor instruments to indicate the interest rate at which this instrument begins paying
Pay/Receipt Code	Code that identifies whether it is a payment or a receipt
Instrument I.D.	Links pay and receive sides of swaps
Swap Reference	Links mortgage-linked derivative to reference security (e.g., when changing principal balance of a specific security is also notional amount of swap)
Original Discount	Discount from par represented by purchase price of security (e.g., price of 99.0 equates to discount of 1.0)
Counterparty Identification	Uniquely identifies the counterparty to a derivative agreement
Public Rating of Counterparty or Security	Credit rating of counterparty or security (if applicable), as issued by a nationally recognized statistical rating agency

[b] Occasionally, instruments have complex or non-standard features, and cash flows cannot be computed using the basic data listed above. In these cases the accurate modeling of cash flows requires additional information, such as amortization schedules, interest rate coupon reset formulas, and the terms of European call options, which is obtained from the Enterprises (and is included in public securities disclosure materials for publicly offered securities).

3.1.5 Operations, Taxes, and Accounting

The stress test determines how much total capital an Enterprise must hold at the start of the stress test so that total capital never falls below zero during the stress period. To accomplish this objective, projected cash flows for Enterprise financial instruments must be supplemented by projected operating expenses, taxes, and capital distributions. All of these must be recorded in pro forma financial statements in order to determine an Enterprise's total capital for each month of the stress period. Thus, complete information on the Enterprise balance sheet as of the start of the stress period is required. The necessary information is listed in section 3.1.5.1, Data Required to Calculate Taxes, Operating Expenses, and Dividends, below.

3.1.5.1 Data Required to Calculate Taxes, Operating Expenses, and Dividends

The following Enterprise data are necessary to calculate taxes, operating expenses, and dividends:

- Operating expenses (e.g., administrative expenses, salaries and benefits, professional services, property costs, equipment costs) for the quarter prior to the beginning of the stress test
- Earnings before income taxes and provision for income taxes for the three years prior to the beginning of the stress period
- Year-to-date income before taxes and provision for income taxes
- Dividend payout ratio for the four quarters prior to the beginning of the stress period
- Minimum capital requirement as of the beginning of the stress period

3.1.5.2 Balance Sheet as of the Start of the Stress Test

The data are necessary to create Enterprise balance sheets as of the start of the stress period are described below.

1. Balances for all instruments for which the stress test calculates cash flows. These are included with data the Enterprises provide for cash flow calculations. Balances are required for:

- Whole loans
- Mortgage-related securities
- Non-mortgage investments and investment-linked derivative contracts
- Debt and related cash flows

2. Additional starting position balances:

- Amounts required to reconcile starting position balances from cash flow components of the stress test with an Enterprise's balance sheet (for example, differences between actual and estimated loan prepayments during the last few days in the month)
- Cash
- Low income housing tax credit investments
- Unamortized balances of premiums, discounts, and fees from the acquisition of retained loans and mortgage-related securities at other than par value
- Allowances for loan losses
- Accrued interest receivable on retained loans, mortgage-backed securities, mortgage-linked derivatives, and non-mortgage investments
- Amounts receivable from Index Sinking Fund Debentures, currency swaps, fees, income taxes, and other accounts receivable
- Real estate owned (REO)
- Fixed assets
- Clearing accounts
- Unamortized premiums, discounts, and fees related to debt securities
- Unamortized balances related to the sold portfolio
- Deferred balances related to liability-linked derivatives
- Accrued interest payable
- Principal and interest payable to mortgage security investors
- Other liabilities, including payables from currency swaps, escrow deposits income taxes
- Dividends payable
- Components of stockholder's equity (i.e., common stock, preferred stock, paid-in capital, retained earnings, treasury stock, and unrealized gains and losses on available-for-sale securities)

3.1.6 Other Off-Balance-Sheet Guarantees

In addition to the MBS they issue, the Enterprises guarantee other securities. The stress test does not simulate the cash flows associated with these guarantees, but it does calculate an incremental capital requirement for them. This calculation requires Enterprise information on the sum of the outstanding balances of all tax-exempt multifamily housing bonds, single-family whole-loan REMICs, multifamily whole-loan REMICs, and similar instruments or obligations as of the beginning of the stress period (excluding all guarantees of securities where 100 percent of collateral is insured by FHA or guaranteed by VA).[2]

3.2 Commitments

3.2.1 Overview

The Enterprises make contractual commitments to their customers to purchase or securitize mortgages. The stress test provides for deliveries of mortgages under the commitments that exist at the start of the stress period. It also determines all of the relevant characteristics of these mortgages by reference to the characteristics of the mortgages securitized by the Enterprise that were originated in the six months preceding the start of the stress period. Based on this information, the Commitments component of the stress test creates loan groups with coupon rates that vary based upon the interest rate scenario. These loan groups are added to the Enterprise's sold portfolio and the stress test projects their performance during the stress period. In the down-rate scenario, the stress test provides that 100 percent of the mortgages specified in the commitments are delivered. In the up-rate scenario, 75 percent are delivered. Loans are delivered over the first three months of the stress period in the down-rate scenario and the first six months in the up-rate scenario.

3.2.2 Inputs

The stress test uses two sources of data to determine the characteristics of the mortgages delivered under commitments. One is information from the Enterprises on commitments outstanding at the start of the stress period and deliveries of loans originated in the six months preceding the start of the stress period (*See* section 3.1.2, Whole Loans, of this Appendix). The other is interest rate series generated by the Interest Rates component of the stress test (*See* section 3.3, Interest Rates, of this Appendix).

3.2.2.1 Loan Data

[a] To determine the total dollar amount of mortgages that will be delivered under commitments during the course of the stress period, the Enterprises are required to provide the total dollar amount of all commitments outstanding to purchase or securitize mortgages at the start of the stress period. In addition, to determine the composition of mortgages delivered to fulfill commitments, the stress test identifies loans that meet all of the following criteria:

- Business type-single family
- Origination date-within six months of the start date of the stress test
- Portfolio type-securitized
- Product type-one of the following:

1. 30-year fixed-rate
2. 15-year fixed-rate
3. One-year CMT ARM
4. Seven-year balloon

[b] For the selected loans, the following loan-level information are required:

- Starting UPB
- Original LTV
- Census division
- Guarantee fee
- Margin (for ARM loans)
- Servicing fee

3.2.2.2 Interest Rate Data

The stress test uses the following interest rate series, generated by the Interest Rates component, (*See* section 3.3, Interest Rates, of this Appendix) for the first 12 months of the stress period:

- One-year CMT rate
- Conventional 30-year fixed-rate mortgage rate
- Conventional 15-year fixed-rate mortgage rate
- Seven-year balloon mortgage rate [3]

[2] These include: (1) Any guarantee, pledge, purchase arrangement, or other obligation or commitment provided or entered into by an Enterprise with respect to multifamily mortgages to provide credit enhancement, liquidity, interest rate support, and other guarantees and enhancements for revenue bonds issued by a state or local government unit (including a housing finance agency) or other bond issuer; and (2) all off-balance-sheet obligations of an Enterprise that are not mortgage-backed securities or substantially equivalent instruments and that are not resecuritized mortgage-backed securities, such as real estate mortgage investment conduits or similar resecuritized instruments. *See* 12 CFR 1750.2.

[3] The stress text assumes that mortgage interest rates on seven-year balloon mortgages are 50 basis

Continued

3.2.3 Procedures

[a] Based on the characteristics of the mortgages securitized by the Enterprise that were originated in the six months preceding the start of the stress period and the interest rate projections in the stress period, the stress test determines all of the relevant characteristics of the loans delivered under the commitments that exist at the start of the stress test. Using this information and the classification variables-business type, portfolio type, product type, original loan-to-value ratio, and Census division, the stress test creates loan groups for commitments in the same manner as loan groups are created for other loans (specified in section 3.1.2, Whole Loans, of this Appendix). One exception is that the stress test uses an additional classification variable—delivery month—to form subgroups within each commitment loan group. This variable is used to create origination dates, which are the same as delivery dates for these loan groups. The procedures to create commitment loan groups are as follows.

1. Establish the values for classification variables—business type, portfolio type, product type, original loan-to-value ratio, and Census division as defined in section 3.1, Enterprise Data, of this Appendix.

2. Aggregate the loan-level information for the mortgages identified above into loan groups by the classification variables.

3. Concurrently with step 2, compute total starting UPB, the UPB weighted average Original LTV, Servicing fee, Guarantee fee, and Margin (for ARM loans) for each loan group.

4. Using loan group information from step 3, calculate the percent of total balance of all commitment loan groups for each loan group as follows:

% of total balance = total starting UPB for the loan group (from step 3 above) ÷ total starting UPB for all commitment loan groups added together

5. For each loan group, set the loan term and amortization period as shown in Table 3–7.

Table 3-7. Loan Term and Amortization Period

Product Type	Loan term	Amortization Period
30 YR Fixed-rate	360 MO	360 MO
15 YR Fixed-rate	180 MO	180 MO
ARM	360 MO	360 MO
7 YR Balloon	84 MO	360 MO

6. For each loan group, set remittance cycle to the shortest available option for the Enterprise.

[b] Procedures for adding subgroup characteristics to each loan group are described below.

1. Establish values for the subgroup classification variable—delivery month using percentages from Table 3–8, and divide each loan group into subgroups, one for each delivery month. Three subgroups are created in the down-rate scenario, and six subgroups are created in the up-rate scenario.

2. The total starting UPB for the subgroup is calculated as follows: subgroup balance = total dollar amount of commitments outstanding × % of total balance of the subgroup (from step 4 above) × Percent delivered in that delivery month (from Table 3–8).

Table 3-8. Monthly Deliveries as a Percentage of Commitments Outstanding

Delivery month	Up-Rate Scenario	Down-Rate Scenario
1	18.75%	62.50%
2	18.75%	25.00%
3	12.5%	12.50%
4	12.5%	0.00%
5	6.25%	0.00%
6	6.25%	0.00%
Total[1]	75%	100%

[1] In the down-rate scenario, 100 percent of outstanding commitments will be delivered. In the up-rate scenario, 75 percent of outstanding commitments will be delivered.

3. Set the original coupon rate and starting coupon rate (as of delivery date) for each subgroup as set forth in Table 3–9.

points less than 30-year conventional mortgage rates in the down-rate environment, and equal to the 30-year rate in the up-rate environment.

Table 3-9. Original and Starting Coupon Rates for Commitment Loan Groups

Product Type	Original and Starting Coupon Rate (as of delivery date)
30 YR Fixed-rate	Conventional 30-year mortgage rate
15 YR Fixed-rate	Conventional 15-year mortgage rate
ARM	One-year T-bill rate + weighted average margin for the loan group
7 YR Balloon	Down-rate scenario: Conventional 30-year mortgage rate - 50 basis points; Up-rate scenario; Conventional 30-year mortgage rate

4. Based on the original coupon rate and starting coupon rate set for the subgroup in step 3, assign the subgroup with original coupon rate class value and starting coupon rate class value as defined in section 3.1.2, Whole Loans, of this Appendix.

5. Set the origination year and month of the subgroup by adding the delivery month to the starting date of the stress period.

6. Set the age of the subgroup in the stress period to the number of months elapsed in the stress period minus the delivery month. Set the remaining term of the subgroup to the amortization term minus the age of the subgroup.

7. Set the net yield of the subgroup to the starting coupon rate minus the servicing fee.

8. Set the passthrough rate of the subgroup to the net yield minus the guarantee fee.

3.2.4 Output

[a] The output of the Commitment component of the stress test is data for a set of loan subgroups that are virtually identical to loan groups created for loans on the books of business of the Enterprises at the start of the stress test, except that an additional classification variable, delivery month, is used to supplement origination year for each subgroup of commitment loans. This additional information tells when the mortgages in that particular subgroup are delivered to the Enterprise.

[b] The data for loan subgroups created by the Commitments component of the stress test allows the stress test to project the defaults, losses, prepayments, scheduled amortization, interest payments, guarantee fee income, and float income for loans purchased under commitments for the ten-year stress period.

3.3 Interest Rates

3.3.1 Overview

The 1992 Act specifies changes in the ten-year constant maturity Treasury yield (CMT) for the two interest rate scenarios of the stress test. It further states that yields of Treasury instruments with other maturities will change relative to the ten-year CMT in patterns that are reasonably related to historical experience. The Interest Rates component of the stress test projects these Treasury yields as well as other interest rate indexes that are needed to calculate cash flows, to simulate mortgage performance for mortgages and other financial instruments, and to calculate the risk-based capital requirement. The Interest Rates component produces values for the interest rates and indexes for the starting date of the stress test and for each of the 120 months in the stress period. The process for determining interest rates can be divided into five steps. First, identify values for the necessary interest rates and indexes on the starting date. Second, project the ten-year CMT for each month of the stress period as specified in the 1992 Act. Third, project the one-, two-, three-, and six-month Treasury yields and the one-, two-, three-, five-, 20-and 30-year CMTs.[4] Fourth, project non-Treasury indexes and interest rates. Fifth, project borrowing rates for the Enterprises.

3.3.2 Inputs

Projecting interest rates and indexes in the stress test requires initial values as of the start date of the stress test. Initial values for the stress test are the averages of the values for the month preceding the start of the stress period. Additional months of historical data are input to the stress test in order to project interest rates other than the ten-year CMTs during the stress period. The historical data input for non-Treasury interest rate indexes are listed in Table 3–12. Table 3–10 below contains a list and a description of the interest rates and indexes input to the stress test.

[4] For ease of discussion, all of the Treasury yields are referred to as CMTs.

Table 3-10. Interest Rate and Index Inputs for the Interest Rates Component

Interest Rate Variable	Source	Description
1 MO Treasury Bill	Bank of America, San Francisco	One-Month Treasury bill yield, monthly average of daily rate, secondary market, bond-equivalent yield
2 MO Treasury Bill	Bank of America, San Francisco	Two-Month Treasury bill yield, monthly average of daily rate, secondary market, bond-equivalent yield
3 MO Treasury Bill[1]	Federal Reserve H.15 Release	Three-month Treasury bill yield, monthly average of daily rates, secondary market, bond-equivalent yield
6 MO Treasury Bill[a]	Federal Reserve H.15 Release	Six-month Treasury yield, monthly average of daily rates, secondary market, bond-equivalent yield
1 YR CMT	Federal Reserve H.15 Release	One-year constant maturity Treasury yield, monthly average of daily rates, bond-equivalent yield
2 YR CMT	Federal Reserve H.15 Release	Two-year constant maturity Treasury yield, monthly average of daily rates, bond-equivalent yield
3 YR CMT	Federal Reserve H.15 Release	Three-year constant maturity Treasury yield, monthly average of daily rates, bond-equivalent yield
5 YR CMT	Federal Reserve H.15 Release	Five-year constant maturity Treasury yield, monthly average of daily rates, bond-equivalent yield
10 YR CMT	Federal Reserve H.15 Release	Ten-year constant maturity Treasury yield, monthly average of daily rates, bond-equivalent yield
20 YR CMT	Federal Reserve H.15 Release	Twenty-year constant maturity Treasury yield, monthly average of daily rates, bond-equivalent yield
30 YR CMT	Federal Reserve H.15 Release	Thirty-year constant maturity Treasury yield, monthly average of daily rates, bond-equivalent yield
Overnight Federal Funds	Dow Jones Telerate and Federal Reserve Bank of New York	Overnight effective Federal funds rate, monthly average of daily rates, bond-equivalent yield
7-day Federal Funds	Reuters America	Seven-day Federal funds rate, monthly average of daily rates, bond-equivalent yield
180-day Federal Funds	Reuters America	One hundred and eighty-day Federal funds rate, monthly average of daily rates, bond-equivalent yield
Conventional Mortgage Rate	Federal Reserve H.15	FHLMC (Freddie Mac) contract interest rates on commitments for fixed-rate first mortgages, monthly average of weekly rates
FHLB 11th District Cost of Funds	Federal Home Loan Bank of San Francisco	11th District (San Francisco) weighted average cost of funds for savings and loans, monthly

Table 3-10. Interest Rate and Index Inputs for the Interest Rates Component (Continued)

Interest Rate Variable	Source	Description
15 YR fixed-rate mortgage	Dow Jones Telerate	Fifteen-year, fixed-rate mortgage, commitments for delivering in 0-10 days, monthly average of daily rates
7 YR balloon mortgage	N/A	Seven-year balloon mortgage, equal to the conventional mortgage rate in the up case and the conventional mortgage rate less 50 bp in the down case

[1] The three-month, six-month, and one-year Treasury rates are used to determine the historical relationship between the ten-year CMT and the ten other CMTs and to estimate ARIMAs, both of which are discussed later in this section; however, the referenced source is used to determine historical relationships, while the source used for ARIMA estimations is Bank of America, DRI/McGraw Hill.

3.3.3 Procedures

3.3.3.1 Identify Starting Values

The starting values for all of the interest rates and indexes listed in Table 3–10 are their daily averages during the month preceding the start of the stress test.

3.3.3.2 Project the Ten-Year CMT

The 1992 Act specifies that the stress test be based on increases or decreases in the ten-year CMT, whichever would require more capital. The ten-year CMT increases or decreases during the first year of the stress period and remains at that level for the remainder of the stress period. The 1992 Act further specifies how the increases and decreases in the ten-year CMT are determined.

3.3.3.2.1 Down-Rate Scenario

[a] To determine the ten-year CMT in the down-rate scenario, the stress test first computes the average of the ten-year CMT for the nine months prior to the start of the stress test, and subtracts 600 basis points; and second, computes the average yield of the ten-year CMT for the 36 months prior to the start of the stress test, and multiplies by 60 percent.

[b] The ten-year CMT in the down-rate scenario is decreased to the lesser of these two yields unless that yield is less than 50 percent of the average for the nine months preceding the start date. In that case, the ten-year CMT decreases 50 percent of the nine-month average described above.

[c] Once the ten-year CMT for the down-rate scenario is determined, the stress test decreases the ten-year CMT from the value as of the start of the stress period to this level in equal increments over the first twelve months of the stress period. The ten-year CMT remains at this level for the remaining nine years of the stress period.

3.3.3.2.2 Up-Rate Scenario

[a] To determine the ten-year CMT in the up-rate scenario, the stress test first computes the average for the ten-year CMT the nine months prior to the start of the stress test, and adds 600 basis points; and second, computes the average for the ten-year CMT for the 36 months prior to the start of the stress test, and multiplies by 160 percent.

[b] The ten-year CMT in the up-rate case is equal to the greater of these two rates unless that yield is greater than 175 percent of the average for the nine months preceding the stress period. In that case, the ten-year CMT increases to 175 percent of the nine-month average.

[c] Once the ten-year CMT for the up-rate scenario is determined, the stress test increases the ten-year CMT from the value as of the start of the stress period to this level in equal increments over the first twelve months of the stress period. The ten-year CMT remains at this level for the remaining nine years of the stress period.

3.3.3.3 Project the Ten Other CMTs

In the third step, yields for the one-, two-, three-and six-month and the one-, two, three-, five-, 20-and 30-year CMTs are projected.

3.3.3.3.1 Down-Rate Scenario

[a] In the down-rate scenario, the ten other CMTs are calculated by first computing the long-term averages for the ten-year CMT and each of the ten CMTs, and then computing the ratios of the ten-year CMT long-term average to the ten other CMT long-term averages. The long-term averages are calculated over the period from May, 1986, through April, 1995. These are presented in Table 3–11 below. The stress test multiplies the ten-year CMT for the last nine years of the stress test by the appropriate ratio to create the six other CMTs for the last nine years of the stress test.

Table 3-11. Ratios of the 10-Year CMT to Ten Other CMTs

CMTs	Ratio
1 MO / 10 YR	0.68271
2 MO / 10 YR	0.71825
3 MO / 10 YR	0.73700
6 MO / 10 YR	0.76697
1 YR / 10 YR	0.79995
2 YR / 10 YR	0.86591
3 YR / 10 YR	0.89856
5 YR / 10 YR	0.94646
20 YR / 10 YR	1.06246
30 YR / 10 YR	1.03432

[b] In the first twelve months of the stress period, the ten other CMTs are computed in a manner similar to the calculation of the ten-year CMT for that period. From its value at the start of the stress test, each of the ten other CMTs is decreased in equal steps in each of the first twelve months of the stress period until it reaches the appropriate level for the nine remaining years of the stress test.

3.3.3.3.2 Up-Rate Scenario

In the up-rate scenario, the six other CMTs are equal to the ten-year CMT in the last nine years of the stress test. Each of the six other CMTs is increased in equal increments over the first twelve months of the stress test until it equals the ten-year CMT.

3.3.3.4 Project Non-Treasury Interest Rates

[a] Table 3–12 presents the equations for projecting the non-Treasury interest rates for each month of the stress test. These equations were developed using the percentage spread between the non-Treasury interest rate and the CMT with the same or similar maturity over a historical period [5] and an ARIMA procedure (Autoregressive Integrated Moving Average).[6] The stress test applies these equations to forecast the spreads between each non-Treasury interest rate and the CMT from which it is estimated for the 120 months of the stress period. Finally, the stress test converts the projected values for the proportional spreads into rate and index levels. As used here, the percentage spread for the three-month LIBOR rate, for example, is:

$$\frac{(\text{3-month LIBOR rate} - \text{3-month Treasury Yield})}{\text{3-month Treasury Yield}}$$

[b] In Table 3–12, equations are grouped according to the Treasury maturity against which the spread was calculated. For example, the first group's spread was computed against the one-month Treasury yield. Where the dependent variable was estimated as a first difference, this is indicated in the Description column. ''*T*'' represents the spread variable.

[5] Various historical data series have missing values.

[6] SAS ETS Users Guide, SAS Institute, 1993.

Table 3-12. Non-Treasury Interest Rate Indexes: ARIMA Forecasting Models (Continued)

Variable Name	Description	Historical Period for Spread Estimation	Equation
Percentage Spread Based on 2-year CMT			
*FA*024	24-month Federal Agency Cost of Funds	Jun 1979-Jun 1997	$0.66928 \times T\_FA024_{t-1} + 0.22178 \times T\_FA024_{t-6} - 0.08219 \times T\_FA024_{t-18} + 0.21423 \times ERROR_{t-5} - 0.12729 \times ERROR_{t-11}$
Percentage Spread Based on 3-year CMT			
*FA*036	36-month Federal Agency Cost of Funds	Jun 1979-Jun 1997	$0.86153 \times T\_FA036_{t-1}$
Percentage Spread Based on 5-year CMT			
*FA*060	60-month Federal Agency Cost of Funds	Jun 1979-Jun 1997	$0.88777 \times T\_FA060_{t-2}$
Percentage Spread Based on 10-year CMT			
CONVR	Conventional Mortgage Rate	Jun 1979-Jun 1997	$0.20924 + 1.04067 \times T\_CONVR_{t-1} - 0.47582 \times T\_CONVR_{t-2} + 0.27044 \times T\_CONVR_{t-3}$
*FA*120	120-month Federal Agency Cost of Funds	Jun 1979-Jun 1997	$0.70427 \times T\_FA120_{t-1} + 0.27343 \times T\_FA120_{t-2}$
*FRM*15Y	15-year, fixed-rate mortgage	May 1985-Jun 1997	$0.09307 + 1.021800 \times T\_FRM15Y_{t-1} - 0.25518 \times T\_FRM15Y_{t-2}$
Percentage Spread Based on 30-year CMT			
*FA*360	360-month Federal Agency Cost of Funds	Jun 1979-Jun 1997	$0.03528 + 0.92765 \times T\_FA360_{t-1}$

Table 3-12. Non-Treasury Interest Rate Indexes: ARIMA Forecasting Models

Variable Name	Description	Historical Period for Spread Estimation	Equation
Percentage Spread Based on 1-month Treasury Yield			
ONFFD	Overnight Fed Funds	Jan 1973 - Jun 1997	.11729+.72093xT_ONFFD_{t-1}+ .13259xT_ONFFD_{t-5}
*FFD*07	7-day Fed Funds (first difference)	Apr 1984 - Jun 1997	.37803x$ERROR_{t-1}$+.15897x$ERROR_{t-2}$+ .16638x$ERROR_{t-4}$
*LBR*01	1-month LIBOR - Mid-Market Yield (first difference)	Jun 1973-Jun 1997	.35113x$ERROR_{t-1}$+.02264x$ERROR_{t-2}$+ .20959x$ERROR_{t-3}$
Percentage Spread Based on 3-month Treasury Yield			
*LBR*03	3-month LIBOR - Mid-Market Yield (first difference)	Jun 1973-Jun 1997	0.13277x$ERROR_{t-1}$+0.13495x$ERROR_{t-3}$+ 0.39554x$ERROR_{t-4}$
*FA*003	3-month Federal Agency Cost of Funds (first difference)	Jun 1979-Jun 1997	0.45841xT_FA003_{t-1} +0.91842x$ERROR_{t-1}$
PRIME	Prime Rate	Dec 1969-Jun 1997	0.14323+1.12090xT_PRIME_{t-1}-0.35995xT_PRIME_{t-2} +0.22184xT_PRIME_{t-3}
Percentage Spread Based on 6-month Treasury Yield			
*LBR*06	6-month LIBOR - Mid-Market Yield (first difference)	Jun 1973-Jun 1997	-0.31747xT_LBR06_{t-4}-0.11106xT_LBR06_{t-6}+ 0.12368xT_LBR06_{t-7}-24605xT_LBR06_{t-8}+ 0.07568x$ERROR_{t-1}$
*FA*006	6-month Federal Agency Cost of Funds	Jun 1979-Jun 1997	0.02397+0.74541xT_FA006_{t-1}
*FF*180	180-day Fed Funds	Dec 1979-Jun 1997	$0.96842 \times T\_FF180_{t-1}$
Percentage Spread Based on 1-year CMT			
*COF*11	FHLB 11th District Cost of Funds	Jul 1981-Jun 1997	1.25858xT_COF11_{t-1}-0.31799xT_COF11_{t-2}
*LBR*12	12-month LIBOR - Mid-Market Yield (first difference)	Jun 1973-Jun 1997	0.14073x$ERROR_{t-1}$+0.12690x$ERROR_{t-2}$+ 0.10781x$ERROR_{t-3}$+0.22280x$ERROR_{t-4}$
*FA*012	12-month Federal Agency Cost of Funds	Jun 1979-Jun 1997	0.01806+0.59137xT_FA012_{t-1}

3.3.3.5 Project Borrowing Rates

The stress test adds a 50 basis point credit spread to the federal agency cost of funds index to project Enterprise borrowing costs for the last nine years of the stress period.

3.3.4 Output

The output from the interest rate calculations are 120 monthly interest rate and index values for the projected eleven points on the Treasury yield curve (one-month, two-month, three-month, six-month, one-year, two-year, three-year, five-year, ten-year, 20-year and 30-year) and the 20 non-Treasury yields.

3.4 Property Valuation

3.4.1 Overview

[a] The Property Valuation component provides the monthly single family house price growth rates, rent growth rates, and rental unit vacancy rates that contribute to the determination of property values in the calculation of mortgage performance. The rates are those associated with the benchmark loss experience, the ten-year experience of loans originated in Arkansas, Louisiana, Mississippi, and Oklahoma during 1983 and 1984. The benchmark loss experience spans twelve years from the beginning of 1983, when the first benchmark loans were originated, through the end of 1994, ten years after the last benchmark loans were originated. The rates used in the stress test are those for the middle ten years of this period, 1984 through 1993.

[b] Single family house price growth rates are taken from the HPI series for the West South Central Census Division, which includes all of the benchmark states except Mississippi. House price growth rates are used to project single family mortgage performance. Rent growth rates and vacancy rates are taken from information for the major metropolitan areas in the four benchmark States, published by the Institute for Real Estate Management, and State level vacancy rates published by the Bureau of the Census. These rates are used to project multifamily mortgage performance.

[c] As required by the 1992 Act, in the up-rate scenario, house price rates and rent growth rates may require adjustment for inflation. If the ten-year CMT rises more than 50 percent from the average yield during the nine months preceding the stress period, rates are adjusted upward to take into account the effect of inflation.

[d] This section includes a description of the required inputs and procedures for inflation adjustments, and concludes with outputs. These outputs include tables of benchmark house price and rent growth rates unadjusted for inflation and rental vacancy rates. These rates will not change unless the benchmark loss experience changes.

3.4.2 Inputs

The inputs required for adjusting house price and rent growth rates are:

- The average yield of the ten-year CMT for the nine months preceding the stress period, as computed in section 3.3, Interest Rates, of this Appendix)
- The highest 10-year CMT during the stress period, as computed in section 3.3, Interest Rates, of this Appendix

• Unadjusted house price and rent growth rates during the stress period, as shown in Tables 3–13 and 3–14 below

3.4.3 Procedures

Inflation adjustments are applied over the final five years of the up-rate scenario stress test. The procedures are described below.

1. Determine whether an adjustment is necessary. Multiply the average10-year CMT for the nine months preceding the stress period by 1.50, and subtract the product from the highest value of the10-year CMT during the stress period. The difference is *YD.* If *YD* > 0, follow steps 2–4 to apply an inflation adjustment. Otherwise, use the rates provided in the Tables 3–13 and 3–14.

2. Compute the adjustment. Use the following formula to compute the cumulative adjustment as if *YD* were to apply over 9 years and 2 months:[7]

$$IN = (1 + YD)^{55/6}$$

where:

IN = cumulative inflation adjustment

3. Calculate the monthly inflation adjustment factors to apply to house price and rent rate growth rates. The cumulative adjustment is applied over the last five years of the stress period, and monthly adjustment factors are computed as follows:

a. For house-price growth rates, the monthly adjustment factor is:[8]

$$IH_t = \frac{ln(IN)}{60}, \quad \text{for } t = \{61,...,120\}$$

where:

IH_t = monthly house-price growth adjustment factor

b. For rent growth rates, the monthly adjustment factor is:[9]

$$IR_t = \sqrt[60]{IN} - 1, \quad \text{for } t = \{61,...,120\}$$

where:

IR_t = monthly rent growth rate adjustment factor

4. Compute final monthly growth rates. Add the monthly inflation adjustment factors IH_t and IR_t to the house and rent growth rates for months 61 through 120. The resulting series will be inflation-adjusted growth rates.

3.4.4 Output

[a] Monthly house price growth rates, rent growth rates, and rental vacancy rates are used by the Mortgage Performance components of the stress test (*see* section 3.5, Mortgage Performance, of this Appendix). If there are no inflation adjustments, the house price and rent growth rates in Tables 3–13 and 3–14 are used. If the inflation adjustment is necessary, then the adjusted growth rates are used.

[b] House price growth rates are inputs to the Single Family Default and Prepayment and the Single Family Loss Severity components of the stress test (See sections 3.5.2 and 3.5.3 of this Appendix). The rent growth rates and vacancy rates are inputs to the Multifamily Default and Prepayment and Multifamily Loss Severity components (See sections 3.5.4 and 3.5.5 of this Appendix).

[7] If the ten-year CMT increases 75 percent over the base month, a 50 percent increase will be achieved by month eight. The full increase will be achieved by month twelve. On average, the difference YD will apply for 9 years and 2 months.

[8] This factor is in continuous rate form (note use of natural logarithm) to be compatible with the house p

[9] This factor is in discrete rate form to be compatible with the

Table 3-13. Stress Test Single Family House Price Growth Rates (Unadjusted)

Stress Test Months	Historical Months	Value
1-3	Oct - Dec 1983	0.0016826850
4-6	Jan - Mar 1984	0.0003819304
7-9	Apr - Jun 1984	0.0005691805
10-12	Jul - Sep 1984	-0.0026117430
13-15	Oct - Dec 1984	-0.0023250310
16-18	Jan - Mar 1985	0.0013926963
19-21	Apr - Jun 1985	-0.0019789320
22-24	Jul - Sep 1985	-0.0064738920
25-27	Oct - Dec 1985	0.0087437819
28-30	Jan - Mar 1986	0.0076169107
31-33	Apr - Jun 1986	-0.0071341580
34-36	Jul - Sep 1986	-0.0061689600
37-39	Oct - Dec 1986	0.0015192552
40-42	Jan - Mar 1987	-0.0131018780
43-45	Apr - Jun 1987	-0.0081272530
46-48	Jul - Sep 1987	-0.0089202740
49-51	Oct - Dec 1987	-0.0010606320
52-54	Jan - Mar 1988	0.0039512034
55-60	Apr - Sep 1988	-0.0068292010
61-63	Oct - Dec 1988	0.0020974158
64-66	Jan - Mar 1989	0.0035077580
67-69	Apr - Jun 1989	0.0059641985
70-72	Jul - Sep 1989	-0.0016271130
73-75	Oct - Dec 1989	-0.0000758170
76-78	Jan - Mar 1990	0.0029346442
79-81	Apr - Jun 1990	0.0011470552
82-84	Jul - Sep1990	-0.0012589880
85-87	Oct - Dec 1990	0.0033172551
88-90	Jan - Mar 1991	0.0042053432

Table 3-13. Stress Test Single Family House Price Growth Rates (Unadjusted) (Continued)

Stress Test Months	Historical Months	Value
91-93	Apr - Jun 1991	0.0007557299
94-96	Jul - Sep 1991	0.0041740394
97-99	Oct - Dec 1991	0.0044594285
100-102	Jan - Mar 1992	-0.0001728910
103-105	Apr - Jun 1992	0.0053448952
106-108	Jul - Sep 1992	0.0018970089
109-111	Oct - Dec 1992	0.0019075056
112-114	Jan - Mar 17993	0.0035380290
115-117	Apr - Jun 1993	0.0046397580
118-120	Jul - Sep 1993	0.0037558008

Table 3-14. Stress Test Rent Growth Rates (Unadjusted)

Stress Test Months	Historical Months	Value
1-12	Jan - Dec 1984	0.0035706091
13-24	Jan - Dec 1985	0.0020566625
25-36	Jan - Dec 1986	0.0051870916
37-48	Jan - Dec 1987	0.0007700712
49-60	Jan - Dec 1988	0.0010384258
61-72	Jan - Dec 1989	0.0032714078
73-84	Jan - Dec 1990	0.0029505423
85-96	Jan - Dec 1991	0.0037578051
97-108	Jan - Dec 1992	0.0035665268
109-120	Jan - Dec 1993	0.0035279667

Table 3-15. Stress Test Vacancy Rates

Stress Test Months	Historical Months	Value
1-12	Jan - Dec 1984	0.0987886700
13-24	Jan - Dec 1985	0.1095145375
25-36	Jan - Dec 1986	0.1145000000
37-48	Jan - Dec 1987	0.1325000000
49-60	Jan - Dec 1988	0.1192500000
61-72	Jan - Dec 1989	0.1160000000
73-84	Jan - Dec 1990	0.1107500000
85-96	Jan - Dec 1991	0.0885000000
97-108	Jan - Dec 1992	0.0795000000
109-120	Jan - Dec 1993	0.0847500000

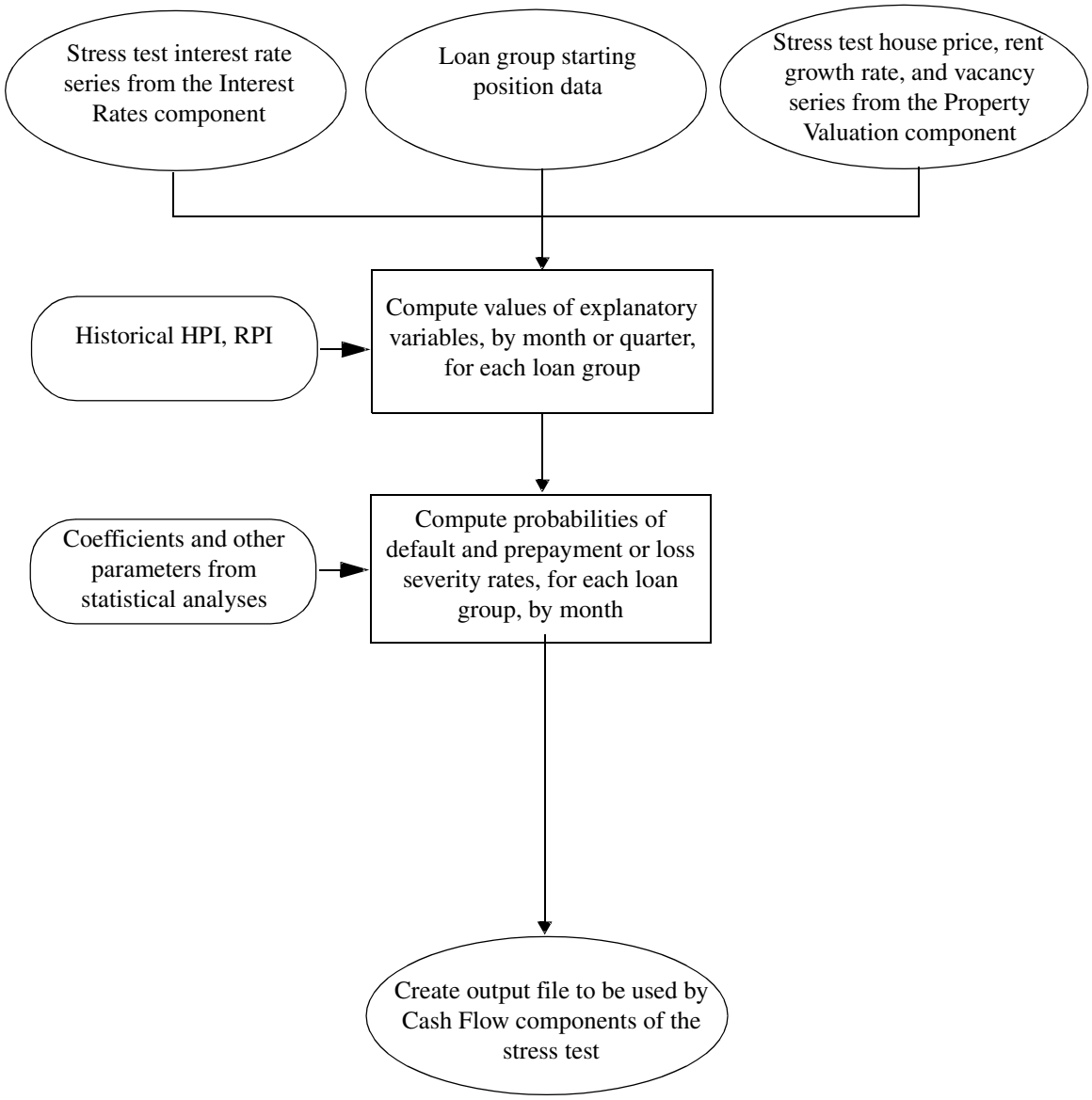
3.5 Mortgage Performance

3.5.1 General

[a] The four components of the stress test that simulate various elements of mortgage performance are single family default and prepayment, single family loss severity, multifamily default and prepayment, and multifamily loss severity.

[b] Figure 3–1 is a schematic overview of the basic structure of each mortgage performance component. Each mortgage performance component uses as inputs loan group starting position data, interest rate series from the Interest Rates component (*see* section 3.3, Interest Rates, of this Appendix), historical house-price indexes (HPI) and rental-price indexes (RPI) from government sources, and HPI and RPI growth and rental vacancy rate series for the stress period from section 3.4, Property Valuation, of this Appendix. These inputs are used to calculate the values of explanatory variables that are then used to compute monthly default, prepayment, and loss severity rates. These monthly default, prepayment, and loss severity rates are used to compute cash flows (refer to section 3.9, Cash Flows, of this Appendix).

Figure 3-1. Mortgage Performance Components: Basic Structure



3.5.2 Single Family Default and Prepayment

3.5.2.1 Overview

The stress test calculates conditional default and prepayment rates for single family mortgages for each month of the ten-year stress period. A conditional rate of default or prepayment refers to the percentage of the outstanding balance in a loan group that defaults or prepays during a given period of time. Computing default and prepayment rates requires information on the risk characteristics of a loans, historical and projected rates of interest, and the historical and projected rates of property value appreciation (or depreciation). Some of this information is used directly, while other information is combined together to create new variables for use in the default and prepayment rate calculations. In all, nine explanatory variables are used to determine default and prepayment rates for single family loans: mortgage age, mortgage age squared, original loan-to-value ratio, probability of negative equity, prepayment burnout, the percentage of investment property loans, relative interest rate spread, yield curve slope, and mortgage product-type. A statistical analysis of the relationship between the explanatory variables and historical default and prepayment rates was used to estimate the weights (also known as regression coefficients) associated with each variable. The selected weights are combined as described below to compute quarterly default and prepayment rates throughout the stress test period. The quarterly rates are then converted to monthly conditional default and prepayment rates and used by the cash flow component (*See* section 3.9, Cash Flows, of this Appendix) of the stress test to calculate monthly principal reductions resulting from defaults and prepayments, and to calculate default losses for each month in the ten-year stress period.

3.5.2.2 Inputs

[a] There are three categories of data inputs for single family default and prepayment rate calculations: characteristics of loan groups, interest rates, and house price index values and volatilities.

[b] The loan group characteristics used here are listed below with their

corresponding variable names, where relevant, as they appear in subsequent formulas:

- Product type
- Origination year (Y_0)
- Origination month (required for loans delivered under commitments only)
- Census division (d)
- Origination LTV (LTV_0)
- Origination UPB (UPB_0)
- Original coupon interest rate ($r_{c,0}$)
- Mortgage origination term, in months (T_o)
- Mortgage amortization term, in months (T_a)
- Remaining term, in months (T_r)
- Percentage of investor loans (P) (this refers to the percent of investor property loans in an Enterprise's entire loan portfolio)

[c] The interest rate variables are listed below, along with their reference names as they appear in subsequent formulas:

- Conventional 30-year fixed-rate mortgage coupon rates ($r_{f,q}$)
- One-year (Constant Maturity) Treasury yields ($y12_q$)
- Ten-year (Constant Maturity) Treasury yields ($y120_q$)

[d] All interest rate series are provided by the Interest Rate component in monthly form. They are converted to quarterly series by taking simple averages of monthly values within each calendar quarter. Each interest-rate series represents 30 years of historical values, plus 10 years of stress test values. As described below in section 3.5.2.3, Procedures, of this Appendix, loans with origination years prior to 1979 are treated as having an origination year of 1979. Therefore, no interest rate variable values before that year are used. The conventional 30-year fixed-rate mortgage rate series does not begin until the second half of 1979, so values for the first two quarters of 1979 are equal to the third-quarter value.

[e] House price growth rates are used to adjust the value of collateral properties before and during the stress period. Before the stress test is run, mortgages are seasoned using historical Census Division HPI series from the most recent OFHEO HPI report. House price growth rates for the stress period are determined as discussed in section 3.4, Property Valuation, of this Appendix. The two house price growth rate volatility parameters published in the OFHEO HPI Report, for each Census division, are also used, as described below. The volatility parameters measure the distribution of individual house price growth paths around the measured HPI value, as a function of the age of a mortgage.

3.5.2.3 Procedures

3.5.2.3.1 Overview

Five general steps for generating default and prepayment rates for single family loans are repeated for each loan group throughout the stress period.

1. Obtain the loan group characteristics, the interest rates, and the HPI index and volatility values.

2. Using the loan characteristics and other input data, compute the values for the nine explanatory variables, by loan group, for each quarter of the stress period.

3. Match the time series of explanatory variables for each loan group to associated regression weights (coefficients) for use in calculating default and prepayment rate series. Some of the variables are multiplied by the weights and then used in the default and prepayment rate calculations. These are called ''continuous'' variables, and they include age (and age squared), investor-property percent. Other variables are categorical and do not get multiplied by the weights. Rather, for these explanatory variables, one of several available weights is assigned based on the value-range or category of the explanatory variable value in each quarter. For categorical variables, the underlying values can change from quarter to quarter, and the weights used will also change, as the variable value moves from one category to another.

4. Sum the results of Step 3—a combined set of weighted continuous variables and categorical variable weights for each quarter—to produce factors that go into default and prepayment rate calculations. The rate calculations use logistic probability formulas. Table 3–17 provides all weights needed to compute the default and prepayment rates for each product type. There is one set of beta (β) and gamma (γ) weights for 30-year fixed-rate mortgages, one set for adjustable rate mortgages, and one set for all other product types.

5. Convert the quarter default and prepayment rates into monthly equivalent rates so that the stress test has monthly series for cash flow projections.

3.5.2.3.2 Explanatory Variables Calculations

The following sections describe how each explanatory variable is calculated and how the weights are combined to compute default and prepayment rates for a group of single family loans of similar risk characteristics.

3.5.2.3.2.1 Mortgage Age (A_q)

[a] The mortgage age in each quarter of the stress period is computed as:

$$A_q = \begin{cases} int((T_0 - T_r)/3) + q, \text{ when } Y_0 \geq 1979 \\ (Y_s - 1979) \cdot 4 + q_s + q, \text{ when } Y_0 < 1979 \end{cases}$$

where:

A_q = mortgage age in quarters, in each stress period quarter, q, where $q = \{1,...,40\}$

$int(.)$ = function which returns the integer value (whole number) portion of the expression in brackets

T_o = mortgage origination term in months

T_r = remaining term of mortgage in months, at the start of the stress period

Y_0 = calendar year of loan origination

Y_s = calendar year of the start of the stress test

q_s = number of the calendar quarter immediately preceding the stress test, $q_s = \{1,...,4\}$. if calendar quarter number is 4 (i.e., stress test begins in the first quarter of a calendar year) then reset $q_s = 0$

[b] Loans with origination years prior to 1979 are treated as if they were originated in 1979. The age value and the squared value of age are used directly in the default and prepayment formula, along with their weights (coefficients).

3.5.2.3.2.2 Origination LTV (LTV_0)

The value of the original LTV for each loan group does not change throughout the stress test. Once it is matched to an LTV_0 category in Table 3–17, the associated default and

prepayment weights are used throughout the stress test.[10]

3.5.2.3.2.3 Probability of Negative Equity ($PNEQ_q$)

[a] The probability of negative equity variable requires creating a time series of property values and amortizing loans to create updated LTV ratios throughout the stress period. The updated LTV ratios are used along with the standard deviations of house price growth paths to compute probabilities of negative equity. The probability of negative equity measures the percent of loans underlying a loan group that are likely to have negative equity positions, in each quarter of the stress period. The step-by-step process for computing the variable $PNEQ_q$ follows. *See* Figure 3–2 for an overview of the derivation process.

1. Create a time series of property values that extends from loan origination through the stress period as described below.

a. Extend the historical HPI series for each of the nine Census divisions through the stress period by adding the growth rate factors (g_i) that are described in section 3.4, Property Valuation, of this Appendix:

$$HPI_{d,\,q} = HPI_{d} \cdot exp\left(\sum_{i=1}^{3 \cdot q} g_{i} \right)$$

where:

$HPI_{d,q}$ = HPI value for Census Division, d, in quarter, q, of the stress period, q = {1,...,40}

HPI_{d} = HPI value for Census Division, d, at the start of the stress period

g_i = monthly HPI growth rate factor for month i in the stress period, i = {1,...,120}. These growth rates associated with the benchmark loss experience, they are *not* specific to Census Divisions.

b. Create an index for average house value in each quarter of the stress period (V_q) using HPI values from the loan origination quarter and from each quarter of the stress period, by Census division:

$$V_{q} = (HPI_{d,q} / HPI_{d,O})$$

where:

$HPI_{d,O}$ = HPI value for Census division, d, in the loan origination quarter, O

O = calendar year and quarter of mortgage origination, found by subtracting mortgage age (in quarters) at the start of the stress test (A_1) from the calendar quarter in which the stress period starts. If, for example, a mortgage is 33 quarters old in the first quarter of the stress test, and the stress test starts in 2001:2, then O = 1993:1.

The published HPI series begins in the first quarter of 1980. Values for the four quarters of 1979 are produced by OFHEO, but are not published. Table 3–16 provides these values, which are assigned to $HPI_{d,O}$ for loans originating in 1979. Loans with origination years prior to 1979 are treated as if they were originated in 1979.

[10] Note that Table 3–1 of this Appendix shows eight categories for original LTV ratio classes. The default and prepayment component of the stress test combines the last three categories into one category.

Table 3-16. HPI Values in 1979, by Census Division, Consistent with Calculations used in the OFHEO HPI Report, 1996:3

Census Division	$HPI_{d,1979:1}$	$HPI_{d,1979:2}$	$HPI_{d,1979:3}$	$HPI_{d,1979:4}$
East North Central	94.31	97.95	99.16	100.20
East South Central	95.93	96.96	98.86	96.74
Mid-Atlantic	91.10	93.49	95.19	98.31
Mountain	90.78	94.34	96.56	98.97
New England	97.43	99.15	100.98	103.88
Pacific	84.95	88.98	93.33	96.66
South Atlantic	89.16	92.14	93.31	96.54
West North Central	95.42	98.56	99.70	99.73
West South Central	91.04	92.92	95.66	98.05

2. Amortize the average loan balance from loan origination through the stress period. This procedure does not use the current mortgage coupon rate at the start of the stress period, but rather creates a history of interest rate paths for the loan group, from origination, as if all adjustable rate mortgages are Constant Maturity Treasury ARMs, with one-year adjustment periods.

a. Create the coupon interest rate series, $r_{c,q}$. For fixed-rate mortgages, set $r_{c,q} = r_{c,0}$, (original coupon) for every quarter. However, for adjustable-rate mortgages, adjustments must be made over time, taking into account period and lifetime interest rate caps as follows:

First, set $r_{c,q} = r_{c,0}$ for $q = \{1,\ldots,4\}$.

where:

$r_{c,0}$ = original coupon rate

Then, for every fourth quarter of loan life, evaluate:

$$r_{c,q} >< (y12_q + 0.0275), \quad \text{for } q = \{4, 8, 12, \ldots, \text{int}((A_1+38)/4) \cdot 4\}$$

where:

$r_{c,q}$ = current mortgage coupon rate in quarter, q, of loan life

$y12_q$ = 12-month constant maturity Treasury yield, in quarter q

0.0275 = index margin used to create fully-adjusted market interest rate

int(.) = the integer value of the term in parentheses. This multiplied by 4 represents the final quarter in the life of the loan—before the last quarter of the stress period—in which the mortgage age is an even multiple of 4.

When $r_{c,q} < (y12_q + 0.0275)$, then set:
$r_{c,q+1\ldots q+4} = \min\{(y12_q + 0.0275), (r_{c,q} + 0.02), (r_{c,0} + 0.05)\}$
When $r_{c,q} > (y12_q + 0.0275)$, then set:
$r_{c,q+1\ldots q+4} = \max\{(y12_q + 0.0275), (r_{c,q} - 0.02), (r_{c,0} - 0.05)\}$
When $r_{c,q} = (y12_q + 0.0275)$, then set:
$r_{c,q+1\ldots q+4} = r_{c,q}$

where:

$r_{c,q+1\ldots q+4}$ = the reset mortgage coupon rate, in effect for loan-life quarters q+1 through q+4

.02 = maximum coupon interest rate change at each time of adjustment

.05 = lifetime maximum change in coupon interest rate

b. Compute the monthly mortgage payment factor (PMT_q) for each quarter of the stress period, $q = \{1,\ldots,40\}$ using the formula:

$$PMT_q = \frac{LTV_0 \cdot \left(\frac{r_{c,q}}{12}\right)}{1 - \left(\frac{1}{1 + r_{c,q}/12}\right)^{T_0}}$$

where:

$r_{c,q}$ = current loan coupon rate in quarter, q, of the stress period (in decimal form). This is always equal to the original coupon rate for fixed-rate mortgages

T_0 = Mortgage origination term, in months[1]

q = Stress period quarters. This will be used to represent time for the remainder of this Appendix

[1] In the case of balloon mortgages, in the calculation of mortgage amortization, the equation applies the mortgage origination term (T_0) instead of the amortization term. This is consistent with procedures used to estimate the related equations.

In this formula, LTV_0 represents the original loan balance. Using LTV_0 allows the UPB time series to be calculated in index form to match V_q. PMT_q will be constant throughout the stress test for fixed-rate loans because $r_{c,q}$ is fixed at $r_{c,0}$.

c. Calculate a remaining loan balance index for the UPB outstanding at the beginning of each quarter of the stress period, UPB_q, based on PMT_q, T_r, and elapsed time in the stress period, q, using the formula:

$$UPB_q = PMT_q \cdot \left(1 - \left(\frac{1}{1 + r_{c,q}/12}\right)^{(T_r - (q-1)\cdot 3)}\right) \Big/ \left(\frac{r_{c,q}}{12}\right)$$

where:

T_r = remaining mortgage term at beginning of stress period

3. Compute updated LTV ratios (LTV_q) for each quarter of the stress period:

$$LTV_q = \frac{UPB_q}{Vq}$$

4. Compute the standard deviation of house price growth paths ($\sigma_{d,q}$) around the $HPI_{d,q}$ value. Limit the value of the age variable to avoid negative ''diffusion.'' Negative diffusion occurs when the variance of house prices declines over time. The quadratic formula used here for the standard deviation of individual house price index values will create negative diffusion unless age is limited. The age limit formula is found by solving the first derivative of the house price volatility variance with respect to age, for zero. This variance is the function under the root sign in the $\sigma_{d,q}$ equation below (but using A_q rather than MA_q). The age limit gives the value of age for which the diffusion of house price growth is maximized. Once this age value is reached, the stress test then holds diffusion at the maximum value for the remainder of the life of the loan:

$$\sigma_{d,q} = \sqrt{\alpha_d \cdot MA_q + \beta_d \cdot (MA_q)^2}$$

where:

α_d = "alpha" volatility parameter for Census Division, *d*, (from OFHEO HPI Report, most recent quarter)

β_d = "beta" volatility parameter for Census Division, *d*, (from OFHEO HPI Report, most recent quarter)

MA_q = $\min\{A_q, \text{age limit}\}$, where age limit = $-\alpha_d/(2 \cdot \beta_d)$

5. Calculate the probability of negative equity in each stress period quarter:

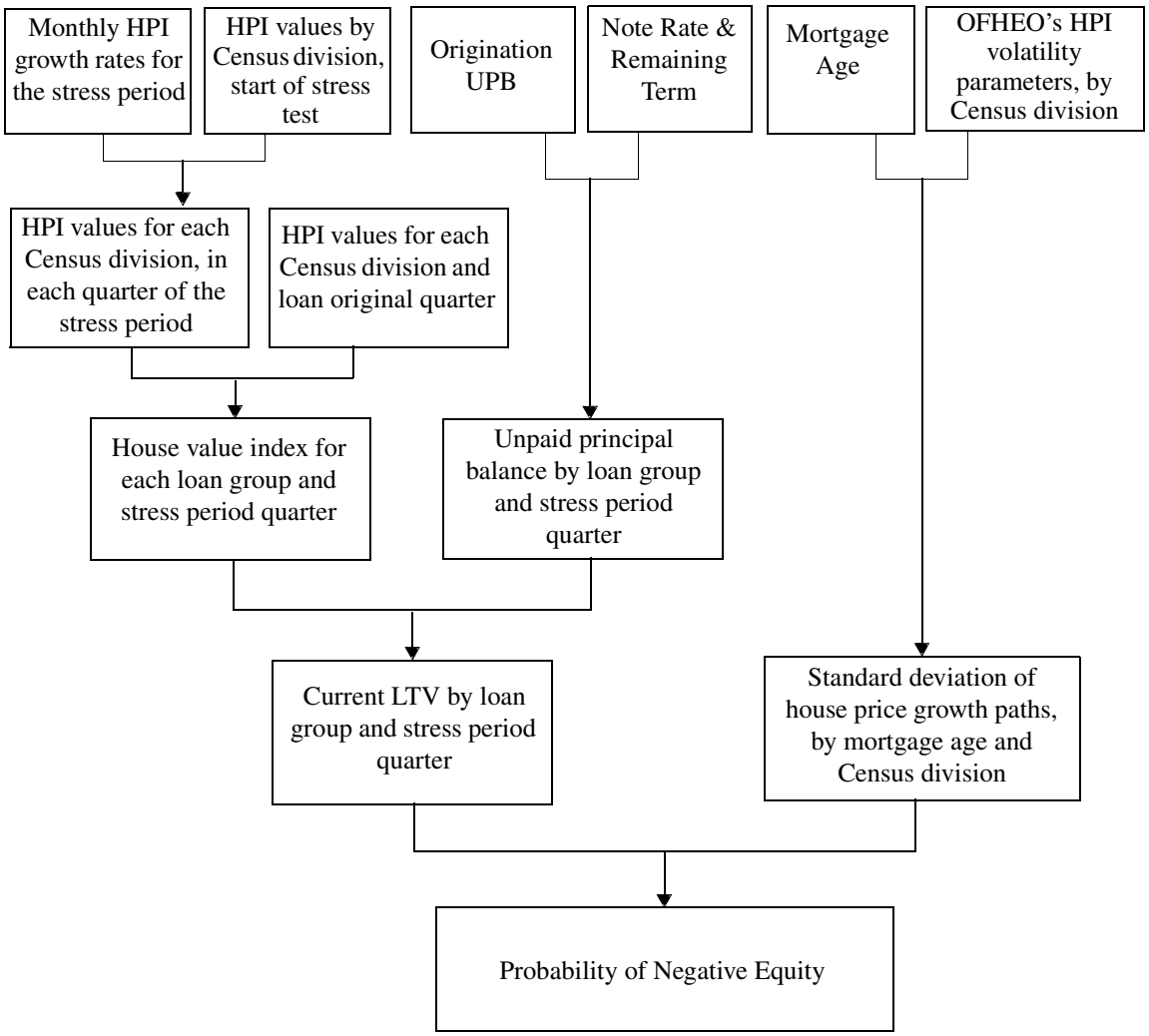
$$PNEQ_q = N\left(\frac{ln(LTV_q)}{\sigma_{d,\,q}}\right)$$

where:

N(.) = cumulative standard normal distribution function, evaluated at the value of the term in brackets

ln(.) = natural logarithm

Figure 3-2. Derivation of Probability of Negative Equity



3.5.2.3.2.4 Burnout (B_q)

[a] The prepayment ''burnout'' variable, B_q, indicates whether there have been at least two quarters of ''significant refinance opportunities'' among the previous eight quarters of loan life. A mortgage undergoes a significant refinance opportunity when its coupon is at least two percentage points above the then-prevailing rate on 30-year mortgages. The rate on 30-year mortgages is always used as the benchmark for defining refinance opportunities, regardless of the type of mortgages being analyzed. Prepayment burnout is a binary variable—two quarters of significant refinance opportunities either occur or do not occur.

[b] If $A_q \leq 8$, then $B_q=0$. If $A_q > 8$, then:

$$B_q = \begin{cases} 0, \textit{ if } (r_{f,q-s} + 0.02) < r_{c,q} \textit{ for less than 2 values of } s,\ s = \{1,...,8\} \\ 1, \textit{ if } (r_{f,q-s} + 0.02) < r_{c,q} \textit{ for 2 or more values of } s,\ s = \{1,...,8\} \end{cases}$$

where:

$r_{f,q-s}$ = conventional mortgage rate, fixed-rate 30-year loans, s quarters prior to the present quarter, q

$r_{c,q}$ = current coupon rate of mortgage in present quarter, q

3.5.2.3.2.5 Occupancy Status (OS)

The occupancy status variable is the percentage of loans in an Enterprise portfolio that are investor-owned (rental) properties rather than owner-occupied properties. It is a constant value (OS) applied equally to all loan groups and in all stress period quarters, computed as follows:

$$OS = \frac{\Sigma_j UPB_{j,\ q=0}}{\Sigma_j UPB_{j,\ q=0} + \Sigma_k UPB_{k,\ q=0}}$$

where:

j = indicator for investor (rental property) loans (do not include second-liens in this calculation)

k = indicator for owner-occupied, first-lien property loans (do not include second-liens in this calculation)

q=*0* = represents the month immediately preceding the first quarter of the stress period (index for the unpaid principal balance at the start of the stress period)

3.5.2.3.2.6 Relative Spread (RS_q)

The relative spread variable (RS_q in the formula below) is the percentage spread between a loan's contract rate and the rate on 30-year fixed-rate mortgages in the current quarter of the stress test. The higher this percentage is, the more likely a loan is to prepay:

$$RS_q = \frac{r_{c,\ q} - r_{f,\ q}}{r_{c,\ q}}$$

3.5.2.3.2.7 Yield Curve Slope (YS_q)

The variable YS_q in the formula below represents the slope of the yield curve. It is included in the prepayment calculations to represent different relationships between short-and long-term interest rates. Different yield curve slopes represent different relationships between short and long term interest rates, and these relationships impact incentives to refinance either into ARMs or into fixed-rate mortgages:

$$YS_q = \frac{y120_q}{y12_q}$$

where:

$y120_q$ = 120-month constant maturity Treasury yield in quarter, q, of the stress period

$y12_q$ = 12-month constant maturity Treasury yield in quarter, q, of the stress period

3.5.2.3.2.8 Product Type Adjustment Factors

Product types other than fixed-rate 30-year mortgages and ARMs receive unique product-specific adjustment factor weights in the stress test. These factors relate the default and prepayment risk of each product type to the fixed-rate 30-year mortgage. ARMs do not need a risk adjustment factor because they use separate default and prepayment equations. All products other than 30-year fixed-rate and adjustable-rate mortgages use the same pair of default and prepayment equations. The product types included in this combination grouping, which receive product-specific risk adjustment factors, are: 20-year fixed-rate, 15-year fixed-rate, balloon, government insured or guaranteed loans, and second mortgages. All loan products with payment changes, such as graduated payment mortgages, two-step mortgages, and buydown mortgages, are treated as ARMs and use the ARMs default and prepayment formulas without a product adjustment factor. Biweekly and reverse mortgages are included with standard monthly mortgages of similar term and do not therefore require separate adjustments. The adjustment factor values are provided in Table 3–17.

3.5.2.3.2.9 Benchmark Calibration Factor

A calibration adjustment of 0.146 is added to each statistical default equation to reasonably relate current loan default rates to the historical benchmark experience. The value 0.146 is a weighting factor, not an explanatory variable.

3.5.2.3.3 Combining Explanatory Variables and Weights

[a] Each explanatory variable outlined above has associated numerical weights that are used in default and prepayment rate calculations. These weights, which are the estimated coefficients from statistical regressions, are referred to here as beta factors, β_j, for default weights, and gamma factors, γ_k, for prepayment weights. As mentioned above, there is also a constant weight for benchmark calibration. In addition, each statistical equation has a different regression constant. These constants appear as separate weights, not tied to any explanatory variables.

[b] The weights are combined to compute two sums: $X\beta_q$ for defaults and $X\gamma_q$ for prepayment as follows:

$$X\beta_q = \beta_A A_q + \beta_{A2} A2_q + \beta_{LTV0} + \beta_{PNEQq} + \beta_{Bq} B_q + \beta_p OS + \beta_T + \beta_C + \beta_0$$

and

$$X\gamma_q = \gamma_A A_q + \gamma_{A2} A2_q + \gamma_{LTV0} + \gamma_{PNEQq} + \gamma_B B_q + \gamma_p OS + \gamma_{RSq} + \gamma_{YSq} + \gamma_T + \gamma_0$$

where:

where:

β_j	=	default rate weighting factors for explanatory variables
j	=	$\{A_q, A2_q, LTV_0, PNEQ_q, B_q, P\}$
β_T	=	product-type adjustment factor
β_C	=	benchmark calibration factor
β_0	=	fixed factor for equation
γ_k	=	prepayment rate weighting factors for explanatory variables
k	=	$\{A_q, A2_q, LTV_0, PNEQ_q, B_q, OS, RS_q, YS_q\}$
γ_T	=	product-type adjustment factor
γ_0	=	fixed factor for equation

[c] The only explanatory variables for which both the variable and its weight are included in the formula above are age (A_q), age squared ($A2_q$), occupancy status (OS) and burnout (B_q). For each of these variables, the variable value is multiplied by its weight, which can be found in Table 3–17. For other (categorical) explanatory variables, however, the weights are not accompanied by the actual values of the explanatory variables. For these variables the computed variable value is only used to identify the category to which it belongs so that a representative weight can be selected from the weight table (Table 3–17) of this Appendix. Only the obtained weight is included in the $X\beta_q$ and $X\gamma_q$ formulas for these variables.

Table 3-17. Explanatory Variable Weights[1] for Quarterly Conditional Prepayment and Default Probabilities

Explanatory variables and Categories	Weighting Factors by Product Type and Variable Category					
	30-Year Fixed-Rate		Adjustable Rate		All Other Products	
	Prepayment weights (γ_j)	Default weights (β_j)	Prepayment weights (γ_j)	Default weights (β_j)	Prepayment weights (γ_j)	Default weights (β_j)
Age variables						
A_q	0.072	0.118	0.061	0.057	0.078	0.139
$(A_q)^2$	−0.002	−0.002	−0.001	−0.002	−0.002	−0.002
Original LTV (LTV_0)						
$LTV_0 \leq 60$	0.169	−1.465	0.097	−1.424	0.117	−1.491
$60 < LTV_0 \leq 70$	0.069	−0.219	−0.008	−0.348	0.041	−0.219
$70 < LTV_0 \leq 75$	−0.024	0.426	−0.080	0.121	−0.027	0.374
$75 < LTV_0 \leq 80$	0.013	0.272	−0.071	0.191	−0.004	0.220
$80 < LTV_0 \leq 90$	−0.070	0.399	0.081	0.322	−0.049	0.412
$90 > LTV_0$	−0.157	0.587	−0.019	1.138	−0.078	0.704
Probability of negative equity ($PNEQ_q$)						
$.0 \leq PNEQ_q \leq 0.05$	0.234	−1.269	0.603	−1.206	0.328	−1.198
$.05 < PNEQ_q \leq 0.10$	0.199	−0.559	0.239	−0.413	0.174	−0.344
$.10 < PNEQ_q \leq 0.15$	0.196	−0.263	0.060	−0.292	0.132	−0.062
$.15 < PNEQ_q \leq 0.20$	0.169	−0.135	0.027	−0.043	0.074	−0.080
$.20 < PNEQ_q \leq 0.25$	0.015	0.254	−0.005	0.177	−0.042	0.164
$.25 < PNEQ_q \leq 0.30$	−0.207	0.563	−0.155	0.398	−0.125	0.404
$.30 < PNEQ_q \leq 0.35$	−0.249	0.647	−0.242	0.607	−0.169	0.421
$.35 > PNEQ_q$	−0.357	0.762	−0.527	0.772	−0.372	0.695
Burnout (B_q)	−0.212	1.238	−0.054	0.936	−0.174	1.132
Occupancy status (OS)	−0.280	0.488	−0.456	1.782	−0.284	0.538
Relative Spread (RS_q)						
$RS_q \leq -0.20$	−1.160		−1.473		−1.027	
$-0.20 < RS_q \leq -0.10$	−0.822		−0.524		−0.810	
$-0.10 < RS_q \leq 0$	−0.680		−0.328		−0.710	
$0 < RS_q \leq 0.10$	−0.432		−0.162		−0.343	
$0.10 < RS_q \leq 0.20$	0.633		0.414		0.628	
$0.20 < RS_q \leq 0.30$	1.182		1.066		1.098	
$0.30 < RS_q$	1.279		1.007		1.164	

Table 3-17. Explanatory Variable Weights[1] for Quarterly Conditional Prepayment and Default Probabilities (Continued)

Explanatory variables and Categories	Weighting Factors by Product Type and Variable Category					
	30-Year Fixed-Rate		Adjustable Rate		All Other Products	
	Prepayment weights (γ_j)	Default weights (β_j)	Prepayment weights (γ_j)	Default weights (β_j)	Prepayment weights (γ_j)	Default weights (β_j)
Yield Curve Spread (YS_q)						
$YS_q < 1.00$	−0.215		0.042		−0.214	
$1.00 \leq YS_q < 1.20$	−0.228		−0.156		−0.211	
$1.20 \leq S_q < 1.50$	0.022		−0.101		−0.004	
$1.50 \leq YS_q$	0.421		0.215		0.429	
Product Type Adjustment factors (γ_T, β_T)						
20-year fixed-rate					−0.017	−0.143
15-year fixed-rate					−0.004	−1.064
Balloon					0.564	1.439
Government					−0.184	0.693
Second mortgages					−0.107	0.659
Calibration constant (β_c)		0.146		0.146		0.146
Fixed Effects (γ_0, β_0)	−4.217	−7.888	−4.362	−6.522	−4.286	−8.184

[1] The explanatory variable weights given in this table were estimated based upon equations using mortgage origination term (T_0) to amortize balloon loans, rather than mortgage amortization term (T_a) to amortize balloon loans, as seen in the formula used for PMT_q.

3.5.2.3.4 Calculating Default and Prepayment Rates

The total weighting factors, $X\beta_q$ and $X\gamma_q$, are converted into quarterly default and prepayment probabilities using the following logistic probability equations:

$$Def_q = \frac{exp\{X\beta_q\}}{1 + exp\{X\beta_q\} + exp\{X\gamma_q\}}$$

$$Prep_q = \frac{exp\{X\gamma_q\}}{1 + exp\{X\beta_q\} + exp\{X\gamma_q\}}$$

where:

Def_q = quarterly, conditional default rate in stress period quarter, q

$Prep_q$ = quarterly, conditional prepayment rate in stress period quarter, q

$exp\{.\}$ = exponential function

3.5.2.3.5 Monthly Default and Prepayment Rates

To this point, all calculations involved creating quarterly time series of values throughout the ten-year stress period (40 quarters). In this step, the quarterly conditional default and prepayment rates are converted into monthly rates as follows:

$$Def_{j,q} = 1 - \sqrt[3]{1 - Def_q}$$

$$Prep_{j,q} = 1 - \sqrt[3]{1 - Prep_q}$$

where:

$Def_{j,q}$ = monthly conditional default rate for each month j={1,2,3} in quarter q={1,…,40}

$Prep_{j,q}$ = monthly conditional prepayment rate for each month j={1,2,3} in quarter q={1,…,40}

3.5.2.4 Output

Use the resulting 120 monthly conditional default and prepayment rates for each loan group to calculate monthly principal reductions resulting from defaults and prepayments, and to calculate default losses for each month in the ten-year stress period.

3.5.3 Single Family Loss Severity

3.5.3.1 Overview

[a] The Single Family Loss Severity component of the stress test computes loss severity rates for single family mortgages that default in each month of the stress test. The loss severity rate is the net cost of a loan default expressed as a percentage of the unpaid principal balance (UPB) at the time of default. Based on various cost and revenue elements associated with a loan default, the stress test calculates loss severity rates as the present value (at default date) of the net cash flows that occur following the default date. Most cost and revenue elements are entered as constant rates across loan groups throughout the stress period. Two exceptions are proceeds from property disposition and asset funding costs. Proceeds are derived through a formula that uses both historical and stress period house price appreciation rates, and that accounts for loan amortization from origination through default. Funding cost of the defaulted mortgages and the resulting foreclosed properties is captured by discounting the loss severity elements, using a cost-of-funds interest rate that varies during the stress period. Loss severity rates throughout the stress period will also vary according to the application of percent-denominated credit enhancements (dollar-denominated credit enhancements are directly applied in the Cash Flow component of the stress test) and their associated credit ratings.

[b] The inputs used to compute loss severity rates include several starting position loan group characteristics, counterparty credit risk factors, historical house price index series and stress period house price growth rates, house price appreciation volatility parameters, and stress test interest rate series. The output of loss severity rates for each loan group are used in the Cash Flow component of the stress test (*see* section 3.9, Cash Flows, of this Appendix) to calculate (dollar) default losses.

3.5.3.2 Inputs

[a] The Single Family Loss Severity component of the stress test uses loan group characteristics as of the start of the stress test, including information on certain types of credit enhancements, and credit risk factors associated with counterparty rating categories (*see* section 3.6, Other Credit Factors, of this Appendix). In addition, it uses historical and stress period HPI series, house price appreciation volatility parameters, and one interest rate series (*see* section 3.4, Property Valuation, of this Appendix).

[b] The particular loan group characteristics (refer to section 3.1, Enterprise Data, of this Appendix for the definitions of these loan group characteristics), with associated variable names used in the procedures below, are:

- Product Type
- Portfolio (retained or sold portfolio)
- Origination Year (subscript ''y'')
- Origination Month (t_m, for commitment loan groups only)
- Census Division (subscript ''d'')
- Starting Coupon ($r_{c,s}$)
- Original Coupon ($r_{c,0}$, only used for ARMs)
- Passthrough Rate (r_p, for sold loans only)
- Original LTV (LTV_0)
- Mortgage Age (A_s)
- Amortization Term (T_a)
- Credit Enhancement Coverage Type 1 (C_{mi}, PMI coverage rate)
- Credit Enhancement Coverage Type 2 (C_{rc}, seller/servicer recourse coverage rate)
- Percent of UPB under ''AAA'' coverage in a loan group (C_R)
- Percent of UPB under ''AA'' coverage in a loan group (C_R)
- Percent of UPB under ''A'' coverage in a loan group (C_R)
- Percent of UPB under ''BBB'' coverage in a loan group (C_R)

[c] Credit enhancement coverages, both Type 1 and Type 2, are reduced throughout the stress test according to ''haircuts,'' as defined in section 3.6, Other Credit Factors, of this Appendix. These haircuts represent percentage reductions to credit enhancement coverage due to the inability of a counterparty to meet its obligations under stressful conditions. The final (end-of-stress-period) haircuts, by credit rating class (AAA, AA, A, and BBB), are obtained from section 3.6, Other Credit Factors, of this Appendix.

[d] In addition, historical Census division HPI series and house price appreciation volatility parameters are obtained from the most recently available *OFHEO HPI Report.* The HPI series are used to update collateral property values to the beginning of the stress test. Property values are then updated during the stress period with monthly house price growth rates obtained from section 3.4, Property Valuation, of this Appendix. The historical volatility parameters are used with stress period property values to develop distributions of property values and levels of home equity within loan groups.

[e] The final input used here is the six-month Federal agency cost-of-funds rate, for each month of the stress period (variable ''$r_{d,t}$''). This monthly series is generated by the interest rate component of the stress test (*See* section 3.3, Interest Rates, of this Appendix) and is used as the discount rate for computing the present value of the three major elements of the loss severity rate—defaulting UPB, net costs or proceeds associated with foreclosure, and net cash flows from holding and disposition of Real Estate Owned (REO) property.

3.5.3.3 Procedures

[a] The process of deriving loss severity rates involves calculating the present value of three loss elements. The first loss element (*PV1*) is the amount of defaulting UPB. The second loss element (*PV2*) is the expense related to foreclosure, net of any mortgage insurance proceeds. The third loss element (*PV3*) combines post-foreclosure property expenses with proceeds from REO property disposition. Each of these three loss elements is computed as the present value (as of the default date) of the net cash flows occurring at a separate point in time—four months after default for the first loss element, 13 months after default for the second loss element, and 20 months after default for the third loss element. The present values of the three loss elements then are added together to derive an initial loss severity rate (*NPV1*). Finally, available seller/servicer recourse against the (initial) loss is applied to calculate the final loss severity rate (*NPV3*). Figure 3–3 of this Appendix depicts the timing of the three loss elements and how they are combined to produced initial and final loss severity rates.

[b] In the procedures for calculating loss severity rates, loan amortization is performed each month for surviving loans in each loan group; all discounting of cash flows uses semi-annual compounding of interest rates; all calculations add expenses and subtract revenues to calculate loss severity rates; and all loss elements are calculated as percentages of the UPB of the defaulting loans. With the exception of computations for FHA and VA loans, calculations are not specific to any particular loan product types, although loan group characteristics (coupon rate and amortization term) are used in the severity calculations.

[c] The lack of product type distinctions in severity calculation means that adjustable

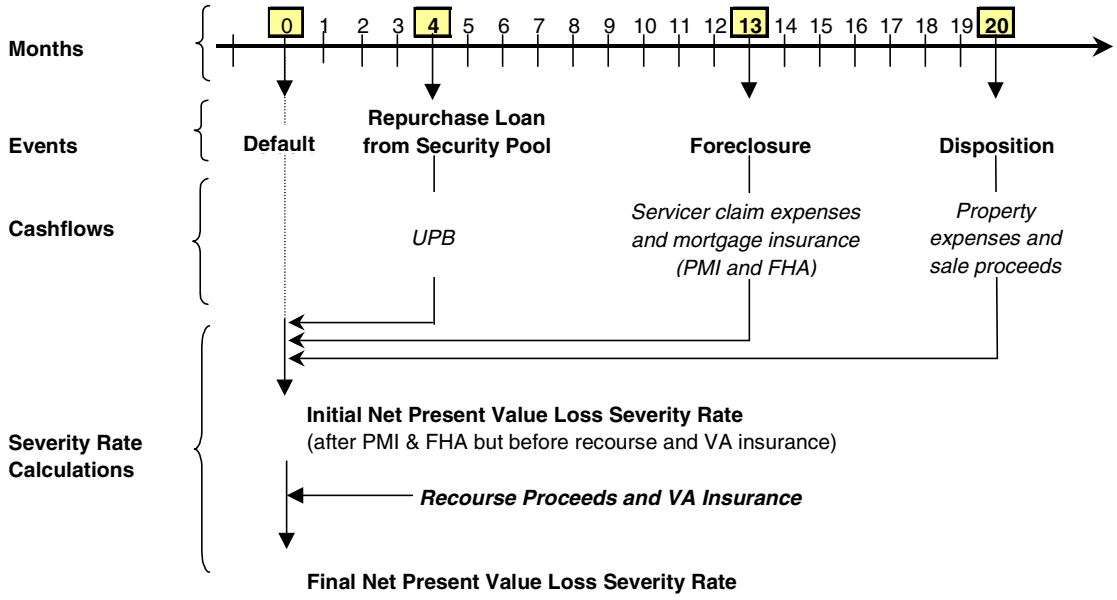
rate mortgages are treated like fixed-rate mortgages. Their coupon rates are not updated during the stress test, and the original coupon is used to perform loan amortizations used in the statistical equation for property disposition proceeds. This simplification does not affect the actual defaulting UPB used to calculate dollar losses. The cash flow portion of the stress test does update coupon rates for adjustable rate products, and uses the updated rates to amortize loan group UPB. There are also no differences in loss severity rate calculations for investor loans. The stress test does not group loans according to occupancy status (owner-occupant versus investor/rental), although the statistical analysis used to derive the loss severity elements for the stress test used data on both occupancy status types. Thus, the loss severity elements shown here reflect a balance of owner-occupant and investor loans.

[d] The stress test groups FHA and VA loans together. To calculate severity rates, FHA and VA insurance coverage amounts are calculated separately for all FHA/VA loan groups. Loan group credit enhancements are then calculated by summing the coverage amounts, with FHA insurance receiving a 0.67 weight and VA insurance receiving a 0.33 weight. Final loss severity rates for FHA/VA loan groups are then computed based on these weighted average coverage amounts.

3.5.3.3.1 Defaulting UPB

The defaulting UPB is the first loss element included in the loss severity rate calculation. The stress test recognizes defaulting UPB four months after the month of default. At this point, the defaulting UPB is recognized as a loss severity element and a potential cost (pending offsetting revenues from mortgage insurance and property disposition). For sold loans, defaulting mortgages are first purchased from the security pools, requiring a cash outlay equal to the UPB. Because only sold loans involve actual cash outlays, sold and retained loans are treated slightly differently in this loss element calculation.

Figure 3-3. Single Family Loss Severity Event Timing



1. For sold loans, recognize the cash outlay by discounting UPB back to the date of default:

$$PV1_t = \frac{1}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{4}{6}}}$$

where:

$PV1_t$ = present value of the defaulting UPB

1 = defaulting UPB

$r_{d,t}$ = discount rate (six-month Federal agency cost-of-funds rate) in effect in month of the stress period

2. For retained loans, set $PV1_t = 1$ to represent the full UPB. No discounting is necessary because recognition of the defaulting UPB does not involve an actual cash outlay.

3.5.3.3.2 Net Costs or Proceeds Associated with Foreclosure

The second loss element includes foreclosure related transactions. There are

several cash flows, so that multiple computations are required.

1. Calculate survival factors for each counterparty rating category, for each month of the stress period. The monthly survival factors represent percentages of obligations that counterparties with given credit ratings are expected to meet as the stress period continues. They are derived from the final haircuts defined in section 3.6, Other Credit Factors, of this Appendix. These factors are applied here to private mortgage insurance (PMI) coverage, and later to seller/servicer recourse obligations. Survival factors for each credit rating category are constant across loan groups:

$$SF_{\mathrm{R,t}} = 1 - \frac{FH_{\mathrm{R}}}{120} \cdot t$$

where:

$SF_{\mathrm{R},t}$ = survival factor for counterparties rated R in month t of the stress period

R = credit rating categories of counterparties

FH_{R} = final haircut for counterparties rated, R. This reflects their abilities to meet obligations toward Enterprises in the final month of the stress period. Values are defined in the Other Credit Factors component of the stress test

2. Calculate private mortgage insurance (PMI) proceeds.

a. Calculate the weighted average survival factor for each loan group. For each month, t, of the stress period, multiply the survival factor for each counterparty rating, $SF_{\mathrm{R},t}$, by the percentage of the loan group UPB covered by counterparties with the same rating, C_{R}. Sum the results across all counterparty ratings, R. Next, divide that sum by the sum of all counterparty coverage percentages. This produces a weighted average survival factor, SF_{w},t, by loan group, for each month, t, of the stress period:

$$SF_{\mathrm{w,t}} = \frac{\sum_{R}(SF_{R,\mathrm{t}} \cdot C_R)}{\sum_{R} C_R}$$

where:

$SF_{\mathrm{w,t}}$ = weighted average counterparty survival factor in month t of the stress period

C_{R} = percentage of loan group UPB that has a counterparty rating of R

b. Multiply the weighted average survival factors, $SF_{\mathrm{w,t}}$, by the PMI percentage coverage rate, C_{mi}, to derive monthly adjusted percentage coverage rates, $C_{\mathrm{mi,t}}$:

$$C_{\mathrm{mi,t}} = C_{\mathrm{mi}} \cdot SF_{\mathrm{w,t}}$$

where:

$C_{mi,t}$ = adjusted PMI percentage coverage rate for month t of the stress period

C_{mi} = loss coverage rate for Credit Enhancement Coverage Type 1, PMI

c. Compute mortgage insurance proceeds (mi_{t}), by multiplying the adjusted PMI percentage coverage rate, $C_{\mathrm{mi,t}}$, by the mortgage insurance claim amount. First, for all conventional loans—loan groups other than FHA/VA:

$$mi_{\mathrm{t}} = \tilde{C}_{\mathrm{mi,t}} \cdot \left(1 + F + \left(\frac{r_{\mathrm{c,s}}}{12}\right) \cdot t_{\mathrm{f}}\right)$$

For FHA/VA loan groups, calculate the FHA insurance proceeds:

$$mi_{\mathrm{t}} = 1 + (0.67 \cdot F) + \left(0.75 \cdot \left(\frac{r_{\mathrm{c,s}}}{12} \cdot t_{\mathrm{f}}\right)\right)$$

where:

mi_t	=	mortgage insurance proceeds in month *t* of the stress period
1	=	defaulting UPB
F	=	foreclosure expenses as a percentage of UPB (five percent)
$r_{c,s}$	=	starting coupon
t_f	=	foreclosure time (13 months)
0.67	=	FHA reimbursement rate on foreclosure related expenses
0.75	=	adjustment to reflect that FHA reimbursement on unpaid interest is at a government debenture rate, and not at the mortgage coupon rate

3. Discount all foreclosure related cash flows by t_f=13 months to compute the post-foreclosure loss element, $PV2_t$.

a. For retained loans:

$$PV2_t = \frac{F - mi_t}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}}$$

b. For sold loans, add passthrough interest expense to mortgage-backed security holders for 4 months:

$$PV2_t = \frac{\left(\frac{r_p}{3} + F\right) - mi_t}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}}$$

c. For FHA/VA loans:

$$PV2_t = \frac{\left(F + \left(\frac{r_{c,s}}{12} \cdot t_f\right)\right) - mi_t}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}}$$

where:

$PV2_t$	=	present value of net cost or proceeds associated with foreclosure for loans defaulting in month *t* of the stress period
r_p	=	passthrough rate on mortgage-backed securities
F	=	foreclosure expenses as a percentage of UPB (five percent)

4. Calculate the payment to the loan servicer (PVS_t) net of any interest paid by the seller/servicer to the Enterprise that would be repaid in the post-foreclosure servicer claim. The present value factor generated here is not used in the computation of the foreclosure loss component, but will be used later to account for cases where there is full recourse to the seller/servicer. This is required only where there is Type 2 Credit Enhancement coverage. It is not used for FHA/VA loans. For retained loans:

$$PVS_t = \frac{F}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}}$$

For sold loans, add the (4 months) interest passed through by the Enterprise to security holders:

$$PVS_t = \frac{\frac{r_p}{3} + F}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}}$$

where:

PVS_t = present value of the (net) servicer claim payment for loans defaulting in month t of the stress period

3.5.3.3.3 Net Cash Flow from Holding and Disposition of REO Property

The third loss element includes cash flows associated with management and disposition of REO property. Cash flows used in calculating this element are sales proceeds from disposition of foreclosed property and REO property management (maintenance and operating) expenses.

3.5.3.3.3.1 Calculate Proceeds From Property Sale

Sales proceeds is a dynamic loss severity element whose calculation involves updating property values and loan balances over time. Several steps are required. First, property values and UPB are updated from origination to the time of default. This is done with index values, rather than dollar values. Property values are represented by a house price index, and loan balances by a UPB index (ratios of defaulting UPB to the original house price). Second, a statistical measure (z-score) of the distance between the logarithm of house price index and the logarithm of the loan balance index is calculated. Third, an econometric equation uses the z-score to compute the portion of UPB that is not recovered at property disposition. Finally, the unrecovered portion of UPB is converted into proceeds from property sale.

1. Update property values.

a. Calculate a house price index at the start of the stress test, according to origination year and Census division cohort:

$$I_{d,q} = \frac{HPI_{d,-1}}{HPI_{d,q}}$$

where:

$I_{d,q}$ = house price index value at the start of the stress test for loan groups in Census division d, originating in quarter q

$HPI_{d,-1}$ = HPI value for Census Division d, for the quarter immediately preceding the stress test

$HPI_{d,q}$ = HPI value for Census Division d in quarter q

Because HPI values are as of the end of each quarter, $HPI_{d,-1}$ gives the value as of the start of the stress period. The OFHEO HPI is published beginning with the first quarter of 1980. OFHEO has also produced (but not published) values for earlier years. To season loans originating in 1979, assign $HPI_{d,q}$ according to the Census division specific values listed in Table 3–16. Treat all pre-1979 originations as if they were originated in 1979.

b. Calculate house price index values during the stress period by multiplying the $I_{d,q}$ by cumulative house price growth rates in the stress period:

$$HPI_{d,q,t} = I_{d,q} \cdot exp\left(\sum_{s=1}^{t} g_s\right)$$

where:

$HPI_{d,q,t}$ = house price index for loan groups in Census division d, originated in quarter q, and defaulting in month t of the stress period

g_s = house price growth rate in month s of the stress period, $s = \{1,...,t\}$

Do not calculate $I_{d,q}$ for loans that an Enterprise has committed to buy, but not yet purchased at the beginning of the stress period, because pre-stress period house price appreciation is not applicable. The house price index for these loans is the cumulative monthly growth rate from the month after delivery to the month of loss severity calculations (month of default):

$$HPI_{d,q,t} = exp\left(\sum_{s=(t_m+1)}^{t} g_s\right)$$

where:

t_m = loan delivery month in the stress period, for commitment loans

t = month of loan default and loss severity calculation, $t = \{t_{m+1},...,120\}$

2. Calculate the standard deviation of house price growth paths, $\sigma_{d,t}$, around the average growth path implied by the $HPI_{d,q,t}$ value. This first requires limiting the value of the age variable to avoid negative ''diffusion.'' Negative diffusion occurs when the variance of house prices declines over time. While negative diffusion is not expected to happen in practice, the formula for the standard deviation of house price growth paths (which is a quadratic function of time, where the first-order term is positive and the second-order term is negative) will create negative diffusion unless age is limited.

a. Create a variable for mortgage age in the stress test:

$$A_t = A_s + t$$

where:

A_s = mortgage age at the start of the stress test

t = month t in the stress test

b. Create a mortgage age variable (MA_t) that limits the mortgage age to a maximum value:

$$MA_t = min\ \{A_t/3, \text{age limit}\}$$

where:

$A_t/3$ = the age of the loan group in quarters, during month t of the stress period

age limit = $-\alpha_d/(2 \cdot \beta_d)$

α_d = "alpha" volatility parameter for Census division d (from the OFHEO HPI Report, most recent quarter)

β_d = "beta" volatility parameter for Census division d (from the OFHEO HPI Report, most recent quarter)

c. Calculate the standard deviation of house price growth rate path using MAK_t:

$$\sigma_{d,t} = \sqrt{(MA_t \cdot \alpha_d) + (MA_t^2 \cdot \beta_d)}$$

where:

$\sigma_{d,t}$ = standard deviation of cumulative house price growth rates for loans in Census division d, in month t of the stress period

3. Compute a monthly loan payment factor using the original coupon rate and original LTV (LTV_0). Since original property value is specified to be equal to one, LTV_0 represents the original UPB. Use this payment factor to compute the time series of UPB index (see below) to capture amortization of surviving loans in each loan group throughout the stress period:

$$PMT = \frac{LTV_0 \cdot \frac{r_{c,o}}{12}}{1 - \left(1 + \frac{r_{c,o}}{12}\right)^{-T_a}}$$

where:

PMT = monthly mortgage payment factor
LTV_0 = original LTV
$r_{c,o}$ = original coupon rate
T_a = loan amortization term

4. Calculate the time series of UPB index—the ratios of defaulting UPB in each month of the stress period to the original house price:

$$B_t = PMT \cdot \left(\frac{1 - \left(1 + \frac{r_{c,o}}{12}\right)^{-T_a + A_t}}{\frac{r_{c,o}}{12}} \right)$$

where:

B_t = UPB index, the ratio of defaulting UPB in month t of the stress period to original house price

5. Compute the z-score for the ''distance'' between the logarithm of the house price index and the logarithm of the UPB index. The use of logarithmic values allows each variable to be specified as a percentage difference from the original property value (1.0). This transformation makes the distance between the house price and UPB indexes consistent with the standard deviation of the house price growth rates used to calculate the z-score.[11] The formula for the z-score is:

$$z_t = \frac{ln(HPI_{d,q,t}) - ln(b_t)}{\sigma_{d,t}}$$

where:

z_t = z-score for the distance between the logarithm of the house price index and the logarithm of the UPB index, in month t of the stress test
$\sigma_{d,t}$ = standard deviation of cumulative house price growth rates for loans in Census division, d, in month t of the stress period
$ln(.)$ = natural logarithm
b_t = $max\,(B_t, 0.05)$

The allowable values of z_t are bounded by 4.0 and –0.50. If the computed value z_t is outside either of these bounds, it is reset to its closest boundary value.

6. Compute the percentage of UPB that is not recovered at property disposition based on the statistically derived relationship between the percentage of UPB unrecovered at property disposition and the z-score:

$$L_t = (exp\,(0.2704 - 0.0770 \cdot z_t) - 1) + 0.1034\,, \text{ for } -0.50 \le z_t \le 4.0$$

[11] This standard deviation is of cumulative house price growth rates. The log of HPI is the cumulative growth of average house prices in the geographic area, while the log of b gives an HPI-growth-rate-equivalent interpretation to owner invested equity (downpayment plus amortization). The resulting log difference is the amount by which the individual house price growth must be lower than average market growth in order to eliminate any equity in the property and thus lead the borrower to consider default.

where:

L_t = uncovered portion of UPB, for loans in a loan group that default in month t of the stress period

0.1034 = calibration factor to reasonably relate loss severity rate to the benchmark experience

Because log-transformed values of the unrecovered UPB ($ln(L_t) + 1$)) were used in the regression, the "1" in the equation above is a result of using the antilog to derive the formula for L_t. In addition, the formula also includes the calibration factor to reasonably relate loss severity rate to the benchmark experience.

7. Calculate sales proceeds from the disposition of each foreclosed property, P_t, as UPB less the portion that was not recovered at disposition, L_t:

$$P_t = 1 - L_t$$

where:

P_t = sales proceeds from property disposition for loans defaulting in month *t* of the stress period

3.5.3.3.3.2 Net Cash Flow at Property Disposition

Subtract sales proceeds from expenses related to REO property, then discount the result by (t_f+t_i = 20 months) to obtain the present value of the third loss severity element:

$$PV3_t = \frac{R - P_t}{\left(1 + \frac{r_{d,t}}{2}\right)^{\left(\frac{t_f + t_i}{6}\right)}}, \text{ for all loan groups other than FHA/VA}$$

$$PV3_t = 0, \text{ for FHA/VA loan groups}$$

$$PV3_t = 0, \text{ for FHA/VA loan groups}$$

or

where:

$PV3_t$ = present value of net cash flows associated with holding and disposition of REO property for loans defaulting in month *t* of the stress period

R = REO expenses as a percentage of UPB (13.7 percent). This includes property management and disposition expenses.

t_i = property inventory time (seven months)

3.5.3.3.4 Final Calculations of Loss Severity Rates

At this point, all cost elements of loss severity are included in *PV1, PV2,* and *PV3.* Revenues from private mortgage insurance (Type 1 credit enhancement) or FHA insurance are also included in *PV2.* The sum of *PV1, PV2,* and *PV3* then provides an initial net-present-value loss severity rate (*NPV1*). Once this is calculated, potential revenues from seller/servicer recourse (Type 2 credit enhancement) and VA insurance guaranty proceeds are computed. For non-government (conventional loans), the recourse proceeds are subtracted from *NPV1* to arrive at final loss severity rates (*NPV3*) for each loan group, in each month of the stress test. For FHA/VA loan groups, final loss severity rates are calculated using a weighted average of the proceeds from the two forms of government insurance.

1. Calculate the initial loss rates (after mortgage insurance and FHA coverage, but before seller/servicer recourse or VA coverage):

$$NPV1_t = PV1_t + PV2_t + PV3_t$$

where:

$NPV1_t$ = initial loss severity rates for loans defaulting in month t of the stress period (after mortgage insurance or FHA coverage, but before other recourse or VA guaranty)

2. Proceed based upon whether the loan group represents conventional or FHA/VA loans:

a. For conventional loans, check the initial losses in $NPV1_t$ to evaluate whether there is any loss remaining. Loans with losses less than zero, where $NPV1_t \leq 0$, will not receive any additional credit for seller/servicer recourse. For those loans, set $RC_t = 0$, and proceed to Step 6. Otherwise, if $NPV1_t > 0$, go to Step 3.

b. For FHA/VA loans, proceed to Step 5.

3. Re-calculate initial loss severity rates using the full seller/servicer claim amount, PVS_t, rather than the post-insurance foreclosure cash flow, $PV2_t$:

$$NPV2_t = PV1_t + PVS_t + PV3_t$$

where:

$NPV2_t$ = initial loss severity without any credit enhancements

4. Use $NPV2_t$ with appropriate percentage recourse (Type 2) coverage rates and survival factors to calculate seller/servicer recourse coverage amounts, RC_t:

$$\tilde{C}_{rc,t} = C_{rc} \cdot SF_{w,t}$$

$$RC_t = NPV2_t \cdot \tilde{C}_{rc,t}$$

where:

$\tilde{C}_{rc,t}$ = recourse coverage rate in month t of the stress period, adjusted for the potential survival rates of counterparties in the stress test

C_{rc} = contractual seller/servicer recourse coverage (Type 2) percentage

$SF_{w,t}$ = weighted average counterparty survival factor in month t of the stress period

RC_t = seller/servicer recourse coverage amount to be applied in the stress test.This is adjusted for counterparty credit ratings, in month t of the stress period

Go to Step 6.

5. For FHA/VA loan groups, calculate the effective loss rate after recourse coverage amounts provided by VA guarantees:

$$NPVVA_t = \frac{\left[\left(1 + (R - P_t)\right) + \left(F + \frac{r_{c,s}}{12} \cdot t_f\right)\right] - 0.30}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}}$$

and then:

$$NPVVA_t = max(NPVVA_t, 0)$$

stress test, and stress test simulation values are used to extend the series throughout the stress period.

3.5.4.2.3 Historical Rent Indexes

Updating property values of collateral for multifamily loans at the beginning of the stress test requires use of rent indexes. The stress test uses the residential rent component of the Consumer Price Index (CPI), which is available from the U.S. Department of Labor, Bureau of Labor Statistics (BLS). The series required for this part of the stress test are those for the U.S., the four Census regions, and the 29 Metropolitan Statistical Areas (MSAs) covered by the BLS surveys.

3.5.4.2.4 Stress Period Vacancy Rates and Rent Growth Rates

Monthly vacancy rate and rent growth rate series for the stress period are generated by the Property Valuation component of the stress test (*see* section 3.4, Property Valuation, of this Appendix). These series are used to update multifamily property values throughout the stress period.

3.5.4.3 Procedures

[a] Separate default equations are used to distinguish between loans acquired through: one, cash purchases and two, negotiated transaction. In a cash purchase, an Enterprise acquires a newly originated loan that meets standard underwriting guidelines; the purchase can include recourse to the seller/servicer. In a negotiated transaction, an Enterprise generally acquires a pool of seasoned, nonconforming loans.

[b] FHA-insured loans are a subset of loans that are purchased through negotiated transactions, but they are included with the cash transaction loans for default calculation purposes.

[c] Fixed-rate multifamily loans have prepayment restrictions, for example, yield maintenance fees and lockouts, that severely limit prepayments for about two-thirds of the loan term. To account for the differences in prepayment speeds that result from these restrictions, five prepayment equations are used for the following types of loans: fixed-rate loans in the restriction period, fixed-rate balloon loans beyond the restriction period, self-amortizing fixed-rate loans beyond the restriction period, balloon loans at the balloon point, and adjustable rate mortgages.

[d] To calculate default and prepayment rates in the stress text, the input data described above are used to compute the values of explanatory variables for the equations for multifamily default and prepayment rates. A total of 16 explanatory variables (shown in Table 3–20) are computed for each loan group, and for each month of the stress period. The following describes calculations of explanatory variables and the resulting default and prepayment rates. Unless otherwise indicated, each variable subscripted with a ''t'' is computed for the 120 months of the stress period. To illustrate each procedure, formulas are shown for one loan group for each month of the stress test. The same logic applies to all loan groups.

[e] The values of explanatory variables in each month are used in the default and prepayment equations to calculate annual default and prepayment rates. The stress test computes default and prepayment rates that would result if the conditions prevailing in each month were to continue for an entire year. These annual rates are converted to monthly rates for use in section 3.9, Cash Flows, of this Appendix.

3.5.4.3.1 Computation of Explanatory Variables

3.5.4.3.1.1 Mortgage Age (A_t, AY_t)

[a] Mortgage age in each month of the stress period is calculated as:

$$A_t = A_s + (t - 1)$$

where:

A_s = mortgage age at the start of the stress period, in months

t = month of stress period, where $t = \{1,...,120\}$

[b] Since mortgage age enters the default and prepayment equations in years, rather than in months, an age-in-years variable, AY_t, is created:

$$AY_t = A_t/12$$

3.5.4.3.1.2 Program Restructuring (*PR*)

The stress test differentiates between cash programs in effect before 1988 for Fannie Mae and before 1992 for Freddie Mac (''original programs'') and later cash programs. This differentiation accounts for the greater credit risk of the earlier cash programs. The variable *PR* is used in two ways to adjust original program loan groups for this greater risk. *PR* is only used for loans in the cash programs (except FHA-insured loans) because OFHEO has identified the program structure deficiencies that caused this greater risk only on these loans. The variable is not used to adjust the risk profile of loans acquired through negotiated programs. The *PR* variable is computed for each loan group according to the following:

$$PR = \begin{cases} 1, \text{ if loan originated/purchased in an original cash program} \\ 0, \text{ otherwise} \end{cases}$$

First, *PR* is used as a categorical variable to distinguish the original cash programs from more recent cash programs of the Enterprises (''current programs''). This usage of *PR* captures the higher default risk of the Enterprises' original programs. Second, *PR* is used as a flag for when to adjust DCR_0 and LTV_0 for overly optimistic appraisal practices inherent in original cash program loans. (*See* sections 3.5.4.3.3.10, Formula for Constructing the DCR Time Series and 3.5.4.3.4.4, Construct the LTV Time Series, of this Appendix.)

3.5.4.3.1.3 Value of Depreciation Write-off (*DW*)

The present value of tax benefits afforded to an investor/owner in a multifamily property is captured in a depreciation write-off variable (*DW*). Based on depreciation rules and OFHEO's estimates of the marginal tax rate for ordinary income, the marginal tax rate for capital gains, and the risk-adjusted return for multifamily projects, a value of 9.27 for this variable (*DW*) is used in the stress test. This value represents a 9.27 percent estimated return for a 20-year holding period on investments in multifamily property resulting from tax benefits associated with ownership and taxes paid on the ultimate sale of the property, based on 1995 data. OFHEO may change the value for this variable if there are significant changes in depreciation rules or tax rates. DW affects defaults and is held constant for

all cash programs throughout the stress period. However, it is not used to project default rates of negotiated programs.

3.5.4.3.1.4 Seller/Servicer Repurchase Flags (*RF*, *RA*)

[a] Mortgage default in the stress test is defined as a loan termination in which the borrower must relinquish title to the property because of an inability to make loan payments. However, there is one exception for multifamily mortgages in certain negotiated programs. In these negotiated programs, when a loan becomes 90 days delinquent, the seller/servicer must buy the loan out of the pool and attempt to resolve the delinquency. For these loans, the stress test defines default as a 90-day delinquency, rather than a full default. The occurrence of 90-day delinquencies is always higher than the occurrence of full defaults, since many 90-day delinquent loans cure or are modified.

[b] To distinguish a ''90-day delinquency'' type of default from a full default, the stress test includes two categorical variables that flag fixed-rate (*RF*) and adjustable rate (*RA*) negotiated program loans with repurchase requirements:

$$RF = \begin{cases} 1 & \text{, for fixed-rate, negotiated program loans with seller/servicer repurchase} \\ 0 & \text{, otherwise} \end{cases}$$

$$RA = \begin{cases} 1 & \text{, For ARMs in negotiated programs with seller/servicer repurchase} \\ 0 & \text{, otherwise} \end{cases}$$

3.5.4.3.1.5 Joint Probability of Negative Equity and Negative Cash Flow (JP_t)

The joint probability of negative equity and negative cash flow (JP_t) is defined as the probability that any given loan will simultaneously experience a loan-to-value ratio (LTV_t) greater than 1.00 and a debt coverage ratio (DCR_t) less than 1.00. JP_t is the principal variable used in the stress test to measure the value of default to multifamily borrowers. Creating this variable involves updating DCR_t and LTV_t over time using a property net operating income (NOI) growth factor, changes in mortgage payments, loan amortization, and a capitalization rate multiplier. The NOI growth factor is updated over time using vacancy rate changes and rental inflation since loan origination. The capitalization rate multiplier is updated based on changes in interest rates since loan origination.

3.5.4.3.2 Updating Average Property Income

3.5.4.3.2.1 Create Rent Indexes for the Start of the Stress Period

Rent indexes at the start of the stress period are created using time series of annual percent changes in the residential rent component of the CPI for each of the four Census regions and the 29 MSAs covered by BLS surveys. If the stress test begins at a time other than January 1 (first quarter of the year), the residential rent component of the CPI at the end of the quarter just preceding the start of the stress test is used to create the final ''year'' of the rent index time series. Most MSA level CPI series produced by BLS start in 1970, but some do not begin until the 1980s. The regional CPI series are available beginning in 1978, so percent changes for these can only be computed starting in 1979. Each regional and MSA percent-change series is constructed as follows:

1. Fill-in the pre-1979 regional series with percent changes in the rent index values for the national CPI, going back 30 years from the start of the stress test. If any MSA is missing one or more years of data, fill-in missing values from regional series. This results in 33 time series of annual rent growth rates for 30 years, ending in the year and quarter just preceding the beginning of the stress test.

2. Using these time series, create the rent index value for each loan group at the start of the stress period, as a cumulative index from the loan origination year to the start of the stress test:

$$I_{m,y} = \sqrt{1 + g_{m,y}} \left(\prod_{k=y+1}^{K} (1 + g_{m,k}) \right)$$

where:

$I_{m,y}$ = rent index value for a loan group at the start of the stress period for loans in geographic area, *m*, originated in year, *y*

m = geographic indicator for matching loans to the time series of annual percentage change of the residential rent component of CPI (Use the MSA code for *m* (loan characteristic, classification variable) if loan is in an MSA covered by the residential rent component of the CPI, otherwise use the Census region of the property (loan characteristic, classification variable) for *m*.)

$g_{m,y}$ = rent growth rate for geographic area, *m*, in loan origination year, *y*, as computed from the CPI residential rent index in the previous steps

$g_{m,k}$ = rent growth rate for geographic area, *m*, in calendar year *k,* where k starts in the year after loan origination and extends through the year that the stress test begins

k = year index variable

K = calendar year of the start of the stress test

3. In order to link the rental series to loan group characteristics, first match each loan group by MSA code to the available residential rent series from BLS. If there is a match, then use that MSA series of historical annual growth rates of residential rent, as described above, to generate the value for $I_{m,y}$. If the loan group is not in an MSA covered by the BLS residential rent series, then match the Census region of the property to the appropriate regional residential rent series, and use the regional historical annual growth rates of the residential rent series to generate the value for $I_{m,y}$. Assume that all loans originate in the middle of the year, for purposes of the first-year rent growth rate. To accomplish this, the above formula uses the square root of the growth rate in the year of loan origination.

3.5.4.3.2.2 Update Each Rent Index throughout Stress Period

The rent index at the beginning of the stress test ($I_{m,y}$) is updated, for each loan group, throughout the stress period based on the following equation:

$$I_t = I_{m,y} \cdot \prod_{i=1}^{t} \left(1 + g_i\right)$$

where:

t = number of current months in stress period, $t = \{1,...,120\}$

i = index counter for month number

g_i = monthly rent growth rate in month *i* of the stress period, which is a monthly, rather than annual, rate of growth (See section 3.4, Property Valuation, of this Appendix.)

3.5.4.3.2.3 Create a Property Net Income Multiplier

[a] The rent index series just created is combined with the vacancy rate series (V_t) provided by the Property Valuation component of the stress test to create a formula for updating the average, underlying, NOI in each month of the stress period. The following formula provides a multiplication factor that gives the ratio of current property NOI to NOI at loan origination (for cash programs), or at acquisition (for negotiated programs):

$$N_t = I_t \cdot (1 - 2.15(V_t - 0.0623))$$

where:

N_t = net income update multiplier in month *t* of the stress period (This provides a measure of the ratio, NOI_t/NOI_0, where NOI_0 is NOI at loan origination or acquisition.)

V_t = rental vacancy rate in month *t* of the stress period

2.15 = the percentage decline in NOI due to a one percent increase in the vacancy rate

.0623 = the average vacancy rate observed for multifamily rental properties in 1983-95

[b] There are two constants in the above equation. The first, 2.15, is the percentage decline in NOI due to a one percent increase in the vacancy rate. The second, 0.0623, is the average vacancy rate observed for multifamily rental properties in 1983–95. The average vacancy rate is used to approximate the vacancy rate of each loan at the time of origination (cash programs) or acquisition (negotiated programs). N_t measures how changes in rental inflation and vacancy rates together translate into percentage changes in net operating income since loan origination.

3.5.4.3.3 Create a DCR Time Series

[a] DCR is the ratio of the property NOI to the mortgage payment. DCR at loan origination or acquisition (DCR_0) is a loan characteristic input to the stress test. It is updated over time using the formula for N_t, and by updating the mortgage payment, if and when applicable. The mortgage payment changes regularly for ARMs. The stress test also changes mortgage payments for balloon loans that do not pay off at maturity. For such loans, the coupon interest rate is changed to the prevailing market rate at the time of balloon maturity. DCR_0 for loans purchased under original cash programs (when PR=1) of the Enterprises are adjusted to make them consistent with current cash programs (current measurement practices) by multiplying them by 0.8655.[12] This adjusts for differences in appraisal practices between original and current cash programs.

[b] In addition, because UPB is decremented over time, according to the coupon rate and amortization term for each loan group, updates to UPB are required to update payments on ARM and balloon loans at maturity. Updates to UPB are also used to create current LTVs. Procedures for creating a time series of LTV ratios follows this discussion involving DCR construction. In the following procedures, both UPB and mortgage payments (PMT) are factors based on an original loan balance of one dollar and do not represent actual dollar amounts.

3.5.4.3.3.1 Create the Original Payment Factor for All Loans

The original payment factor is based on original loan terms:

$$PMT_0 = \frac{r_{c,0}/12}{1-\left(1+r_{c,0}/12\right)^{-T_a}}$$

where:

PMT_0 = monthly payment at mortgage origination, per dollar of mortgage

$r_{c,0}$ = mortgage coupon at loan origination

T_a = amortization term of mortgage in months

3.5.4.3.3.2 Create Time Series of UPB Values for Fixed-rate, Fully Amortizing Loans

For all fixed-rate, fully amortizing loans, create the UPB time series in the stress test period according to the following equation:

$$UPB_t = PMT_0\left(\frac{1-(1+r_{c,0}/12)^{(A_s+t-T_a)}}{r_{c,0}/12}\right), \quad \text{for all} \quad t=\{1,...,120\}$$

3.5.4.3.3.3 Update Mortgage Payment Factors and UPB for ARMs and Balloon ARMs

[a] Updating UPB_t and PMT_t for ARMs requires first creating the coupon interest rate series ($r_{c,t}$) for each ARM loan group. This series will capture the effect of period and lifetime caps on the path of coupon rates.

1. The current coupon rate at the start of the stress period, $r_{c,s}$, is used for the mortgage coupon rates in the first 12 months of the stress period $r_{c,t}$:

$r_{c,t} = r_{c,s}$, for t = {1,...,12}

2. In every twelfth month, compare:

$r_{c,t} >< (r_{b,t} + 0.02375)$, for t = {12, 24, 36,...108}

where:

$r_{b,t}$ = Federal Home Loan Bank 11th District Cost of Funds Index, value in month t of stress period

0.02375 = index margin used to create fully-adjusted coupon rate

3. When, upon evaluation in step 2, $r_{c,t} < (r_{b,t} + 0.02375)$, set:

$r_{c,t+1...t+12} = \min\{(r_{b,t} + 0.02375), (r_{c,t} + 0.01), (r_{c,0} + 0.05)\}$

where:

0.01 = interest-rate change cap per adjustment period (period cap)

0.05 = interest-rate change cap over the life of the loan (life cap)

[12] For Fannie Mae, these are cash loans purchased prior to 1988. For Freddie Mac, these are cash loans purchased prior to 1992.

4. When, upon evaluation in step 2, $r_{c,t} > (r_{b,t} + 0.02375)$, set:

$r_{c,t+1...t+12} = \max\{(r_{b,t} + 0.02375), (r_{c,t} - 0.01), (r_{c,0} - 0.05)\}$

5. When, upon evaluation in step 2, $r_{c,t} = (r_{b,t} + 0.02375)$, set:

$r_{c,t+1...t+12} = r_{c,t}$

[b] The UPB percent at the start of the stress test is calculated using an original loan balance of one dollar, remaining term, and an average of the origination and starting coupons. The resulting UPB percent is used to calculate the payment factor in month one of the stress period:

$$\bar{r} = (r_{c,0} + r_{c,s})/2$$

$$\overline{PMT} = \frac{\bar{r}/12}{1 - \left(1 + \frac{\bar{r}}{12}\right)^{-T_a}}$$

$$UPB_{t=1} = \overline{PMT}\left(\frac{1 - (1 + \bar{r}/12)^{(A_s - T_a - 1)}}{\frac{\bar{r}}{12}}\right)$$

$$PMT_{t=1} = \frac{UPB_{t=1} \cdot (r_{c,s}/12)}{\left(1 - \left(1 + \frac{r_{c,s}}{12}\right)^{\left(A_s - T_a - 1\right)}\right)}$$

where:

$\bar{r}$	=	average of origination and current (as of the start of the stress test) coupon rates
$\overline{PMT}$	=	monthly payment factor, based on $\bar{r}_a$, per dollar of mortgage
$UPB_{t=1}$	=	percentage of loan balance outstanding at the beginning of the stress period
A_s	=	mortgage age at the start of the stress period
$PMT_{t=1}$	=	monthly payment factor at the start of the stress period
T_a	=	mortgage amortization term

[c] The time series of mortgage coupon rates ($r_{c,t}$) from steps 1–5 is used to generate time series of payment factors and UPB percent factors for the remaining months of the stress period. These two series are developed simultaneously. In each month, each series is updated based on what happened in the other series in the previous month:

$$UPB_t = UPB_{t-1} - \left(PMT_{t-1} - UPB_{t-1} \times \frac{(r_{c,t-1})}{12}\right), \quad \text{for } t = \{2,...,120\}$$

$$PMT_t = UPB_{t-1}\left(\frac{r_{c,t}/12}{1-\left(1+\frac{r_{c,t}}{12}\right)^{\left(A_t - T_a\right)}}\right), \quad \text{for } t = \{2,...,120\}$$

where:

A_t = age of mortgage, in month t of the stress test

3.5.4.3.3.4 Create Payment and UPB Factors for Fixed-Rate Balloons

Payment factors for balloon loans with fixed interest rates are held constant at PMT_0 until the loans reach maturity. At maturity, the payment factor is updated to reflect current market interest rates, the remaining loan balance, and a new amortization term.[13] Payment factors and UPB for balloon ARMs are constructed using the procedures just described for ARM loans, rather than the instructions for fixed-rate balloon loans.

1. Set balloon term in months, T_m, according to product types listed in Table 3–18.

Table 3-18. Balloon Term

Balloon Product	Term, T_m
5 YR fixed-rate	60
7 YR fixed-rate	84
10 YR fixed-rate	120
15 YR fixed-rate (and ARM balloons)	180

2. Create UPB_t and PMT_t throughout the stress period, according to when the balloon matures in the stress period. Loan group UPBs are reduced according to default and prepayment (balloon payoffs) rates (*see* section 3.5.4.3.6, Calculation of Default and Prepayment Rates, of this Appendix) in the balloon year, and for up to five years beyond the month of balloon maturity. Loan groups with balloon maturity prior to the start of the stress test are terminated after three years in the stress period (thirty-seventh month). Loan groups that mature during the stress test are terminated five years after maturity.

a. If balloon term, T_m, is less than or equal to mortgage age at the start of the stress test, A_s, i.e., the loan has passed its balloon date or is just maturing when the stress test begins, then UPB_t and PMT_t are updated as follows:

$$UPB_{t=1} = PMT_0\left(\frac{1-(1+r_{c,s}/12)^{(A_s - T_a)}}{r_{c,s}/12}\right)$$

$$PMT_t = \left(UPB_{t=1}\left(\frac{r_{f,1}/12}{1-\left(1+\frac{r_{f,1}}{12}\right)^{-T_a}}\right)\right), \quad \text{for } t = \{1,...,\tau\}$$

[13] The remaining life of the loan is reset to equal the amortization term of the loan at origination.

$$UPB_t = PMT_t\left(\left(\frac{1-(1+r_{f,1}/12)^{(t-1-T_a)}}{\frac{r_{f,1}}{12}}\right)\right), \quad \text{for t} = \{2,...,t\}$$

where:

τ = 60 when $\underline{A}_s = \underline{T}_m$, or 36 when $\underline{A}_s > \underline{T}_m$

$\underline{r}_{f,1}$ = conventional 30-year fixed-rate mortgage rate, in month one of stress period

b. If balloon term, T_m, is greater than mortgage age at start of stress test, A_s, then update UPB_t and PMT_t as follows.

$$PMT_t = PMT_0\ , \quad for\ t=\{1,...,m\}$$

$$UPB_t = \left(PMT_t\left(\frac{1-(1+r_{c,s}/12)^{(A_t-T_a)}}{r_{c,s}/12}\right)\right), \quad \text{for t} = \{1,...,\text{m}\}$$

$$PMT_t = \left(UPB_m\left(\frac{r_{f,m}/12}{1-\left(1+\frac{r_{f,m}}{12}\right)^{-T_a}}\right)\right), \quad \text{for t} = \{\text{m}+1,...,\ m+60\}$$

$$UPB_t = \left(PMT_t\left(\frac{1-(1+r_{f,m}/12)^{(t-m-T_a)}}{\frac{r_{f,m}}{12}}\right)\right), \quad \text{for } t = \{m+1,...,m+60\}$$

where:

m = $T_m - A_s$, which is the month of balloon maturity

$r_{f,m}$ = conventional 30-year fixed-rate mortgage rate in month, m

3.5.4.3.3.5 Formula for Constructing the DCR Time Series

The formulas for updating DCR over time in the stress period are described below.

1. For loans originated under current cash programs (where *PR*=0), and for all negotiated programs:

$$DCR_t = \frac{DCR_0 \cdot N_t}{PMT_t/PMT_0}$$

2. For loans originated under original cash programs, where *PR*=1:

$$DCR_t = \frac{DCR_0 \cdot N_t \cdot 0.8655}{PMT_t/PMT_0}$$

where:

0.8655 = factor required to make measurement of DCR_0 in original cash programs comparable to measurements used in current cash programs (this adjusts for differences in appraisal practices between original and current programs)

3.5.4.3.4 Create an LTV Time Series

LTV is the ratio of the unpaid principal loan balance (UPB) to the value of the property. The UPB is updated over time as described above. The value of the property is adjusted based on the property net operating income multiplier (N_t) and a capitalization rate multiplier (described below). As with DCR, LTV must be adjusted for loans purchased under original Enterprise cash programs, to make them consistent with current cash programs.

3.5.4.3.4.1 Updating the Capitalization Rate Multiplier

[a] The capitalization rate multiplier is the reciprocal of the capitalization rate and reflects what investors are willing to pay for an annual cash flow stream on a property, given the property and market conditions, as well as the opportunity cost of capital. LTV is updated in the stress test according to changes in the multiplier that result from changes in the opportunity cost of capital, as reflected through changes in market interest rates.

[b] The capitalization rate multiplier is updated in two steps, based on changes in the ten-year CMT yield (a proxy for changes in the opportunity cost of capital).

1. Compute the average monthly ten-year CMT yield for the loan origination-year:

$$y120_0 = \frac{\sum_{i=1}^{12} y120_{0,i}}{12}$$

where:

$y120_0$ = average monthly ten-year CMT yield in loan origination year

i = index variable used to identify individual monthly average rates of the ten-year CMT yield, i = {Jan,...Dec}

2. Compute the time series of ratios of capitalization rate multipliers based on the relative spread between the origination-year ten-year CMT and each of the monthly values of the ten-year CMT throughout the stress period:

$$C_t = 1 + 0.23 \cdot \left(\frac{y120_0 - y120_t}{y120_0} \right)$$

where:

C_t = ratio of the capitalization rate multiplier in month t of the stress period, t={1,...,120}, to that of the capitalization rate multiplier at origination

$y120_t$ = ten-year CMT yield in month t of the stress period

0.23 = regression coefficient from historical estimation

3.5.4.3.4.2 Construct the LTV Time Series

[a] For loans acquired through current cash programs (where PR=0), or through negotiated programs:

$$LTV_t = \frac{LTV_0 \cdot UPB_t}{C_t \cdot N_t}$$

[b] For loans acquired through original cash programs, where PR=1:

$$LTV_t = \frac{LTV_0 \cdot UPB_t \cdot 1.2778}{C_t \cdot N_t}$$

where:

1.2778 = factor required to make measurement of LTV_0 in original loan programs comparable to LTV_0 in current loan programs

[c] For all loans, prevent LTVt from approaching zero by resetting small values to 0.01:

$$LTV_t = max(LTV_t, 0.01)$$

3.5.4.3.5 Compute Joint Probability of Negative Equity and Negative Cash Flow

[a] The values of the joint probability of negative equity and negative cash flow (JP_t) are computed as the area under a bivariate standard normal density function. The form for this function is:

$$BV(a, b, \rho) = \frac{1}{2\pi \cdot \sqrt{1-\rho^2}} \int_{-\infty}^{a} \int_{b}^{\infty} exp\left(\frac{x^2 - 2\rho xy + y^2}{2(1-\rho^2)}\right) dy\, dx$$

where:

π = mathematical value 'pi'

ρ = correlation between the two standard normal random variables, x and y

a = limit of integration for x

b = limit of integration for y

[b] In the calculations of JP_t, the two standard normal random variables (x and y) represent transformations of DCR and LTV values for individual properties. Standard normal random variables have normal (Gaussian) distributions, with a mean of zero and standard deviation of one. Any normally distributed random variable can be ''standardized'' by subtracting the mean from the variable, and then dividing by the standard deviation. In this application, the ''sample'' group for which the standard deviations apply could include all multifamily properties in the geographic location of the properties underlying the loan group being studied. Here the normally distributed variables are the true, but unknown *ln* (*DCR*) and *ln* (*LTV*) values for each loan, and their mean values are:

$$\bar{D}_t = ln(DCR_t) - 0.50 \cdot \sigma^2_{lnZ,\,t} \quad \text{and}$$

$$\bar{L}_t = ln(LTV_t) + 0.50 \cdot \sigma^2_{lnZ,\,t}$$

where:

Z = $1 - 2.15\ (V_t - 0.0623)$

lnZ = natural logarithm of Z

and

$$\sigma^2_{lnZ,\,t} = \left(ln\ 1 + \left(\frac{2.15^2 \cdot V_t \cdot (1 - V_t)}{\left(1 - 2.15 \cdot (V_t - 0.0623)\right)^2}\right)\right)$$

[c] The limits of integration (a and b) represent the distance between the logs of the at-risk boundaries for underlying properties—DCR=1.00 and LTV=1.00 and—$\bar{D}_t$ and $\bar{L}_t$ respectively. The joint probability variable is then the value of the bivariate density function, evaluated at particular values of the integration limits in each month of the stress period:

$$JP_t = BV(a_t, b_t, \rho)$$

[d] The following steps describe how to calculate the values of a_t and b_t.
1. First, compute the standard deviation of ln(DCR_t) and ln (LTV_t):

$$\sigma_t = \sqrt{0.005625 \cdot A_t + \sigma^2_{lnZ,\,t}}$$

where:

σ_t = standard deviation of both ln(DCR_t) and of ln(LTV_t) in month *t* of the stress period
A_t = age of mortgage (in years) in month t of the stress period
V_t = vacancy rate in month *t* of the stress period
.075 = standard deviation of the rent growth rate
2.15 = percentage decline in net operating income for each percentage point increase in the vacancy rate since origination

2. The limits of integration in each month of the stress test, a_t and b_t, are:

$$a_t = \frac{ln(1.00) - \bar{D}_t}{\sigma_t}$$

$$b_t = \frac{ln(1.00) - \bar{L}_t}{\sigma_t}$$

where:

ln (.) = natural logarithm of value in brackets

These equations reduce to:

$$LTV_t = \frac{LTV_0 \cdot UPB_t \cdot 1.2778}{C_t \cdot N_t}$$

[e] The coefficient of correlation between the logarithms of *DCR* and *LTV* is: $\rho = -0.5975$. It should be noted that standard software packages that compute bivariate normal probabilities do their integrations over the left tails of both (*x* and *y*) distributions. To estimate the left tail of the *lnDCR* and the right tail of the *lnLTV* distribution which is required to estimate JP_t, one simply reverses the signs on the *lnLTV* integration limit (from b to −b) and the correlation coefficient (from −0.5975 to 0.5975).

3.5.4.3.5.1 Balloon Maturity Risk (BJP_t)

[a] The balloon year is defined as the 12 months leading up to and including the maturity month. Because of the contractual requirement to pay off a loan at maturity, a balloon loan with weak financials is more likely to default in the balloon year than at any previous time. The stress test captures this additional credit risk for balloon loans by giving extra weight to the JP_t variable in the balloon year. This is accomplished by including a second JP_t term in the default equations, which is only used for balloon loans, in the balloon year:

$$BJP_t = \begin{cases} JP_t, \text{ if the loan is a balloon in month } t = \{(m-11), ..., m\} \\ 0, \text{ otherwise} \end{cases}$$

where:

m = T_m - A_s, the stress period month when balloon maturity occurs

[b] Not all loans will pay off or default by balloon maturity. For those that continue beyond balloon maturity, the stress test updates PMT_t after the balloon date with current market interest rates (as described earlier) to simulate any increase (or decrease) in payments upon refinancing the property. This change in loan payments changes the default risk in the post-balloon period.

3.5.4.3.5.2 Relative Spread Variables (RS_t, RSD_t, RSU_t)

The incentive to prepay a mortgage because of the ability to refinance at lower interest rates is proxied by relative interest rate spreads. The difference here is that, for fixed-rate mortgages, the relative spread is split into two variables: one for when market rates are below the coupon rate (RSD_t), and one for when market rates are above the coupon rate (RSU_t). RSD_t captures in-the-money prepayment options, and RSU_t captures any dampening effect on cash-out refinancing when the prepayment option is out-of-the-money. For ARM loans, the relative spread variable (RS_t) compares the current coupon rate to the current market rate on fixed-rate products.

1. For each ARM loan group, compute the relative spread as:

$$RS_t = \frac{r_{c,t} - r_{f,t}}{r_{c,t}}$$

2. For each fixed-rate loan group (including balloons), create the two spread variables:

$$RSD_t = \begin{cases} \dfrac{r_{c,0} - r_{f,t}}{r_{c,0}}, & \text{when } r_{c,0} > r_{f,t} \\ 0\ , & \text{otherwise} \end{cases}$$

$$RSU_t = \begin{cases} \left| \dfrac{r_{c,0} - r_{f,t}}{r_{c,0}} \right|, & \text{when } r_{c,0} < r_{f,t} \\ 0\ , & \text{otherwise} \end{cases}$$

3.5.4.3.5.3 Years-To-Go in the Yield-Maintenance Period (YTG_t)

[a] One feature common to most fixed-rate multifamily mortgages, whether balloon or fully amortizing, is the yield maintenance period (YMP). During a yield maintenance period, prepayment is restricted because borrowers cannot prepay the mortgage without incurring substantial penalties. For fixed-rate fully-amortizing mortgages, the YMP is 120 months. For fixed-rate balloon loans, the YMP averages two-thirds of the loan term, up to a maximum of 120 months. ARM loans do not have yield maintenance periods. Table 3–19, of this Appendix provides the term of the YMP for each loan product as follows:

Table 3-19. Yield Maintenance Period by Product Type

Product Type	Yield Maintenance Period (in Months)
FHA-insured	120
30 YR Fixed-Rate Mortgage	120
20 YR Fixed-Rate Mortgage	120
15 YR Fixed-Rate Mortgage	120
15 YR Balloon	120
10 YR Balloon	84
7 YR Balloon	60
5 YR Balloon	36
Fully-amortizing ARMs	0
Balloon ARMs	0
Other	120

[b] The YMP is used to create the explanatory variable years-to-go (YTG_t), which measures the number of years remaining in the yield maintenance period of the mortgage. This explanatory variable is a proxy for the size of prepayment penalties, which decline throughout the YMP:

$$YTG_t = \begin{cases} (YMP - A_t)/12 \ , & \text{when } YMP \geq A_t \\ 0 \ , & \text{otherwise} \end{cases}$$

[c] YTG_t has its maximum value in the first month of loan life, and declines to zero by the end of the YMP. For loan programs with lockouts, which prohibit prepayment for a stated time period, YTG_t is set to ten for the duration of the lockout period.

$$YTG_t = \begin{cases} 10 \ , & \text{for loans with lock-out provisions, when } YMP \geq A_t \\ 0 \ , & \text{for loans with lock-out provisions, when } YMP < A_t \end{cases}$$

3.5.4.3.5.4 Relative Spread Variables in the Pre-balloon Period (RSD_{1t}, RSD_{2t})

For balloon loans during the post-yield-maintenance and pre-balloon period, borrowers must decide whether to lock in a current interest rate or take their chances regarding what the market rate will be when the loan matures. To capture the additional incentive of borrowers to prepay in the two years prior to the balloon date, to take advantage of favorable interest rates when they exist, the stress test provides extra weight to the RSD_t variable in both the year preceding the balloon year, and the year just prior to that:

$$RSD1_t = \begin{cases} RSD_t \ , & \text{when } t = \{(m-23), \ldots, (m-12)\} \\ 0 \ , & \text{otherwise} \end{cases}$$

$$RSD2_t = \begin{cases} RSD_t \ , & \text{when } t = \{(m-35), \ldots, (m-24)\} \\ 0 \ , & \text{otherwise} \end{cases}$$

where:

m = $T_m - A_s$, which is the month of balloon maturity in the stress period

3.5.4.3.5.5 Market Rate for Fixed-Rate Mortgages ($r_{f,t}$)

The current market interest rate on fixed-rate single family mortgages is used to capture the effect of expectations of ARM borrowers with respect to future interest rate movements. This is in addition to the relative spread variable, RS_t, used in the prepayment equation for ARM loans. While RS_t measures differences between long-term and short-term interest rates, the long-term interest rate itself ($r_{f,t}$) indicates the absolute level of interest rates.

3.5.4.3.5.6 Probability of Qualifying for Refinancing at Balloon Maturity (PQ_t)

[a] When a balloon loan matures, the borrower is contractually required to pay off the outstanding UPB. To do this, the borrower generally obtains a new loan. In practice, payoff rates are dependent on the ability of the borrower and property to qualify for a new loan. For multifamily mortgages, the LTV must generally be less than or equal to 0.80, and the DCR must be greater than or equal to 1.20. The need for the property financials to meet origination underwriting criteria at the balloon date adds to extension risk, i.e., the risk that the loan will not pay off, but remain outstanding.

[b] The stress test captures extension risk at the balloon date by estimating a separate payoff equation for balloon loans at or beyond maturity. The payoff equation includes only one variable, the probability of qualifying for refinancing (PQ_t). This is constructed like the joint probability of negative equity and negative cash flow variable (JP_t), except that the limits of integration now reflect the minimal requirements for loan qualification rather than the boundary points for default. The integration limits are from α_t to + ∞ for $lnDCR_t$ (right tail) and from $-\infty$ to b_t for $lnLTV_t$ (left tail), where:

$$a_t = \frac{ln(1.20) - ln\left(DCR_t \cdot \frac{PMT_0}{RPMT_t} - 0.50 \cdot \sigma^2_{V,t}\right)}{\sigma_t}, \quad \text{for t} = \{\text{m},\ldots(\text{m}+60)\}$$

$$b_t = \frac{ln(0.80) - ln\left(LTV_t + 0.50 \cdot \sigma^2_{V,t}\right)}{\sigma_t} \quad , \quad \text{for } t = \{m,...(m+60)\}$$

and

$$RPMT_t = UPB_t \cdot \frac{r_{f,t}/12}{1 - \left(1 + r_{f,t}/12\right)^{-T_a}} \quad , \quad \text{for } t = \{m,...(m+60)\}$$

where:

$RPMT_t$ = mortgage payment if the loan were to be refinanced in month *t*, at current market interest rates, $r_{f,t}$

T_a = mortgage amortization term

m = month of balloon maturity = (T_m - A_s)

[c] The range of the integration limits is reversed from that used in calculating the JP_t variable, because PQ_t is calculating the probability of financially strong loans, while JP_t calculates the probability of financially weak loans. Again, in using a standard software package to calculate PQ_t, set the integration limit for $\alpha_t = -\alpha_t$ and $\rho = -\rho$ because the package is set up to integrate left tails only.

3.5.4.3.5.7 Loan-to-Value Ratio (LTV_t)

The current loan-to-value ratio is used to capture the propensity of investors to initiate cash-out refinancing to increase borrowers' returns on equity. The time series of LTV_t is used as an explanatory variable in prepayment equations.

3.5.4.3.5.8 Summary of All Explanatory Variables

Table 3–20 outlines all of the explanatory variables that are used to calculate default and prepayment rates.

Table 3-20. Summary List of Explanatory Variables

Variable	Description
AY_t	Mortgage age, in (fractional) years
PR	This categorical variable for program restructuring adjusts for differences between original and current cash programs. A switch is set to "1" for loans originated under original cash programs at the Enterprises, and "0" for all other programs
DW	A fixed-value that represents the present value of tax benefits afforded to a new property investor
RF	A categorical variable indicating that the seller/servicer must repurchase the loans from security pools at 90-days delinquency. It is set to "1" for fixed-rate, negotiated program loans with recourse to the seller/servicer, "0" otherwise
RA	A categorical variable indicating that the seller/servicer must repurchase the loans from security pools at 90-days delinquency. A switch is set to "1" for adjustable-rate, negotiated program loans with recourse to the seller/servicer, "0" otherwise
JP_t	The joint probability of negative equity and negative cash flow
BJP_t	The joint probability of negative equity and negative cash flow for balloon loans in the 12 months leading up to and including balloon maturity, 0 otherwise
RS_t	The ratio of the difference between the current coupon on ARMs and the current market rate for 30-year fixed-rate single family loans, to the current coupon rate
RSD_t	The ratio of the difference between the original coupon on fixed-rate loans (including fixed-rate balloons) and the current market rate for single family fixed-rate loans, to the original coupon rate. Set to zero when values are negative
RSU_t	The absolute value of the ratio of the difference between the original coupon rate on fixed-rate loans (including fixed-rate balloons), and the current market rate for fixed-rate loans, to the original coupon rate. It is set to zero when the difference between the two rates is positive
$r_{f,t}$	The conventional 30-year fixed-rate mortgage rate for single-family loans
YTG_t	Years remaining in the yield maintenance period
$RSD1_t$	The relative spread, down rates, variable in the period preceding the balloon maturity (months 13-23 prior to maturity), 0 otherwise
$RSD2_t$	The relative spread, down rates, variable (*RSD*) for balloons in months 13-35 prior to the balloon maturity month, 0 otherwise
PQ_t	The joint probability that DCR and LTV are sufficient to qualify for a refinancing of the property with a new mortgage ($DCR \geq 1.20$ and $LTV \leq 0.80$)
LTV_t	The ratio of the outstanding loan balance to expected property value in each month

3.5.4.3.6 Calculation of Default and Prepayment Rates

Conditional default and prepayment rates are calculated for each multifamily loan group based on the explanatory variables described above, and using statistical regression coefficients estimated on historical data. The regression coefficients provide weighting factors for each explanatory variable. The variables are each multiplied by their associated regression-coefficient (weights), and then added together to yield total weighting factors. Default and prepayment total weighting factors are combined in pairs to calculate the annual-equivalent conditional default and prepayment rates for each corresponding loan group in each month of the stress period. These annual-equivalent rates are then converted into monthly rates.

3.5.4.3.6.1 Combining Explanatory Variables into Total Weighting Factors

3.5.4.3.6.1.1 Default Weighting Factors (Δ_t)

The calculation of the total weighting factors for defaults varies by loan program. Two total weighting factors are calculated for loan defaults. One calculation is for mortgages purchased through cash programs, and the other is for mortgages acquired through negotiated programs. For each loan

group, the appropriate formula is used for the entire stress period.

For loan groups in cash programs:

$\Delta_t = -10.0191 + 1.2687\ AY_t - 0.0790\ (AY_t)^2 + 0.6203\ PR - 0.0829\ DW + 7.8230\ JP_t + 2.6446\ BJP_t$

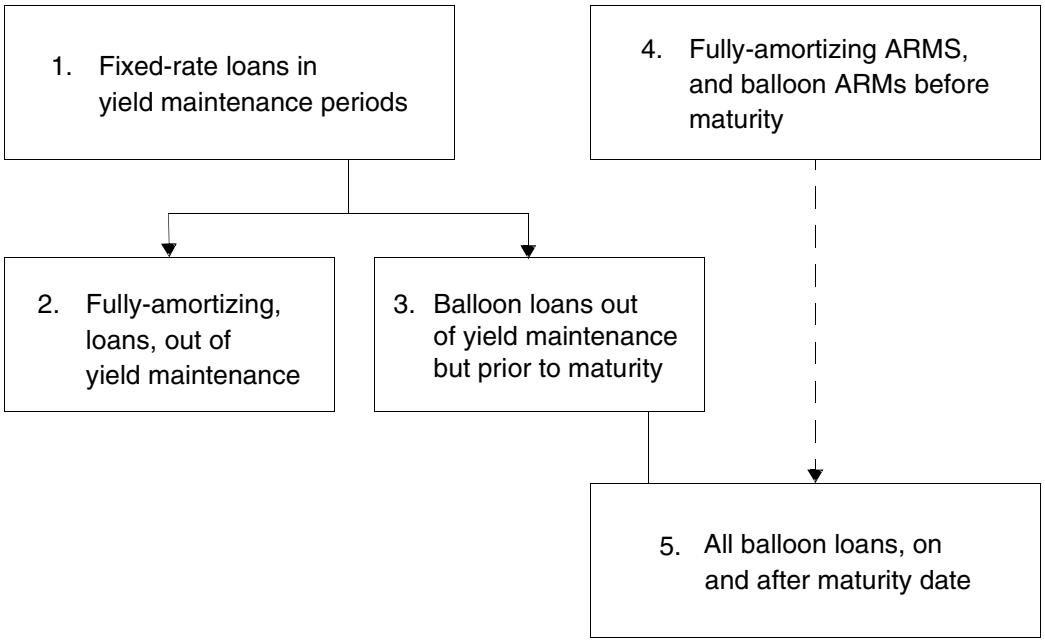
3. For loan groups in negotiated programs:

$\Delta_t = -9.6418 + 1.0596\ AY_t — 0.0633\ (AY_t)^2 + 0.2627\ RF + 0.6751\ RA + 12.1660\ JP_t + 2.6446\ BJP_t$

3.5.4.3.6.1.2 Prepayment Weighting Factors (Π_t)

Prepayment total weighting factors are calculated using equations that differ both by product type and life-cycle stage. For any one loan group, one, two, or three different equations may be used during the stress period. Figure 3–4 illustrates how the prepayment weighting factor equations are used over the life of any particular loan group. Each block represents one of the five different equations for computing the prepayment total weighting factors.

Figure 3-4. Prepayment Weighting Factor Equations



1. Fixed-rate Mortgages (Fully Amortizing and Balloon Loans)

If the loan product is a ''fixed-rate'' or a non-ARM balloon, and for t where YMP $\geq A_t$,

$$\Pi_t = -4.7854 + 0.4393\ AY_t - 0.0263\ (AY_t)^2 + 11.079\ RSD_t - 7.13\ RSU_t - 0.2656\ YTG_t - 0.9499\ LTV_t$$

2. Fully-amortizing loans, out of yield maintenance

If the loan product type is ''fixed-rate,'' and for t where YMP $< A_t$:

$$\Pi_t = 0.7129 - 0.2091\ AY_t + 0.0044\ (AY_t)^2 + 3.994\ RSD_t - 0.796\ RSU_t - 3.8166\ LTV_t$$

3. Balloon loans out of yield maintenance, but prior to maturity.

When the mortgage product is a balloon with a fixed interest rate, and for values of t where YMP $< A_t$ and $t < (m-11)$:

$$\Pi_t = -7.3368 + 1.5412\ AY_t - 0.0952\ (AY_t)^2 + 5.17\ RSD_t - 0.796\ RSU_t + 1.92\ RSD1_t + 1.62\ RSD2_t - 2.2591\ LTV_t$$

where:

m = T_m - A_s, which is the month of balloon maturity in the stress period

4. Fully-amortizing ARMs, and balloon ARMs before maturity.
When the mortgage product is a fully-amortizing ARM, or a balloon ARM where $t < (m\text{-}11)$, then:

$$\Pi_t = -0.9037 + 1.7119\, AY_t - 0.1231\, (AY_t)^2 + 4.8137\, RS_t - 51.31\, r_{f,t} - 3.2223\, LTV_t$$

where:

m = $T_m - A_s$, which is the month of balloon maturity in the stress period

5. All balloon loans, on and after the maturity date.
When the mortgage product is a balloon (ARM or fixed-rate), then the total weighting factors are calculated as:

$$\Pi_t = -1.0021 + 1.8013\, PQ_t, \begin{cases} \text{for } t = \{(m-11),\ldots,(m+60)\}, \text{ when } (m \geq 0) \\ \text{for } t = \{1,\ldots,36\}, \text{ when } m < 0 \end{cases}$$

where:

m = $T_m - A_s$, which is the month of balloon maturity in the stress period

Balloon loans do not all terminate at the balloon date. The stress test allows them to run-off according to default and prepayment (payoff) rate calculations, in the balloon year, and for up to five years beyond the balloon date. All balloon loans that do not terminate within five years beyond the balloon date are terminated in the sixty-first month. Loan groups with balloon dates prior to the start of the stress test ($m < 0$) are terminated in the thirty-seventh month of the stress period.

3.5.4.3.6.1.3 Calculating Annual Equivalent Default and Prepayment Probabilities

[a] Once the time series of default and prepayment total weighting factors are computed for each loan group, they are combined in multinomial logit equations to calculate the annual-equivalent default and prepayment probabilities. These probabilities represent what would happen over the course of a year, were default and prepayment probabilities for a given month (t) to continue for an entire year.

[b] The annual-equivalent default probability, AD_t, in each month, t, is computed as:

$$AD_t = \frac{exp\{\Delta_t\}}{1 + exp\{\Delta_t\} + exp\{\Pi_t\}}$$

and the annual-equivalent prepayment probability, AP_t, in each month (t) is computed as:

$$AP_t = \frac{exp\{\Pi_t\}}{1 + exp\{\Delta_t\} + exp\{\Pi_t\}}$$

3.5.4.3.6.1.4 Terminating Balloon Loans after Maturity

At the final termination point, annual-equivalent probabilities of default and payoff are calculated as functions of two explanatory-variable probabilities: the joint probability of negative equity and negative cash flow (JP_t), and the probability of qualifying for a refinancing (PQ_t):

$$AD_t = \frac{JP_t}{JP_t + PQ_t}$$

$$AP_t = 1 - AD_t$$

where:

for: t = $m + 61$, when $m \geq 0$ and $(m + 61) \leq 120$

t = 37 when $m < 0$

where: m = $T_m - A_s$, which is the month of balloon maturity in the stress period

3.5.4.3.7 Calculating Monthly Default and Prepayment Rates The monthly conditional default and prepayment rates are derived from the annual-equivalent probabilities for each month using geometric means. For default rates:

$$Def_t = 1 - \left(1 - AD_t\right)^{\frac{1}{12}}$$

and for prepayment rates:

$$Prep_t = 1 - \left(1 - AP_t\right)^{\frac{1}{12}}$$

3.5.4.4 Output

The 120 monthly default and 120 monthly prepayment rates are generated for each loan group and are used by the Cash Flow component of the stress test to compute monthly dollar amounts of loans that prepay and default (*see* section 3.9, Cash Flows, of this Appendix).

3.5.5 Multifamily Loss Severity

3.5.5.1 Overview

Loss severity is the net cost to an Enterprise of a loan default. The loss severity rate is expressed as a percentage of the UPB at time of default. The stress test calculates loss severity rates for each multifamily loan group for each month of the stress period. Loss severity rates are discounted to calculate an effective loss rate in the month of default, adjusting various cost and revenue components of loss severity that occur following the default date. The effective loss severity rate is multiplied by the corresponding mortgage default rate to calculate the loan group loss-rate. The loss-rate is multiplied by the UPB in each month to compute the dollar amount of credit losses for each loan group.

3.5.5.2 Inputs

[a] The following loan group characteristics are used:

- Program type
- Portfolio
- Net yield (the variable ''r_y'' in equations below) [14]
- Passthrough rate (the variable ''r_p'' in equations below) [15]

[b] The six-month Federal agency cost of funds (variable ''$r_{d,t}$'') interest rate series is used for discounting default-related cash flows in loss severity calculations. This series is an output from section 3.3, Interest Rates, of this Appendix.

3.5.5.3 Procedures

The loss severity rates are calculated by program type and portfolio. Cash flows are discounted semi-annually. The impact of credit enhancements on cash programs with recourse and FHA-insured loan programs is calculated below. Credit enhancements for other multifamily program types are applied in section 3.9, Cash Flows, of this Appendix.

3.5.5.3.1 Retained Portfolio: Cash Programs Without Recourse

[a] The basic loss severity equation is for loan groups consisting of retained loans purchased under cash programs without recourse. For these loan groups, loss severity rates are calculated as the UPB at the time of default (represented by the ''1'' in the following equation), plus the present value of foreclosure costs and property operating expenses, minus the net proceeds from sale of the property:

$$NPV_t = 1 + \frac{F}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}} + \frac{O \cdot t_i}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f + t_i/2}{6}}} - \frac{P}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f + t_i}{6}}}$$

[14] Net yield at the start of the stress test is used throughout the stress period for all loan groups, including ARMs.

[15] Passthrough rate at the start of the stress test is used throughout the stress period for all loan groups, including ARMs.

where:

NPV_t = net loss severity rate (as a fraction of the unpaid loan balance) in month t= {1,...,120}

F = foreclosure costs (0.0901 of the unpaid loan balance)

O = operating loss, per month (0.00332 of the unpaid loan balance)

P = net property sale proceeds (0.5888063 of the unpaid loan balance)

t_f = time from default to foreclosure (18 months)

t_i = property inventory time (13 months), the time between foreclosure and property disposition

$r_{d,t}$ = discount rate (six-month Federal agency cost of funds) in month t of the stress period

[b] Each NPV_t value represents the loss severity rate for loans defaulting in month t of the stress period. The timing of events (e.g., time from default to foreclosure, etc.) used in the equation shown above is also used in the loss severity rate equations for all other program types and portfolios. The net operating loss on foreclosed properties for the 13 months that the property would be real estate owned (REO) is expensed in the seventh month of the 13-month holding period.

3.5.5.3.2 Sold Portfolio: Programs Without Recourse or Repurchase

There is a slight change in the basic loss severity equation shown above for sold loans purchased under cash programs without recourse, and for negotiated programs without repurchase. Four months of interest are passed through to investors before the loans are bought out of security pools for default resolution. The passthrough interest expense in the second term of the loss severity equation, below, is discounted for two months. This represents a midpoint of the period of interest expenditures. In addition, the UPB at time of default is a direct cash outlay, occurring four months after default. Therefore, the UPB at time of default is discounted because the stress test accounts for this payment in the month of default. Therefore, the following modified equation is applied to sold loans purchased under cash programs without recourse, and negotiated programs without repurchase:

$$NPV_t = \frac{1}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{4}{6}}} + \frac{(r_p/12)\cdot 4}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{2}{6}}} + \frac{F}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}} + \frac{O\cdot t_i}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{(t_f+t_i/2)}{6}}} - \frac{P}{\left(1+\frac{r_{d,t}}{2}\right)^{\frac{t_f+t_i}{6}}}$$

where:

r_p = the passthrough interest rate

3.5.5.3.3 Retained Portfolio: Cash Programs With Recourse

When loans are purchased under cash programs with recourse, the seller/servicer shares any losses with the Enterprise. The stress test computes the amount of recourse and reduces the gross severity rate as described below.

1. Compute two additional revenue elements: interest income paid by the seller/servicer to the Enterprise (*II*) and (additional) proceeds from the seller/servicer (*SP*) recourse.

a. Calculate mortgage interest income, *II*, paid by the seller/servicer during the time between default and foreclosure:

$$II = (r_y / 12)\cdot t_f$$

where:

r_y = Current net yield (coupon rate less servicing fee)

b. Calculate proceeds from the seller/servicer recourse (*SP*).

• Calculate the seller/servicer share of loss, *S*, as a fraction of the UPB:

$$S = 0.10 + p\cdot(II + F + (1 - P) - 0.25)$$

where:

p = seller/servicer loss share percentage (0.10)

0.25 = deduction for amount of total default cost that is covered by the amount of lender recourse embedded in the first term on the right hand side of the equation (0.10)

• Reduce seller/servicer loss share (*S*) by the interest income it has already paid to the Enterprise (*II*). Thus, the final seller/servicer payment will be:

$$SP = S - II$$

2. Calculate net present value loss severity rates for defaults in each month (*t*) by summing the discounted values of all cost and revenue elements:

$$NPV_t = 1 - \frac{II}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f/2}{6}}} + \frac{F}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}} - \frac{SP}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}} + \frac{O \cdot t_i}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f + t_i/2}{6}}} - \frac{P}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f + t_i}{6}}}$$

In this equation, interest income (*II*) is discounted from the mid-point of the time between default and foreclosure, to reflect that interest payments are made monthly by the seller/servicer throughout this period. The seller/servicer's payment, or share of loss, is discounted from the foreclosure date. This is also a midpoint date, because seller/servicers pay the Enterprise some recourse amounts prior to foreclosure, and the rest of the recourse amount approximately two months after foreclosure.

3.5.5.3.4 Sold Portfolio: Cash Programs with Recourse

The steps for computing loss severity rates for cash programs with recourse for sold loans purchased follow the steps outlined for similar programs for retained loans. The differences are that the UPB at time of default is discounted, and there is an added expense element, the interest passthrough expense (*IE*) of payments made by the Enterprise to security holders. The UPB at time of default is discounted because this amount is disbursed to security holders four months after the time of default. The interest expense is computed for four months and discounted for two months.

1. Calculate four months of passthrough interest expense:

$$IE = (r_p/12) \cdot 4$$

where:

r_p = the passthrough interest rate

2. Calculate the loss severity rate for defaults in each month, *t*, using *IE* and other components as described above:

$$NPV_t = \frac{1}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{4}{6}}} - \frac{II}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f/2}{6}}} + \frac{IE}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{2}{6}}} + \frac{F}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}} - \frac{SP}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f}{6}}} + \frac{O*t_i}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f + t_i/2}{6}}} - \frac{P}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{t_f + t_i}{6}}}$$

3.5.5.3.5 Sold Portfolio: Negotiated Programs with Repurchase

In the case of default on negotiated programs with seller/servicer repurchase provisions, the Enterprises' losses represent a combination of foreclosures and alternative resolutions. These alternatives are loan restructuring, note sales, pre-foreclosure property sales, or acceptance of deeds in-lieu-of foreclosure. Seller/servicers are responsible for all resolution processes, including all post-foreclosure property

management and disposition. The Enterprise pays the seller/servicer claim, *C*, that results from the default-resolution expenses. There is typically a recourse account established for this purpose. Thus:

$$NPV_t = \frac{C}{\left(1 + \frac{r_{d,t}}{2}\right)^{\frac{12}{6}}}$$

where:

C = seller/servicer claim amount, as a fraction of the unpaid principal balance (0.39)

12 = time from default to average claim payment

In this equation, the discount time period for the single cost component is the expected time to foreclosure rather than time to final property sale, to reflect a balance of default-resolution types and associated time intervals before claims are filed with the Enterprise.

3.5.5.3.6 FHA-insured Programs

Loss severities on FHA-insured mortgages are set to three percent to reflect the costs of assigning defaulted loans to HUD.

3.5.5.4 Output

The 120 monthly loss severity rates for each loan group are used by the Cash Flow component of the stress test to calculate monthly amounts of credit losses, net of recourse offsets (*see* section 3.9, Cash Flows, of this Appendix).

3.6 Other Credit Factors

3.6.1 Overview

The Other Credit Factors component of the stress test accounts for sources of credit risk other than the risk of default by mortgage borrowers. These sources of credit risk include the risk of default by credit enhancement and derivative counterparties, as well as the risk of default of corporate securities, municipal securities, and rated mortgage-related securities. The stress test classifies these sources of credit risk into four ratings categories (''AAA'', ''AA'', ''A'' and ''BBB'') based on public ratings information, and establishes credit loss factors appropriate to each of these categories that are applied during the stress period.

3.6.2 Input

The stress test uses credit ratings issued by Standard & Poor's, Moody's, Duff & Phelps and Fitch as the basis to assign counterparties (except seller/servicers) and securities into one of the four rating categories. The stress test only uses Standard & Poor's and Moody's ratings for seller/servicers.

3.6.3 Procedures

3.6.3.1 Identifying Other Credit Factors

The stress test first identifies all non-mortgage borrower sources of credit risk and associated financial instruments, and groups them into two major categories-counterparties and securities. Counterparties are mortgage insurers, pool insurers, seller/servicers, and counterparties for derivative contracts. Securities include mortgage-related securities, such as mortgage revenue bonds (MRBs) and private label REMICs, and non-mortgage investments, such as corporate and municipal bonds and asset-backed securities (ABSs).

3.6.3.2 Classifying Rating Categories in the Stress Test

[a] Public ratings of a counterparty or security determine the extent of associated credit losses during the stress period. Based on these ratings, the stress test classifies counterparties and rated securities into one of the four rating categories:

- AAA—all securities/counterparties rated between AAA/Aaa and AAA–/Aa3
- AA—all securities/counterparties rated AA+/Aa1 and AA–/Aa3
- A—all securities/counterparties rated A+/A1 and A–/A3
- BBB—all securities/counterparties rated BBB+/Baa1 and below (Unrated corporate securities and counterparties are included in the BBB category.)

[b] For loans with more than one layer of mortgage credit enhancement coverage, only the ratings of the counterparty providing the primary layer of coverage are used. If the security or the primary coverage provider has different ratings from different rating agencies, i.e., a ''split rating,'' then the lower rating is used.

3.6.3.3 Accounting for Other Credit Factors

[a] The stress test specifies the final haircuts (i.e., the full amount of discount for other sources of credit risk in the stress period) by rating categories as shown in Table 3–21. The stress test further specifies that haircuts increase by equal amounts in each month until the final haircut is reached during the 120th month of the stress period.

Table 3-21. Stress Test Final Haircuts by Credit Rating Category

Rating Category (R)	AAA	AA	A	BBB
All counterparties and securities except derivative counterparties	10%	20%	40%	80%
Derivative counterparties	2%	4%	8%	16%

[b] Haircuts for each credit rating category in each month of the stress period can be obtained from the following formula:

$$H_{R,t} = \frac{FH_R}{120} \cdot t$$

where:

$H_{R,t}$ = haircut for credit rating category R in month *t* of the stress period

FH_R = final haircut for credit rating category R in the stress period

t = month *t* of the stress period

R = credit rating categories (AAA, AA, A, BBB)

[c] The haircut is applied to the cash flows of a rated security or payments due from a counterparty according to the following formula:

$$ACF_{R,t} = (1 - H_{R,t}) \cdot CF_{R,t}$$

where:

$ACF_{R,t}$ = adjusted cash flow of a rated security or payments due from a counterparty with credit rating R in month *t* of the stress period

$CF_{R,t}$ = unadjusted cash flow of a rated security or payments due from a counterparty with credit rating R in month *t* of the stress period

$H_{R,t}$ = haircut for credit rating category R in month *t* of the stress period

3.6.4 Output

The outputs of the Other Credit Factors component are the stress period final haircuts by rating category and by counterparty and security category. These haircuts are inputs to section 3.7, Mortgage Credit Enhancements; section 3.5.3, Single Family Loss Severity; section 3.5.5, Multifamily Loss Severity; and section 3.9, Cash Flows, of this Appendix.

3.7 Mortgage Credit Enhancements

3.7.1 Overview

For each loan group and each month of the stress period, the stress test calculates reductions to mortgage credit losses that reflect the effects of credit enhancements. This component calculates the values of eight loan group characteristics relating to credit enhancements, which are part of the Enterprises' starting position loan group characteristics, as described in Table 3–2 of this Appendix. These characteristics, combined with counterparty ''haircuts,'' are used in section 3.5.3, Single Family Loss Severity and section 3.5.5, Multifamily Loss Severity, of this Appendix to calculate loss severity rates, and in section 3.9, Cash Flows, of this Appendix to calculate dollar reductions to credit losses.

3.7.2 Inputs

This component uses the inputs listed in section 3.7.2.1, 3.7.2.2, and 3.7.2.3 of this Appendix.

3.7.2.1 Enterprise Data on Mortgage Credit Enhancements

[a] Loan-level information on mortgage credit enhancements:

- Type of mortgage credit enhancement
- Starting UPB
- Private mortgage insurance (PMI) percent coverage, if applicable

[b] Contract-level information on mortgage credit enhancements, if applicable:

- Limited recourse coverage remaining
- Limited indemnification coverage remaining
- Starting account balance of spread accounts
- Starting account balance of collateral accounts
- Starting account balance of cash accounts
- Pool insurance coverage remaining
- Coverage expiration date, unless coverage has expired before the beginning of the stress period

3.7.2.2 Public Rating Information

Rating information from four public rating agencies—Standard & Poor's, Moody's, Duff & Phelps and Fitch—is used for mortgage insurers and pool insurers, and Standard & Poor's and Moody's rating information is used for seller/servicers. A ''BBB'' rating category is attributed to unrated counterparties. For loans with more than one layer of credit enhancement coverage, only the ratings of the counterparty providing the primary layer of coverage are used. If the primary coverage provider has different ratings from different rating agencies, i.e., a ''split rating,'' then the lower rating is used. For each credit-enhanced loan, the following information is required where applicable:

- Public ratings of mortgage insurer
- Public ratings of pool insurer
- Public ratings of the seller/servicer

3.7.2.3 Counterparty Coverage Reduction Information

Counterparty coverage reduction data (haircuts) obtained from section 3.6, Other Credit Factors, of this Appendix, are:

- Haircuts for each month of the stress period for counterparties in the ''AAA'' credit rating category
- Haircuts for each month of the stress period for counterparties in the ''AA'' credit rating category
- Haircuts for each month of the stress period for counterparties in the ''A'' credit rating category
- Haircuts for each month of the stress period for counterparties in the ''BBB'' credit rating category

3.7.3 Procedures

Using the loan level and contract level information described above, the stress test first classifies the types of credit enhancement coverage within a loan group. Then it calculates values for the eight loan group characteristics relating to credit enhancements described in Table 3–2 of this Appendix. Of the eight characteristics, three are coverage amounts for the loan group for each of three types of credit enhancements, four are percentages of loan group UPB covered by each counterparty rating category, and one is the percentage of loan group UPB covered by dollar-denominated credit enhancements, as defined in section 3.7.3.1, Classification of Credit Enhancements, of this Appendix.

3.7.3.1 Classification of Credit Enhancements

[a] The stress test separates all of the various mortgage credit enhancements into two categories—percent-denominated credit enhancements and dollar-denominated credit enhancements. Percent-denominated credit enhancements cover losses based on the percentage of the loss incurred. This category includes private mortgage insurance (PMI), unlimited recourse, and unlimited indemnification. In addition to the percent-denominated credit enhancements listed here, certain multifamily programs have risk-sharing arrangements between the Enterprise and the seller/servicer. The process in the stress test that simulates the coverage of these programs is described completely in section 3.5.5, Multifamily Loss Severity, of this Appendix.

[b] Depending on the specific credit enhancement type, the loss covered can be based on either the ''gross claim amount'' (which includes the defaulted principal balance, unpaid interest from default through

foreclosure, and associated expenses, but does not include the subsequent proceeds from the sale of REO), or the net loss incurred (which does include proceeds from the sale of REO). Specifically, private mortgage insurance coverage is based on the gross claim amount, while unlimited recourse and indemnification coverage are based on the net loss incurred. *See* section 3.5.3, Single Family Loss Severity, of this Appendix for details on how the coverage is applied. The stress test further classifies PMI as ''Credit Enhancement Coverage Type 1'' (Type 1), and unlimited recourse and unlimited indemnification as ''Credit Enhancement Coverage Type 2'' (Type 2).

[c] Dollar-denominated credit enhancements cover losses on a dollar-for-dollar basis, up to a maximum amount (i.e., there is a ''dollar cap'' on the coverage). This category includes limited recourse, limited indemnification, pool insurance, spread accounts, collateral posted under collateral pledge agreements, and cash accounts. The stress test classifies all the dollar-denominated coverages as ''Credit Enhancement Coverage Type 3'' (Type 3).

3.7.3.2 Calculating Percentage Coverage and Dollar Coverage Amounts:

For each loan group, the stress test calculates the coverage for the overall loan group UPB provided by each type of credit enhancement (Types 1, 2, and 3) on the individual loans in the group.

1. Credit Enhancement Coverage Type 1 is calculated as the UPB weighted average percent coverage for all the loans in the loan group with PMI coverage. Loans in the loan group that are not covered by PMI are assumed to have coverage of zero percent, for the purpose of calculating the weighted average. Thus if a loan group UPB is ten million dollars, and one million of that balance has 35 percent Type 1 coverage, the overall loan group Type 1 coverage is 3.5 percent.

2. Credit Enhancement Coverage Type 2 is calculated as the UPB weighted average percent coverage for all the loans with unlimited recourse and unlimited indemnification coverage in the loan group. Because coverage is unlimited for each loan, the percent coverage at the loan level is 100 percent for covered loans. Loans in the loan group that are not covered by Type 2 credit enhancements are assumed to have coverage of zero percent, for the purpose of calculating the weighted average. Thus, if a loan group UPB is ten million dollars, and one million of that balance has 100 percent Type 2 coverage, the overall loan group Type 2 coverage is ten percent.

3. To calculate the Credit Enhancement Coverage Type 3 (i.e., the total coverage of all dollar-denominated credit enhancements), the stress test first assigns each loan under a contract its pro-rata share of the total dollar coverage for that contract (loans covered under a single contract may be assigned to several loan groups). The pro-rata dollar coverage of covered loans in a loan group is totaled to determine total dollar-denominated coverage for the entire group. This total dollar coverage is determined at the beginning of the stress period. Although the balances in spread accounts and collateral accounts at the beginning of the stress period could, in practice, fluctuate over time, the stress test specifies that these account balances are adjusted downward only to cover losses during the stress period, and are otherwise fixed.

3.7.3.3 Calculating Percent of UPB Covered by Each Counterparty Rating Category

The stress test calculates the percent of loan group UPB covered by each of the four counterparty rating categories. The UPBs of loans with counterparties falling into each rating category are divided by the UPB of the loan group. The results are values for the following four loan group characteristics:

- Percent of UPB under AAA coverage
- Percent of UPB under AA coverage
- Percent of UPB under A coverage
- Percent of UPB under BBB coverage

3.7.3.4 Calculating the Percent of UPB Under Dollar-Denominated Coverage

The stress test determines the percent of UPB under dollar-denominated coverage for each loan group. This percentage is calculated by dividing the loan group UPB with Type 3 coverage by the total UPB amount of the loan group.

3.7.3.5 Calculating Coverage Against Credit Losses

Based on loan group credit enhancement characteristics, the stress test simulates the coverage provided during the stress period. Percent-denominated and dollar-denominated mortgage credit enhancement coverages are calculated and applied separately and sequentially in the stress test to generate net credit losses for each loan group. The dollar coverage of percent-denominated credit enhancements for any loan group varies based upon the mortgage losses during the stress period for that group. Therefore, the effects of percent-denominated credit enhancements are determined in connection with the calculation of loss severity rates. By contrast, amounts of dollar-denominated credit enhancements (total dollar coverage amounts) are calculated as of the start of the stress period and factored directly into the calculation of cash flows.

3.7.3.5.1 Calculating Percent-Denominated Credit Enhancements

The percent coverage rates for Type 1 and Type 2 credit enhancements are input into section 3.5.3, Single Family Loss Severity and section 3.5.5, Multifamily Loss Severity, of this Appendix to determine loss severity. The Loss Severity component uses this information, together with counterparty haircuts from section 3.6, Other Credit Factors, of this Appendix, to derive loss severity rates. Thus, the effects of percent-denominated credit enhancements are incorporated into the calculations of loss severity rates. These loss severity rates are then input to section 3.9, Cash Flows, of this Appendix to generate the dollar amounts of credit losses.

3.7.3.5.2 Calculating Dollar-Denominated Credit Enhancements

Reductions in credit losses resulting from dollar-denominated credit enhancements depend on the amount of dollar losses for a loan group and the remaining available dollar-denominated coverage in each month of the stress test. Reductions are applied in section 3.9.1, Whole Loans, of this Appendix. The algorithm implementing these reductions is described below.

1. In each month, use the time-and category-specific haircuts ($H_{R,t}$) from section 3.6, Other Credit Factors, of this Appendix to calculate a weighted average haircut for the loan group (H_t). The weights used are the percentages of UPB that fall into each of the four counterparty rating categories for each loan group. The formula is as following:

$$H_t = \sum_R \delta_R H_{R,t}$$

where:

H_t = weighted average haircut for the loan group in month t of the stress period

δ_R = percent of UPB under rating category R coverage in the loan group

$H_{R,t}$ = haircut for counterparty with credit rating category R in month t of the stress period

2. In each month of the stress test, calculate the loan group dollar losses that are eligible for dollar-denominated coverage:

$$TDL_t = \theta_t \cdot UPB_t \cdot Def_t \cdot NPV3_t$$

where:

TDL_t = total dollar losses eligible for dollar-denominated coverage in a loan group

θ_t = percentage of loan group UPB covered by dollar-denominated credit enhancement in month t of the stress test

t = month *t* of the stress test period (*t=1,...,120*)

UPB_t = unpaid principal balance of the loan group

Def_t = default rate for the loan group

$NPV3_t$ = loss severity rate for the loan group (as defined in section 3.5.3, Single Family Loss Severity, of the Appendix)

3. For each loan group, compare the total dollar losses eligible for dollar-denominated coverage (TDL_t) with the remaining dollar coverage for the loan group in month *t* of the stress period ($C3_t$). If $TDL_t \geq C3_t$, then reduce loan group credit losses by $C3_t \bullet (1 - H_t)$. If $TDL_t < C3_t$, then reduce loan group credit losses by $TDL_t(1 - H_t)$.

4. Update the remaining dollar-denominated coverage for the loan group in the following month ($C3_{t+1}$) as the maximum between zero and the value of the remaining dollar-denominated coverage for the loan group in the current month minus the total dollar losses eligible for dollar-denominated coverage for the loan group in that month. The formula is as follows:

$$C3_{t+1} = max[0, C3_t - TDL_t]$$

where:

$C3_{t+1}$ = remaining dollar coverage of all dollar-denominated credit enhancements (Type 3) in the loan group in month *t+1* of the stress test

$C3_t$ = remaining dollar coverage of all dollar-denominated credit enhancements (Type 3) in the loan group in month *t* of the stress test

TDL_t = total dollar losses eligible for dollar-denominated coverage in a loan group in month *t* of the stress test

5. After generating the remaining balance of the dollar-denominated coverage in month *t+1* of the stress test ($C3_{t+1}$), then go to steps 2–4 again, to derive the reduction to credit losses for month *t+1* of the stress test. This process continues for each month of the stress test until all the dollar-denominated coverage for the loan group is used up or until the stress test reaches its 120th month.

3.7.4 Output

For each loan group for each month of the stress period, the Mortgage Credit Enhancements component of the stress test generates loss coverage rates for percentage-denominated credit enhancements, and dollar loss reductions for dollar-denominated credit enhancements. The percentage coverage rates are used in section 3.5.3, Single Family Loss Severity and section 3.5.5, Multifamily Loss Severity, of this Appendix to calculate loss severity rates. Dollar loss reductions are used in section 3.9.1, Whole Loans, of this Appendix to adjust default losses.

3.8 Other Off-Balance Sheet Guarantees

3.8.1 Overview

In addition to guaranteeing mortgage-backed securities they issue as part of their main business, the Enterprises guarantee other instruments, referred to as ''other off-balance-sheet (OBS) guarantees.'' The stress test does not explicitly project the performance of these other OBS guarantees. Instead, it addresses the capital requirement for other OBS guarantees by adding the product of the total other OBS guarantees principal balance and 45 basis points to the total amount of capital required to maintain positive total capital throughout the ten-year stress period.

3.8.2 Input

[a] The OBS Guarantees component requires the Enterprise's outstanding balances for the following OBS guarantees at the beginning of the stress period:

- Tax-exempt multifamily housing bonds
- Single-family whole-loan REMICs
- Multifamily whole-loan REMICs
- Any other instruments or obligations that fit the definition of ''Other Off-Balance Sheet Obligations'' in 12 CFR 1750.2

[b] Any instruments or obligations, 100 percent of whose collateral is guaranteed by the Federal Housing Authority (FHA), are excluded from the total dollar amount of other OBS guarantees.

3.8.3 Procedures

The OBS Guarantees component first calculates the total outstanding balance of all other OBS guarantees at the beginning of the stress period by summing the outstanding balances for tax-exempt multifamily housing bonds, single-family whole-loan REMICs, multifamily whole-loan REMICs, and any other instruments or obligations that fit the definition of other OBS guarantees. The dollar amount of capital required for other OBS guarantees is then computed as the total outstanding balance of all other OBS guarantees at the beginning of the stress period times 45 basis points.

3.8.4 Output

The OBS Guarantees component produces one number: the dollar amount of capital required for other OBS guarantees. This number is input to the Calculation of the Risk-Based Capital Requirement component to compute the risk-based capital required for the Enterprises.

3.9 Cash Flows

3.9.1 Whole Loans

3.9.1.1 Overview

[a] Both Enterprises hold single family and multifamily mortgage loans in their retained portfolios and guarantee passthrough mortgage-backed securities (MBS) owned by investors and backed by pools of such mortgage loans. Loans held in portfolio are referred to as ''retained loans,'' and loans backing guaranteed securities are referred to as ''sold loans.'' Together, retained loans and sold loans are referred to as ''whole loans.''

[b] The Enterprises receive all principal and interest payments on their retained loans, except for a servicing fee—a portion of

the interest payment retained by the servicer as compensation. On sold loans, the Enterprises receive guarantee fees and earn float income. Float income is earned when the Enterprises invest principal and interest payments for sold loans for the period of time between the receipt of the payments and the remittance of the payments, net of guarantee fees, to security holders. The length of time an Enterprise can invest these payments depends on the security payment cycle (the remittance cycle).

[c] The calculation of whole loan cash flows requires loan group information as the basic input data, as well as information on interest rates, mortgage performance and the credit quality of third party credit enhancements. Cash flows are produced for each month of the stress period for each loan group. (The stress test includes the dollar amount of credit losses in cash flows, even though such losses are not literally cash flows.)

3.9.1.2 Inputs

3.9.1.2.1 Loan Group Data

The following data as of the start of the stress test are used for whole loan cash flow computations:

- Product type
- Starting unpaid principal balance
- Starting coupon
- Servicing fee
- Mortgage age
- Remaining term
- Guarantee fee (for sold loans)
- Remittance cycle (for sold loans)
- Passthrough rate (for sold loans)
- Original coupon (for ARMs)
- Margin (for ARMs)
- Amortization term (for balloons)

3.9.1.2.2 Interest Rates

Whole loan cash flow calculations require the following interest rates for each of the 120 months of the stress period:

- One-, three-, and five-year Constant Maturity Treasury yields (CMT)
- 11th District Federal Home Loan Bank Cost of Funds Index (COFI)
- Overnight Federal Funds rate (for calculation of float earnings)

3.9.1.2.3 Mortgage Performance Data

Whole loan cash flow calculations also require the default, prepayment, and loss severity rates, which are computed as described in section 3.5, Mortgage Performance, of this Appendix, for each loan group for each month of the stress period.

3.9.1.3 Procedures

This section describes calculations of prepaid principal, scheduled principal, UPB, interest, and float income for fully amortizing, monthly pay, fixed-rate loan groups. It then describes the adaptation of these calculations for biweekly, adjustable-rate, and balloon loans. Lastly, this section describes calculations of the dollar amount of credit losses.

3.9.1.3.1 Fully Amortizing, Monthly Pay Fixed-Rate Loans

[a] The calculations discussed for fully amortizing, monthly pay, fixed-rate loans apply not only to loan groups made up of 30-year and 15-year loans, but also to loan groups comprised of second lien, step, tiered payment mortgage (TPM), and graduated payment mortgage (GPM) loans.

[b] Scheduled principal and interest payments for fully amortizing monthly pay, fixed-rate loans are computed using standard equations based on three variables: UPB, starting coupon, and remaining term.

[c] The stress test computes the amounts of prepaid principal and defaulted principal in each month by multiplying the loan group's UPB at the end of the previous month by the prepayment and default rates for that loan group for that month. The stress test computes amounts of scheduled principal (the principal that is not defaulted principal nor prepaid principal) in each month by multiplying the scheduled monthly principal (principal computed according to an amortization schedule) by one minus the sum of the monthly prepayment and default rates.

[d] The stress test computes the current loan group UPB for the end of a month by subtracting the amount of scheduled principal, prepaid principal, and defaulted principal in the month from the UPB at the end of the previous month.

[e] To compute monthly interest remitted to an Enterprise for retained loan groups, the stress test multiplies the loan group net yield (current coupon less servicing fee) by the UPB at the end of the previous month less the current month's defaulted principal. To compute monthly guarantee fees for sold loan groups, the stress test multiplies the monthly guarantee fee by the UPB at the end of the previous month less the current month's defaulted principal.

[f] To compute float income earned by an Enterprise on monthly principal and interest payments received from servicers and later remitted to security holders, the stress test multiplies scheduled principal and interest and prepaid principal by the Federal Funds rate for a number of days appropriate to the remittance cycle of the associated MBS. The stress test calculates float for three remittance cycles. Depending on the remittance cycle, prepaid principal may or may not be held for the same number of days as scheduled principal and interest.

1. If an Enterprise holds scheduled principal and interest and prepaid principal for seven days before remittance to the security holder, float is calculated by multiplying the sum of scheduled principal and interest and prepaid principal, by the Federal Funds rate times seven divided by 365. (The Federal Funds rate is an annual rate. Multiplying the rate by this fraction produces the float income for the seven days that the Enterprise has the mortgagor's payment). The Enterprise earns float income on the full scheduled interest payment, because even if a mortgagor prepays a mortgage before the end of a month, remitting less than a full month's interest on the prepaid principal, the servicer must forward the interest for the rest of the month to the Enterprise. The Enterprise remits a full month's interest to the security investor.

2. If an Enterprise remits scheduled principal and interest to the investor three days prior to receiving it from the servicer, but holds prepaid principal 38 days before remittance to the security holder, servicers are not required to forward to the Enterprise any prepayment-related shortfall in monthly interest, so the Enterprise must make up the short fall in interest to the security holder caused by a mortgagor's prepayment. If the prepayment is made in the first part of a month, the Enterprise owes the security holder interest at the security passthrough rate for the balance of the month. If the prepayment is made in the second half of the month, the Enterprise owes the security holder interest at the security passthrough rate for the balance of the current month and all of the following month. This is an average of 30 days of interest at the security passthrough rate on mortgagor prepayments. The float amount for this remittance cycle consists of:

- scheduled monthly principal and interest due the Enterprise multiplied by the Federal Funds rate times minus 3, divided by 365, plus
- prepaid principal multiplied by the Federal Funds rate times 38, divided by 365, minus
- prepaid principal multiplied by the passthrough rate (current coupon less the servicing fee less the guarantee fee) times 30, divided by 360

3. If an Enterprise holds scheduled principal and interest for 57 days prior to remittance to the security holder and holds prepaid principal for 68 days prior to remittance to the security holder, the Enterprise owes the security holder an average of 30 days of interest at the security passthrough rate on mortgagor prepayments. The float amount for this remittance cycle consists of:

- scheduled monthly principal and interest due the Enterprise multiplied by the Federal Funds rate times 57, divided by 365, plus
- prepaid principal multiplied by the Federal Funds rate times 68, divided by 365, minus
- prepaid principal multiplied by the passthrough rate (current coupon less the servicing fee less the guarantee fee) times 30, divided by 360

3.9.1.3.2 Biweekly Loans

While most mortgages require monthly payments, biweekly mortgages require payments every two weeks. The cash flow calculations described above for monthly pay, fully amortizing fixed-rate loans apply, except that the relevant time interval is two weeks rather than one month. In addition, biweekly, rather than monthly default and prepayment rates are applied. The stress test then allocates the biweekly cash flows to the proper month. The first biweekly cash flow occurs 14 days into the stress period. Subsequent biweekly cash flows occur at 14 day intervals. All the cash flows occurring during the same calendar month are added together to arrive at the monthly cash flow.

3.9.1.3.3 Adjustable-Rate Loans

3.9.1.3.3.1 Single Family RMS

(a) The current interest rate for an adjustable-rate mortgage (ARM) is adjusted based on an interest rate index and a margin. ARM loan groups are indexed to either the

one-or three-year CMT, or the COFI, as appropriate to their product types. The product type ''ARMs Other'' is indexed to the COFI index.

(b) The mortgage age of the loan group is used to determine the initial month of the stress test in which to adjust the current interest rate. The loan group interest rate is adjusted then and every 12 months thereafter, regardless of the index.

(c) The stress test calculates annual and lifetime maximum interest rates (ceilings) and minimum interest rates (floors). Annual maximum and minimum new interest rates for the adjustment period are calculated by adding or subtracting, respectively, two percent to, or two percent from, the current interest rate (current coupon). Lifetime maximum and minimum interest rates are calculated by adding or subtracting, respectively, five percent to, or five percent from, the original interest rate (original coupon). The minimum lifetime interest rate is at least three percent. The maximum lifetime interest rate is no more than 14 percent.

(d) The stress test adds the margin to the appropriate ARM interest rate index value to get a prospective interest rate. If the prospective interest rate is greater than the maximum new interest rate, the stress test sets the interest rate to the maximum new interest rate. If the prospective interest rate is less than the minimum new interest rate, the stress test sets the interest rate to the minimum new interest rate. After these steps, the prospective interest rate (adjusted as appropriate) becomes the current interest rate. The computation continues as described above for fully amortizing monthly pay fixed-rate loans groups.

3.9.1.3.3.2 Multifamily ARMs

(a) The interest rate for a multifamily ARM is indexed to the Federal Home Loan 11th District Costs of Funds (COFI). The computations are as described for single family ARMs except that: one, the rate is reset every month subject to 2 percent cap, 2 percent floor, and 3 percent life rate minimum; and two, the borrower payment is reset every 12 months, subject to a payment cap limiting the payment change to no more than 7.5 percent of the previous period payment.

(b) Resetting the multifamily ARM rate at a frequency different from the frequency by which the payment is reset and restricting increases in the borrower payment may result in a payment that is less than the amount necessary to fully amortize the UPB at the current ARM rate. In such situations, the shortfall is added to the outstanding balance. The maximum amount by which the UPB is allowed to increase (negatively amortize) is limited to 125 percent of the original UPB.

3.9.1.3.4 Balloon Loans

Calculations of cash flows for balloon loans are the same as for fully amortizing monthly pay, fixed-rate loans, except the balloon loan matures before the principal is fully amortized. Upon maturity, all unpaid principal is due. Loans are amortized based on their amortization terms. The stress test computes the number of months remaining until the balloon payment by subtracting the loan group mortgage age from the loan group balloon period and adding one. The loan group balloon period is identified according to the value of the variable, Product Type. If the Product Type is Balloons-Other, the balloon period is ten years.

3.9.1.3.5 Credit Losses

To compute the dollar amount of credit losses, the stress test multiplies the monthly defaulting principal for a loan group by the loss severity rate for that month and loan group. That loss severity rate takes into account percentage-based credit enhancements, as described in section 3.5.3, Single Family Loss Severity and section 3.5.5, Multifamily Loss Severity, of this Appendix. The resulting loss amount is further reduced by amounts of available dollar-based credit enhancements, as described in section 3.7, Mortgage Credit Enhancements, of this Appendix.

3.9.1.4 Output

Whole loan cash flows are inputs to the preparation of pro forma balance sheets and income statements for each month of the stress period. *See* section 3.10, Operations, Taxes, and Accounting, of this Appendix. For loan groups made up of retained loans, cash flows consist of 120 months of scheduled principal, prepaid principal, defaulted principal, credit losses, and interest.

3.9.2 Mortgage-Related Securities

3.9.2.1 Overview

(a) Both Enterprises invest in various types of mortgage-related securities: single class MBS, multi-class derivative mortgage securities (Collateralized Mortgage Obligations, REMICs, and Strips), and mortgage revenue bonds (MRBs). Single class MBS and derivative mortgage securities may be issued by the Enterprises, by Ginnie Mae, or by private issuers. MRBs are issued by State and local governments or their instrumentalities. Certain asset-backed securities with housing-related collateral (manufactured housing loans) that are similar in their cash flow characteristics to mortgage derivatives are treated in the stress test as mortgage derivative securities.

(b) The Enterprises receive principal and interest payments on these securities. Payments on single class MBS represent the passthrough from underlying pools of mortgages of all principal and interest payments, minus servicing and guarantee fees, on the underlying pools of mortgages. Payments on derivative mortgage securities represent some of the cash flows produced by an underlying pool of mortgages and/or mortgage-related securities, determined according to rules set forth in public offering documents for the securities. Unlike MBS and derivative mortgage-related securities, mortgage revenue bonds have specific maturity schedules and call provisions; however, the collateral backing MRBs consists largely of mortgages or mortgage securities, and the pattern of principal payments is closely related to that of their underlying mortgage collateral. The stress test treats them in a manner similar to the treatment of single class MBS. A very small number of mortgage-related securities for which data are insufficient for the generation of precise cash flows (referred to as ''miscellaneous MRS'') are also treated in this manner. The category miscellaneous MRS includes a very small number of Enterprise and private label REMIC securities that are not modeled by a commercial information service.

(c) In addition to reflecting the defaults of mortgage borrowers during the stress period, the stress test considers the effects of credit stress on securities that are rated by nationally recognized rating services, that is, mortgage revenue bonds and private-issue mortgage-related securities. Enterprise and Ginnie Mae securities are not rated, and the stress test reflects no credit losses on these securities. In the stress test, all rated securities experience increasing credit impairments throughout the stress period, which are reflected by reductions of contractual interest payments and losses of principal.

(d) The calculation of cash flows for mortgage-related securities requires information from the Enterprises identifying their holdings, publicly available information characterizing the securities, interest rate information, mortgage performance information, and credit rating information for rated securities.

(e) Cash flows-monthly amounts of principal payments, defaulted principal, and/or interest-are produced for each month of the stress period for each security (principal- and interest-only securities pay principal or interest). These cash flows are input to the Operations, Taxes, and Accounting component of the stress test.

3.9.2.2 Inputs

3.9.2.2.1 Securities

3.9.2.2.1.1 Single Class MBS Issued by the Enterprises and Ginnie Mae

For the single class MBS issued by the Enterprises and Ginnie Mae and held by an Enterprise at the start of the stress test, the stress test requires information identifying the Enterprise's holdings and information describing the MBS and the underlying mortgage collateral.

1. The following information is provided by the Enterprises:

- Pool number (identifying the security)
- Original principal balance (the original pool balance multiplied by the Enterprise's percentage ownership)
- Starting principal balance (the pool balance at the start of the stress period multiplied by the Enterprise's percentage ownership)

2. Every month, the Enterprises make public through securities data services updated information about the MBS they issue. The stress test uses pool numbers for MBS held by an Enterprise to access the following information from these monthly data releases:

- Pool prefix (designates the product type of the MBS, for example, 30-year single family fixed-rate)
- Issue date
- Maturity date
- Security coupon
- Original pool balance
- Starting pool balance

- Weighted average maturity of the underlying loans at the time the security was issued
- Weighted average remaining maturity of the underlying loans at the start of the stress test
- Weighted average original coupon of the underlying loans at the time the MBS was issued
- Weighted average current coupon of the underlying loans at the start of the stress test
- Interest rate index (ARM MBS only)
- Weighted average interest rate margin for the underlying loans (ARM MBS only)
- Weighted average passthrough rate (the security coupon for some types of ARM MBS)

3.9.2.2.1.2 Derivative Mortgage Securities Issued by the Enterprises and Ginnie Mae

[a] For the derivative mortgage securities issued by the Enterprises and Ginnie Mae that are held by an Enterprise at the start of the stress test, the stress test requires information identifying the Enterprise's holdings and information describing the underlying mortgage collateral. The Enterprises provide the following information:

- CUSIP number (unique security identifier assigned by the Committee on Uniform Security Identification Procedures)
- Original principal balance of the security (notional amount for interest-only securities) at the time of issuance, multiplied by the Enterprise's percentage ownership
- Starting principal balance, or notional amount, at the start of the stress period multiplied by the Enterprise's percentage ownership

[b] The stress test requires information about the multi-class transactions of which these securities are a part, including information describing all component securities, the underlying collateral, and the rules directing cash flows to the component classes. This information is obtained from public sources, including public offering documents and public securities data services.

[c] Obtaining sufficient information to calculate the cash flows of the underlying collateral may require multiple steps. For example, for a derivative mortgage security backed by single class MBS. Step 1, obtain, from public information, the pool numbers and principal balances for the specific underlying MBS. Step 2, consult public sources to obtain additional information as enumerated in section 3.9.2.2.1.1, for each of these MBS.

3.9.2.2.1.3 Mortgage Revenue Bonds and Miscellaneous MRS

[a] The stress test requires two types of information for mortgage revenue bonds and miscellaneous MRS held by an Enterprise at the start of the stress test: one, information identifying the Enterprise's holdings and two, additional information about the securities. The following are obtained from the Enterprises to identify their holdings:

- CUSIP number
- Original principal balance
- Starting principal balance

[b] The following additional information required for the stress test is available from public sources, including public offering documents and public securities data services:

- Issue date
- Maturity date
- Security interest rate
- Credit rating (for rated securities)

3.9.2.2.2 Interest Rates

Interest rates projected through the stress period are necessary to calculate principal amortization and interest payments for ARM MBS and for derivative mortgage securities with indexed coupon rates. The stress test generates interest rates for each month of the stress period, as described in section 3.3, Interest Rates, of this Appendix.

3.9.2.2.3 Mortgage Performance

The rate and pattern of principal payments of mortgage-related securities depend on the prepayments and, to a much smaller extent, the defaults of the underlying mortgage loans. Cash flow calculations require default and prepayment rates that are appropriate to the underlying mortgage collateral for each mortgage-related security. Rates are generated as described in section 3.5.2, Single Family Default and Prepayment, and section 3.5.4, Multifamily Default and Prepayment, of this Appendix.

3.9.2.2.4 Third-Party Credit Exposure

In calculating the principal and interest payments of mortgage-related securities, the stress test treats defaults the same as prepayments. Thus, investors receive amounts of security principal equal to defaulted, prepaid, and scheduled principal on the underlying loans in the pool. For rated securities (e.g., mortgage revenue bonds and private-issue MRS), the risk of security default is reflected by reducing the calculated principal and interest payments for these instruments. These reductions, or haircuts, are described in section 3.6, Other Credit Factors, of this Appendix.

3.9.2.3 Procedures

The sections below describe the calculations for single class MBS issued by the Enterprises and Ginnie Mae, the calculations for derivative mortgage securities, and calculations for MRBs and miscellaneous MRS.

3.9.2.3.1 Single Class MBS Issued by the Enterprises and Ginnie Mae

[a] The calculation of cash flows for single class MBS issued by the Enterprises and Ginnie Mae follows the procedures outlined earlier in section 3.9.1, Whole Loans, of this Appendix. The collateral underlying each MBS is treated as one single family loan group. (For purposes of identifying appropriate default and prepayment rates for the small number of multifamily MBS held by the Enterprises, the stress test treats the underlying loans as 30-year fixed-rate single family mortgages.) Amounts of defaulted mortgage principal (reflecting the security guarantee) are advanced to security holders, and scheduled and prepaid mortgage principal are passed through to security holders. Interest is calculated at the security coupon rate (the weighted average passthrough rate for ARM MBS issued by the Enterprises). Security cash flows are calculated for the month in which mortgagor payments are made.

[b] For each MBS, the stress test applies default and prepayment rates and computes the amortization of principal, based on the characteristics of the underlying loans. The stress test applies amortization and default and prepayment rates for sold loan groups (of the Enterprise that issued the MBS) that have characteristics consistent with the characteristics of the MBS collateral, with the following caveat. The stress test specifies that loans underlying an MBS reflect the national distribution of original LTV and Census divisions for all otherwise similar sold loans. Therefore, default and prepayment rates represent the weighted averages for loans groups in all LTV categories and Census divisions that are otherwise similar to the MBS collateral.

[c] For Ginnie Mae MBS, the mortgage coupon for the underlying loan group equals the Ginnie Mae passthrough rate plus 0.5 percent. For fixed-rate Ginnie Mae MBS, the underlying loans are assumed to have the same distributions of LTVs and Census divisions as the Enterprise's sold portfolio FHA and VA loans with the same coupon and origination year. For loans underlying Ginnie Mae ARM MBS, the stress test uses default and prepayment rates for otherwise similar conventional ARM loans in the sold portfolio.

[d] For ARM MBS, interest rate and monthly payment adjustments for the underlying loans are calculated in the same manner as they are for ARM loan groups, except that for Ginnie Mae ARM MBS, there is a one percent annual rate cap.

[e] For balloon and biweekly MBS, cash flows for the underlying loans are calculated in the same manner as they are for balloon loan groups; product type information, such as the length of the balloon period, is determined by the MBS pool prefix and the MBS maturity date.

[f] For purposes of calculating cash flows, the stress test treats GPMs, TPMs, GEMs, and Step mortgages that back MBS as 30-year fixed-rate mortgages.

3.9.2.3.2 REMICs and Strips

[a] Cash flows for derivative mortgage securities are generated according to standard securities industry procedures, in five steps.

1. Determine the percentage Enterprise ownership of a particular security by dividing the portion of the original principal balance or notional amount held by the Enterprise by the total original principal balance or notional amount of the derivative mortgage security.

2. Identify the characteristics of the underlying collateral of the derivative mortgage security.

3. Calculate the cash flows for the underlying collateral in the manner described for whole loans and MBS above, based on stress test interest, default, and prepayment rates.

4. Calculate all cash flows for the derivative mortgage security classes by applying the rules stated in public offering materials.

5. Determine the cash flows attributable to the specific securities held by an Enterprise, applying the Enterprise's ownership percentage.

[b] The stress test uses a commercial information service for steps 2 through 5. The stress test models mortgages using a limited set of loan product types and ARM indexes. The information service accurately models a larger set of mortgage product types and all ARM indexes supplied by the interest rate component of the stress test (*see* section 3.3, Interest Rates, of this Appendix).

3.9.2.3.3 Mortgage Revenue Bonds and Miscellaneous MRS

[a] Cash flows for mortgage revenue bonds and miscellaneous MRS are computed in the same manner as for single class MBS, using the approach described above. The stress test uses default and prepayment rates for single family, fixed-rate FHA and VA loans with coupons that are 75 basis points higher than the security coupon, and with the LTV and Census division distributions that are similar in all other respects to sold FHA or VA loans of the Enterprise that holds the security. The stress test uses a 30-year original maturity of the underlying loans, and loan age is computed based on the date when the security was issued. Monthly interest is calculated at the bond coupon for the amortizing balance.

[b] Principal and interest payments are then reduced by applying the haircuts specified in section 3.6, Other Credit Factors, of this Appendix.

3.9.2.4 Outputs

Amounts of principal, interest, and, in the case of rated securities, defaulted principal, are produced for each security. These outputs are used as inputs to the Operations, Taxes, and Accounting component, which prepares pro forma financial statements. *See* section 3.10, Operations, Taxes, and Accounting, of this Appendix.

3.9.3 Debt and Related Cash Flows

3.9.3.1 Overview

[a] The Debt and Related Cash Flows component of the stress test produces cash flows for debt, guaranteed investment contracts (GICs), preferred stock, debt-linked derivative contracts, and mortgage-linked derivative contracts.[16] Although mortgage-linked derivative contracts are usually linked to assets rather than liabilities, they are treated similarly to debt-linked derivative contracts and, therefore, are covered in this section of the Appendix. The Enterprises issue debt to fund their asset portfolios. Preferred stock issued by the Enterprises performs two functions: it funds asset portfolios and serves as capital. The Enterprises enter into derivative contracts for three reasons: to reduce the interest rate risk of specific securities (micro hedge); to hedge the overall interest rate risk of their business (macro hedge); or to create a synthetic liability (combination of a security and a derivative contract) with a lower net cost than the equivalent actual security.

[b] The Debt and Related Cash Flows component produces instrument level cash flows for the ten years of the stress test. Debt and preferred stock cash flows include interest (or dividends for preferred stock) and principal payments (or redemptions for preferred stock), while debt-linked and mortgage-linked derivative contract cash flows are composed of interest payments and receipts. (Throughout the remainder of section 3.9.3, references to ''interest payments'' include interest received, as well as interest paid, on debt-linked and mortgage-linked derivative contracts. ''Principal payments'' refers to payments of principal on debt and redemptions of preferred stock.) Debt and preferred stock are categorized in one of the three classes listed and described in Table 3–22.

Table 3-22. Debt and Preferred Stock

Debt And Preferred Stock Classes	Description
Fixed-Rate Debt or Preferred Stock	Fixed-rate securities that pay periodic interest or dividends
Floating-Rate Debt or Preferred Stock	Floating-rate securities that pay periodic interest or dividends
Discount Instruments (Debt Only)	Securities that are issued below face value and pay a contractually fixed amount at maturity

[c] Debt-linked derivative contracts consist of interest rate caps, floors, and swaps. The primary difference between debt and debt-linked derivative contracts, in terms of calculating cash flows, is that interest payments on debt are based on principal amounts that are eventually repaid to creditors, whereas on debt-linked derivative contracts interest payments are based on notional amounts that never change hands. Table 3–23 describes the six classes of debt-linked derivative contracts.

[16] The notional balance of a mortgage-linked derivative contract declines based on the declining balance of a reference mortgage pool.

Table 3-23. Debt-Linked Derivative Contracts

Debt-linked Derivative Contract Classes	Description
Fixed-Pay Swaps	A derivative contract in which an Enterprise pays a fixed interest rate and receives a floating interest rate
Floating-Pay Swaps	A derivative contract in which an Enterprise pays a floating interest rate and receives a fixed interest rate
Long Cap	A derivative contract in which an Enterprise receives a floating interest rate when the interest rate to which it is indexed exceeds a specified level (strike price)
Short Cap	A derivative contract in which an Enterprise pays a floating interest rate when the interest rate to which it is indexed exceeds the strike price
Long Floor	A derivative contract in which an Enterprise receives a floating interest rate when the interest rate to which it is indexed falls below the strike price
Short Floor	A derivative contract in which an Enterprise pays a floating interest rate when the interest rate to which it is indexed falls below the strike price

[d] Mortgage-linked swaps are similar to debt-linked swaps except that, for the former, the notional balance amortizes based on the performance of certain MBS pools. The two classes of mortgage-linked derivative contracts are listed and described in Table 3–24.

Table 3-24. Mortgage-Linked Derivative Contracts

Mortgage-Linked Derivative Contract Classes	Description
Fixed-Pay Amortizing Swaps	A derivative contract in which an Enterprise pays a fixed interest rate and receives a floating interest rate, both of which are based on a declining notional balance
Floating-Pay Amortizing Swaps	A derivative contract in which an Enterprise pays a floating interest rate and receives a fixed interest rate, both of which are based on a declining notional balance

3.9.3.2 Inputs

[a] The Debt and Related Cash Flows component of the stress test requires numerous inputs. Many of the instrument classes require simulated interest rates because their interest payments adjust periodically based on rates tied to various indices. These rates are generated as described in section 3.3, Interest Rates, of this Appendix. Instrument level inputs provided by the Enterprises are listed in the Table 3–25.

Table 3-25. Input Variables for Debt and Related Cash Flows

Data Elements	Description
Issue Date	First settlement date for this security
Face/Notional Amount	The face amount of a security or notional amount of a derivative contract
Principal/Notional Factor	Factor representing the percentage of original principal or notional amount that remains outstanding relative to the original principal or notional amount
Coupon/Dividend Factor	An adjustment made to the coupon or dividend based on the day count convention (e.g., actual/360)
Coupon	Current interest rate
Dividend Rate	Annual dividend rate on preferred stock
Index	Interest rate index to which interest payments are tied
Spread	The percentage (expressed as a decimal) that is added or subtracted from the index to calculate the coupon rate for floating rate instruments
Index Multiplier	A constant multiplier used in a variable rate formula
Payment Frequency	Frequency with which payments are made
Unpaid Balance	Unpaid principal balance
Contractual Maturity Date	The date on which an instrument matures
Remaining Term	The number of months until an instrument matures
Floor Rate	The minimum coupon for a variable rate security
Cap Rate	The maximum coupon rate for a variable rate security
Pay/Receipt Code	A code that identifies whether the cash flow is a payment or a receipt
Call/Put Strike Price	The price at which the call or put option may be exercised
Call (Cancellation)/Put Date	The date on which the instrument may be canceled (put or called)
Original Discount	Discount from par represented by purchase price of security (e.g., price of 99.0 equates to discount of 1.0)
Swap Reference	Links mortgage-linked derivative contract to a reference security (e.g., when changing principal balance of a specific security is also notional amount of swap)
Instrument I.D.	Links pay and receive sides of swaps
Amortization Schedule	Schedule of decreasing principal/notional balances for instruments that amortize
Cap/Floor Strike Price	Used for cap and floor instruments to indicate the interest rate at which this instrument begins paying or receiving interest

Table 3-25. Input Variables for Debt and Related Cash Flows (Continued)

Data Elements	Description
Counterparty Identification	Identifies the counterparty to a derivative contract
Public Rating of Counterparty	Credit rating of counterparty by a recognized rating agency

[b] In addition to the above inputs, the mortgage-linked derivative contract cash flows require inputs for the performance of linked mortgage assets, including default and prepayment rates from the single family default and prepayment component of the stress test (*See* section 3.5.2, Single Family Default and Prepayment, of this Appendix) and periodic and lifetime minimum and maximum coupons for ARM MBS. Mortgage-linked derivative contract identification numbers are used to link the derivative contract to pool information on specific MBS. This link allows retrieval of pool information that will be used to determine how the notional balance of the swap amortizes, including the coupon rate, issue date, maturity date, weighted average coupon (WAC), and weighted average maturity (WAM) for each pool.

3.9.3.3 Procedures

[a] The debt and related cash flow component calculates separate cash flow streams for principal and interest payments. The stress test performs the following steps: determines the timing of cash flows; calculates a principal or notional factor; obtains the coupon or dividend factor; projects principal cash flows or changes in the notional amount; and projects interest cash flows.

[b] Projected cash flows for callable or cancelable instruments may be altered by implementing a call decision rule for debt or a cancellation decision rule for swaps. In addition, special cases exist where instruments have complex characteristics, thereby requiring additional processing to compute cash flows. Each of these steps is described below.

1. The first step requires determining the timing of cash flows or the payment dates. The three inputs that are required to accomplish this task are maturity date, payment frequency, and the previous payment date. Payment frequency, defined as the number of payments per year, takes on one of five values depending on how often coupon payments are made. These values are given in Table 3–26.

Table 3-26. Payments Per Year

Type Of Payment	Payment Frequency
Non-Coupon Bearing[1]	0
Annual	1
Semi-Annual	2
Quarterly	4
Monthly and More Frequent	12

[1] Non-coupon bearing instruments do not produce any cash flows until maturity; therefore, payment frequency takes the value of zero for these instruments.

2. Payment dates are based on the last payment date and the payment frequency until the instrument matures. For example, if the stress test is run on an Enterprise's data as of June 30, 1998, then an instrument with a previous payment date of April 15, 1998, that matures on October 15, 1999, and has quarterly payments will require payments on July 15, 1998, October 15, 1998, January 15, 1999, and so forth until maturity or, in the case of preferred stock, throughout the stress test. In the stress test, payments are allocated to specific months, not specific days within the month.

3. The second step requires the calculation of a principal factor. The principal factor is defined as a percentage of original value of the instrument. In most instances, where there is no amortization of principal, the principal factor is one for each payment date until the stated maturity date, when it converts to zero. For debt and debt-linked derivative contracts that amortize, either a principal or a notional amortization schedule is provided by the Enterprises, or the amortization schedule is obtained from the offering materials for public securities. In the case of mortgage-linked derivative contracts, notional balances are amortized in the manner described in section 3.9.2, Mortgage-Related Securities, of this Appendix for principal balances of mortgage-backed securities held by an Enterprise. A GIC is a liability that may amortize; however, an amortization schedule may not be available. When amortization information is unavailable, the issue amount of the GIC is assumed to be paid on the maturity date of the instrument. The remaining term is used to determine maturity dates for GICs.

4. The third step requires the calculation of a coupon or dividend factor. The coupon or dividend factor is an adjustment factor used to calculate the portion of the annual coupon or dividend rate applicable to a given period. It depends on day count conventions used to calculate the accrued interest for the instrument and is determined using one of the three calculations in Table 3–27.

Table 3-27. Day Count Conventions

Convention	Coupon Factor Calculation
30/360	Number of days between two payment dates assuming 30 days per month/360
Actual/360	Number of days between two payment dates/360
Actual/365	Number of days between two payment dates/365

5. The fourth step in the process involves calculating principal cash flow. Principal payments can be classified as either principal payments on zero coupon bonds or principal payments on all other instruments. All principal payments are paid at maturity for zero coupon bonds, and the principal amount is equal to the face amount of the bond. For all non-zero coupon bond instruments, principal outstanding for the current period is determined by multiplying the issue amount by the principal factor for the current period. The principal payment equals the amount of principal outstanding at the end of the current period less the principal outstanding at the end of the previous period, or zero if the instrument has a notional balance.

6. The fifth step involves calculating interest and dividend cashflows. Instruments can be classified into six generic categories based on their interest payment characteristics. These are fixed-rate instruments, zero coupon bonds, discount notes, floating-rate instruments, interest rate caps and floors, and swaps. Interest or dividend cash flows for an instrument in a period are calculated as the product of the principal/notional amount of the instrument for the given period, the coupon or dividend rate, and the coupon or dividend factor.

[c] To determine the interest or dividend payments for fixed-rate instruments, the current period principal amount is multiplied by the product of the coupon or dividend rate and current period coupon or dividend factor. Interest payments for zero coupon bonds and discount notes are equal to zero. For discount notes, if the amounts for original discounts are not provided, they are estimated as the product of unpaid balance, yield, and number of days between issue and maturity dates divided by 360.

[d] Interest payments on floating-rate instruments (except for floating-rate preferred stock, which is discussed later in this section) are calculated as principal balance multiplied by the coupon for the current period. The current period coupon is calculated by adding a spread to the appropriate interest rate index and multiplying by the coupon factor. The coupon for the current period is set to this amount as long as the rate lies between the lifetime maximum and minimum rates, as periodic maximum and minimum rates are not recognized. Otherwise the coupon is set to the maximum or minimum rate.

[e] Caps and floors are derivative instruments that pay or receive interest only if their specified index is above the strike price for caps and below it for floors. Interest payments on caps and floors are determined similarly to those for the debt instruments above; however, payments are based on notional amounts instead of principal amounts. The appropriate projected interest rate index is compared to the instrument's cap or floor rate (strike price). Interest payments are either paid or received depending on whether the Enterprise is in a long or short position in a cap or a floor. If a cap is purchased and the strike price is less than the rate on the cap's interest rate index, then the interest payment on the cap is the index less the cap rate multiplied by the notional amount of the cap. If a floor is purchased and the floor rate is higher than the index, then the interest payment on a floor is equal to the floor rate minus the index rate multiplied by the notional balance of the floor. Otherwise interest payments are zero for caps and floors.

[f] A swap is a derivative contract that requires counterparties to exchange periodic interest payments. Swaps are modeled as two separate instruments, consisting of a pay side and a receive side, with interest payments based on the same notional balance but different interest rates. For debt-linked swaps, interest payments are determined using the criteria of fixed-rate or floating-rate instruments as described above.

[g] For the pay side of mortgage-linked swaps, the component calculates the reduction in the notional balance due to scheduled monthly principal payments (taking into account both lifetime and reset period caps and floors), prepayments, and defaults of the reference MBS pool. The notional balance of the swap for the previous period is reduced by this amount to determine the notional balance for the current period. Interest payments for a given period are calculated as the product of the notional balance of the swap in that period and the coupon rate applicable for that period.

[h] For the receive side of mortgage-linked swaps, the component calculates cash flows in the same manner as debt and debt-linked derivative contracts. The only difference is that the notional balance of the swap is amortized based upon the monthly pay-downs for an underlying MBS pool, as described for the pay side above. For the receive side, interest amounts are cash inflows.

[i] In order to reduce interest costs and/or deepen the market for their securities, the Enterprises may issue debt denominated in, or indexed to, foreign currencies, and eliminate the resulting foreign currency exposure by entering into currency swap agreements. When they hedge their foreign exposure in this manner, the component creates synthetic debt denominated in U.S. dollars and pays interest accordingly.

[j] Some debt and debt-linked derivative contracts have call or cancellation features that allow an Enterprise to terminate them at certain points in time. Whether or not a call or cancellation will be exercised is evaluated for all debt and the debt-linked derivative contracts that require cash outflows. For example, only the pay side is evaluated for swaps. If the pay side is cancelled, then the receive side is cancelled at the same time. Callable instruments are treated in the following manner. First, project cash flows for the callable instrument assuming that the instrument is not callable. Second, for each payment period when the instrument can be called, equate the outstanding balance or notional amount of the security to the sum of the discounted values of the projected cash flows. The discount rate that makes these two amounts equivalent is called the yield-to-maturity.[17] Third, convert the yield-to-maturity to a bond-equivalent yield and compare the bond-equivalent yield to the projected Federal Agency Cost of Funds for debt with a comparable maturity. Because the stress test does not project Federal Agency Cost of Funds indexes for every possible maturity, a linear interpolation is performed between the next higher and lower maturities to estimate the cost of funds for those maturities that are not projected. Finally, if the Federal Agency Cost of Funds is lower than 50 basis points below the bond-equivalent yield of the callable instrument, then the instrument is called. Otherwise, the instrument is not called, and it is evaluated for call at the next payment period.

[k] Some instruments have complex or non-standard features, and cash flows cannot be computed using only the data listed earlier. Characteristics of these types of instruments include complex principal or notional amortization schedules, complex coupon reset formulas for floating-rate instruments, and European call options for callable instruments. In these instances, additional information is obtained to define a set of rules to reflect the complex features of debt and debt-linked derivative contracts, thereby permitting the accurate calculation of cash flows for these instruments.

[l] An example of an instrument with complex features is an indexed amortizing swap. This instrument is not standard because its notional amount declines in a way that is dependent upon the level of interest rates. This type of swap is structured

[17] For instruments with notional balances, the yield-to-maturity is equal to the instrument's coupon or interest rate.

with an amortization table that contains a notional balance reduction factor for a given range of interest rates. To compute cash flows for this instrument, the notional balance at each payment date must be calculated. While raw data provides the notional balance at the beginning of the stress period, the notional balance at each payment date during the stress period must be calculated.

[m] Other instruments that require special treatment are currency linked notes, the redemption value of which is tied to a specific foreign exchange rate. They require special treatment because the stress test does not forecast foreign currency rates. If these instruments are hedged, then they become part of synthetic debt created in conjunction with a swap as discussed previously. If these instruments are not hedged, the following treatment applies. In the up-rate scenario, the U.S. Dollar per unit of foreign currency ratio is increased in proportion to the increase in the ten-year CMT. For example, if the ten-year CMT shifts up by 50 percent, then the U.S. Dollar per unit of foreign currency ratio shifts up by 50 percent. In the down-rate scenario, the foreign currency per U.S. Dollar ratio is decreased in proportion to the decrease in the ten-year CMT. The redemption value of these instruments may also have minimum and maximum principal amounts, which also must be taken into consideration in determining cash flows.

[n] As the final step in the process, the interest cash flows for debt-linked and mortgage-linked derivative contracts are ''haircut'' (i.e., reduced) by some percentage to account for the risk of counterparty insolvency. The percentage haircut used is based on the public rating of the counterparty, and the year during the stress period in which the cash flow occurs (Refer to section 3.6, Other Credit Factors, of this Appendix for details on how the haircuts are applied.) The cash flows are all added together (pay side and receive side) for all contracts with a given counterparty.[18] The haircut is applied to the net cash owed by the counterparty in a given month. If the Enterprise owes the counterparty money, then no haircut is applied.

[o] Because the stress test does not forecast foreign exchange rates, the counterparty haircut percentages are applied to the pay side of currency swaps, instead of the receive side, to ''gross up'' the payment. Therefore, when synthetic debt is created, the effect is to increase the cost of the synthetic debt equal to the haircut amount.

3.9.3.4 Output

Output consists of cash flows for debt, preferred stock, and derivative contracts. Cash flows include monthly interest and principal payments for debt, dividends and redemptions for preferred stock, and interest payments for debt-linked and mortgage-linked derivative contracts.

3.9.4 Non-Mortgage Investment and Investment-Linked Derivative Contract Cash Flows

3.9.4.1 Overview

[a] The Enterprises primarily invest in non-mortgage assets as a source of liquidity. They also enter into investment-linked derivative contracts to reduce the interest rate risk of specific securities (micro hedge), hedge the overall interest rate risk of their business (macro hedge), or create a synthetic asset (combination of a security and a derivative contract) with a higher net yield than the equivalent actual security.

[b] The stress test calculates the cash flows for these assets at the instrument level. The cash flows consist of interest payments and receipts and principal payments for the ten years of the stress test. (Throughout the remainder of section 3.9.4, references to interest payments include interest received on investment-linked derivatives products.) Compared to the treatment of debt and related cash flows, the stress test takes a more simplified approach to modeling non-mortgage instruments (including linked derivative contracts) held by the Enterprises. Rather than determining the specific payment frequencies of each instrument, the stress test assumes standardized payment frequencies by types of instruments. For this purpose, the stress test distinguishes among six classes of securities and eight classes of derivative contracts. Table 3–28 lists and defines the six classes of securities.

Table 3-28. Securities

Security Classes	Description
Fixed-Rate Bonds	Fixed-rate securities that pay periodic interest, e.g. corporate and Euro Bonds
Floating-Rate Bonds	Floating-rate securities that pay periodic interest, e.g., Corporate and Euro Bonds
Floating-Rate Municipal Bonds	Floating-rate bonds issued by municipalities
Short-Term Instruments	Fixed-rate securities that pay principal and interest at maturity,[1] e.g., Repurchase Agreements, Federal Funds, Commercial Paper
Fixed-Rate Asset-Backed Securities	Fixed-rate securities collateralized by non-mortgage assets[2]
Floating-Rate Asset-Backed Securities	Floating-rate securities collateralized by non-mortgage assets[2]

[1] For purposes of the stress test, auction rate preferred stock issues are included in this class.

[2] Except for those securities backed by housing-related assets, i.e., manufactured housing loans, which are covered in section 3.9.2, Mortgage-Related Securities, of this Appendix.

[c] Table 3–29 defines the seven classes of derivative contracts and provides a description of what is included in each. (An eighth class, mortgage-related derivatives, is covered in section 3.9.3, Debt and Related Cash Flows, of this Appendix.)

[18] Cash flows are not aggregated together with a given counterparty for currency swaps. Instead, haircuts are applied to each individual currency swap.

Table 3-29. Derivatives

Derivative Contract Classes	Description
Basis Swaps	A derivative contract in which floating-rate interest payments are exchanged based on different interest rate indexes
Fixed-Pay Swaps	A derivative contract in which an Enterprise pays a fixed interest rate and receives a floating interest rate
Floating-Pay Swaps	A derivative contract in which an Enterprise pays a floating interest rate and receives a fixed interest rate
Fixed-Pay Amortizing Swaps	A derivative contract in which an Enterprise pays a fixed interest rate and receives a floating interest rate, both of which are based on a declining notional balance
Floating-Pay Amortizing Swaps	A derivative contract in which an Enterprise pays a floating interest rate and receives a fixed interest rate, both of which are based on a declining notional balance
Long Cap	A derivative contract in which an Enterprise receives a floating interest rate when the interest rate to which it is indexed exceeds a specified level or strike price
Short Cap	A derivative contract in which an Enterprise pays a floating interest rate when the interest rate to which it is indexed exceeds a specified level

[d] Stress test procedures are divided into two distinct steps: one, establishing interest payment dates; and two, calculating the instrument level cash flows based on payment criteria and instrument characteristics.

3.9.4.2 Inputs

[a] The stress test requires instrument and interest rate inputs for the calculation of interest payments and receipts and principal payments. Instrument level inputs provided by the Enterprises are:

- Issue date
- Face/notional amount
- Maturity date
- Coupon rate
- Index
- Spread
- Instrument I.D. to link pay and receive sides of swaps
- Pay/receipt code
- Payment frequency
- Cap rate
- Cap strike price
- Counterparty identification, if applicable
- Public rating(s) of instrument or counterparty

[b] Each instrument class (security or derivative contract) uses only those inputs relevant to that instrument class.

[c] In addition to the inputs provided by the Enterprises, this component requires projections for the stress period for a number of interest rates. The calculation of all of these interest rates is described in section 3.3, Interest Rates, of this Appendix. Ten classes of instruments are linked to various interest rates. These interest rates are required as inputs in order to adjust periodically the interest payments on the respective instruments. The particular interest rate used is based on the instrument's specifications. The available interest rates are listed in Table 3–30.

Table 3-30. Interest Rates and Indexes

Indexes	
Prime Rate	1 MO London Inter-Bank Offered Rate
3 MO Treasury Bill	3 MO London Inter-Bank Offered Rate
6 MO Treasury Bill	6 MO London Inter-Bank Offered Rate
1 YR Constant Maturity Treasury	12 MO London Inter-Bank Offered Rate
3 YR Constant Maturity Treasury	
5 YR Constant Maturity Treasury	
10 YR Constant Maturity Treasury	
20 YR Constant Maturity Treasury	
Overnight Federal Funds	
7-Day Federal Funds	

3.9.4.3 Procedures

[a] One of seven interest payment calculations is assigned to each instrument class. These are a semi-annual fixed rate of interest, quarterly fixed and floating rates of interest, monthly fixed and floating rates of interest, a fixed rate of interest due at maturity based on the number of days an instrument is outstanding, and a monthly floating rate of interest based on the difference between an interest rate index and a strike price. Table 3–31 indicates the type of payment calculation for each of the various instrument classes.

Table 3-31. Interest Rate Payments

Instrument Class	Interest Payment Frequency
Fixed-Rate Bonds	Semi-annual fixed-rate payments
Fixed-Pay Swaps (pay side) Floating-Pay Swaps (receive side)	Quarterly fixed-rate payments
Floating-Rate Bonds Floating-Rate Municipal Bonds Basis Swaps Floating-Pay Swaps (pay side) Fixed-Pay Swaps (receive side)	Quarterly floating-rate payments
Fixed-Rate ABSs Fixed-Pay Amortizing Swaps (pay side) Floating-Pay Amortizing Swaps (receive side)	Monthly fixed-rate payments
Floating-Rate ABSs Floating-Pay Amortizing Swaps (pay side) Fixed-Pay Amortizing Swaps (receive side)	Monthly floating-rate payments
Short-Term Instruments	Fixed-rate with interest payments due at maturity
Long Cap and Short Cap	Monthly floating-rate payments based on the difference between an interest rate index and a strike price

[b] The first step in processing the data is establishing the interest payment dates. Asset-backed securities (ABSs), amortizing swaps, and caps require monthly interest payments. For all other instrument classes, the interest payment dates are determined by working backward from the maturity date, using the payment assumptions for each instrument class. For example, if the maturity date is September 15, 1999, for an instrument that pays interest semi-annually, then interest payment dates are September 15, 1999, March 15, 1999, etc. until the initial payment date within the stress period is determined. Payments made in the stress period are allocated to specific months, not specific days within the month.

[c] The second step is the calculation of instrument level cash flows based on payment criteria and instrument characteristics. Interest payment dates are based on the criteria established above. For the non-derivative instrument classes except for ABS, each interest payment is based on the face amount of the security. ABS interest payments are based on the remaining principal balance of the instrument after adjusting for prepayments. The entire amount of principal is due at maturity, except in the case of ABS, where the face amount is reduced by principal prepayments. Interest and principal payments for securities are, therefore, based on the formulas in Table 3–32.

Table 3-32. Principal and Interest Calculations

Instrument Class	Interest Calculation	Principal Calculation
Fixed-Rate Bonds	$(C \cdot F) \cdot 0.5$	F
Floating-Rate Bonds	$(I + S) \cdot F \cdot 0.25$	F
Short-Term Instruments	$(C \cdot F) \cdot D/360$	F
Floating-Rate Municipals[1]	$(L3 - (L3 \cdot T)) \cdot F \cdot 0.25$	F
Fixed-Rate ABS	$C \cdot P \cdot F \cdot 0.083$	Monthly prepayments $[(P \cdot F) \cdot Q]$ and remaining principal at maturity.
Floating-Rate ABS	$(I + S) \cdot (P \cdot F) \cdot 0.083$	Monthly prepayments $[(P \cdot F) \cdot Q]$ and remaining principal at maturity.

[1] The index on which these securities reset is not modeled by the interest rate component of the stress test; therefore, the stress test approximates a tax-exempt rate by reducing the three-month LIBOR by the assumed marginal tax rate for the Enterprises multiplied by the three-month LIBOR.

where:

C = annual coupon rate

F = face amount of the instrument

S = spread over a given interest rate index

P = principal factor equal to (1-prepayment rate)$^{(\text{sim month} - 1)}$

Q = prepayment rate, assumed to be 3.5% for fixed-rate and 2.0% for floating-rate ABS

T = marginal corporate tax rate, assumed to be 34.0%

D = number of days between settlement and maturity dates

$L3$ = three-month LIBOR

I = interest rate index

[d] For derivative contracts such as swaps and caps, interest payments are calculated using notional amounts instead of principal balances. The stress test treats swaps as two separate instruments, consisting of a pay side and a receive side, using the criteria of fixed-rate or floating-rate instruments as described above. Each interest payment is based on the original notional amount of the derivative contract except for amortizing swaps, which have interest payments based on the remaining notional balance after adjusting for prepayments. Prepayment speeds for amortizing swaps are set equal to the prepayment speeds for floating-rate ABSs.

[e] Caps can be purchased, in which case an Enterprise receives interest, or sold, in which case an Enterprise pays interest. Interest payments on caps are determined in the following manner. If the strike price of the cap is less than or equal to the interest rate index, then interest payments are calculated based on the difference between the index and the strike price. If the strike price of the cap is greater than the interest rate index, then interest payments are zero. The formulas in Table 3–33 are used to calculate interest payments and receipts for investment-linked derivative contracts.

Table 3-33. Interest Payments and Receipts

Instrument Class	Interest Receipts	Interest Payments
Fixed-Pay	$(I + S) \cdot N \cdot 0.25$	$(C + S) \cdot N \cdot 0.25$
Floating-Pay	$(C + S) \cdot N \cdot 0.25$	$(I + S) \cdot N \cdot 0.25$
Basis Swaps	$(I + S) \cdot N \cdot 0.25$	$(I + S) \cdot N \cdot 0.25$
Fixed-Pay Amortizing	$(I + S) \cdot (P \cdot N) \cdot 0.083$	$(C + S) \cdot (P \cdot N) \cdot 0.083$
Floating-Pay Amortizing	$(C + S) \cdot (P \cdot N) \cdot 0.083$	$(I + S) \cdot (P \cdot N) \cdot 0.083$
Long Cap	$(I - K) \cdot N \cdot 0.083$; if $K>I$, then $(I-K)=0$	0
Short Cap	0	$(I - K) \cdot N \cdot 0.083$; if $K>I$, then $(I-K)=0$

[f] Equations for calculating interest on derivative contracts use the same notation as equations for securities. In addition, the following notations are used:

- N = notional amount of the instrument
- K = strike price

[g] Once the cash flows for interest and principal have been calculated for a particular investment or investment-linked derivative contract, the cash flow is ''haircut'' (i.e., reduced) by a specified percentage determined by the public rating of the investment or derivative counterparty and the year during the stress period in which the cash flow occurs, as described in section 3.6, Other Credit Factors, of this Appendix. The haircuts are applied to all investment cash flows at the instrument level. However, for investment-linked derivative contracts, the cash flows are added together (pay side and receive side) for all contracts with a given counterparty. The haircut is applied to the net cash owed by the counterparty in that month. If the Enterprise owes the counterparty money, then no haircut is applied.

3.9.4.4 Output

Interest and principal payments are produced for each instrument for the 120 months of the stress period. These cash flows are inputs to section 3.10, Operations, Taxes, and Accounting, of this Appendix.

3.10 Operations, Taxes, and Accounting

3.10.1 Overview

This component describes the procedures for creating pro forma balance sheets and income statements, determining short-term debt issuance and short-term investments, calculating operating expenses and taxes, and computing capital distributions. Input data include an Enterprise's balance sheet at the beginning of the stress period, interest rates, and the outputs from cash flow components of the stress test. The outputs of the procedures discussed in this section—120 monthly pro forma balance sheets and income statements—are the basis for the capital calculation described in section 3.12, Calculation of the Risk-Based Capital Requirement, of this Appendix.

3.10.2 Inputs

This component uses the data described in section 3.10.2.1, Enterprise Data, section 3.10.2.2, Interest Rates, and section 3.10.2.3, Outputs From Cash Flow Components of the Stress Test, to produce monthly pro forma balance sheets and income statements for the Enterprises.

3.10.2.1 Enterprise Data

[a] In addition to the starting position data described in the cash flow components, the Enterprises provide the dollar values for the following starting position balances:

- Amounts required to reconcile starting position balances from cash flow components of the stress test with an Enterprise's balance sheet (e.g., differences between actual and estimated loan prepayments during the last few days in the month)
- Cash
- Low income housing tax credit investments
- Unamortized balances of premiums, discounts, and fees from the acquisition of retained whole loans and retained mortgage-related securities at other than par value
- Allowances for loan losses
- Accrued interest receivable on retained whole loans, retained mortgage-backed securities, mortgage-linked derivatives, and nonmortgage investments
- Amounts receivable from index sinking fund debentures, currency swaps, fees, income taxes, and other accounts receivable
- Real estate owned
- Fixed assets
- Clearing accounts
- Unamortized premiums, discounts and fees related to debt securities
- Unamortized balances related to the sold portfolio
- Deferred balances related to liability-linked derivatives
- Accrued interest payable
- Principal and interest payable to mortgage security investors
- Other liabilities (e.g., payables from currency swaps, escrow deposits, and income taxes)
- Dividends payable
- Components of stockholder's equity (i.e., common stock, preferred stock, paid-in capital, retained earnings, treasury stock, and unrealized gains and losses on available-for-sale securities)

(b) Other data provided by the Enterprises include:

- Operating expenses for the quarter prior to the beginning of the stress test
- Earnings before income taxes and provision for income taxes for the three years prior to the beginning of the stress test
- Year-to-date income before taxes and provision for income taxes
- Dividend payout ratio for the four quarters prior to the beginning of the stress test
- Minimum capital requirement at the beginning of the stress test

3.10.2.2 Interest Rates

This component of the stress test requires the following interest rates generated by the Interest Rates component described in section 3.3, Interest Rates, of this Appendix:

- Six-month Federal agency cost of funds
- Six-month constant maturity Treasury yield

3.10.2.3 Outputs From Cash Flow Components of the Stress Test

This component of the stress test also requires monthly cash flows generated as described in section 3.9, Cash Flows, for:

- Whole Loans (section 3.9.1)
- Mortgage-Related Securities (section 3.9.2)
- Non-Mortgage Investment and Investment-Linked Derivative Contract Cash Flows (section 3.9.4)
- Debt and Related Cash Flows (section 3.9.3)

3.10.3 Procedures

The stress test calculates new debt and investments, dividends, allowances for loan losses, operating expenses, and income taxes. These calculations are both determined by and affect the pro forma balance sheets and income statements over the stress period.

3.10.3.1 New Debt and Investments

(a) The availability of cash in each month of the stress period determines whether cash is invested, or whether borrowings are required. The stress test calculates cash received and cash disbursed each month in order to determine the net availability of cash. The following describe the many ''sources'' and ''uses'' of cash.

1. Cash sources include:

- Cash at the beginning of the stress test
- Principal and interest payments from retained mortgages and retained mortgage-backed securities
- Principal and interest payments from non-mortgage investments (e.g., Federal funds sold, mortgage securities purchased under agreements to resell, commercial paper, eurodollar time deposits, asset-backed securities, U.S. Treasury securities, municipal obligations, auction-rate preferred stock)
- Amounts received from counterparties on derivative contracts
- Disposition of foreclosed property included in the balance sheet at the beginning of the stress test
- Amounts received from other assets and receivables included in the balance sheet at the beginning of the stress test (e.g., receivables from index sinking fund debentures and currency swaps, Federal income taxes refundable.)
- Guarantee fees
- Float income on principal and interest received on the sold portfolio
- Federal income tax refunds from net operating loss (NOL) carrybacks
- Recoveries on defaulted loans

2. Cash uses include:

- Repayment of principal to investors on debt instruments (as they mature or are called)
- Interest paid to investors on debt instruments
- Amounts paid to counterparties on derivative contracts
- Principal payments to investors (net of recoveries) due to mortgage defaults on loans in the sold portfolio
- Payments of miscellaneous liabilities included in the balance sheet at the beginning of the stress test, e.g., some accounts payable, escrow deposits, principal and interest due to mortgage security investors, and payables from currency swaps (Amounts recorded subsequent to the beginning of the stress period as principal and interest due mortgage securities investors do not affect the cash calculation for new debt and investments.)
- Operating expenses
- Income taxes
- Dividends on preferred and common stock

(b) During the stress period, the net cash position for each of the 120 months is calculated at the end of each month. Timing of sources and uses of cash within each month are ignored.

(c) At the end of any month in which the cash position is calculated to be negative, the stress test issues six month discount notes at the six month Federal Agency Cost of Funds rate, plus a 2.5 basis point issuance cost. When the cash position is positive, the stress test invests the Enterprise's excess cash in one month maturity assets at a rate equivalent to the six month Treasury yield. As a result, the cash position of an Enterprise is zero at the end of each month during the stress test.

3.10.3.2 Dividends

(a) The stress test determines quarterly whether to pay preferred and common dividends and, if so, how much based on the rules that follow.

1. Preferred Stock—An Enterprise will pay dividends on preferred stock as long as that Enterprise meets the estimated minimum capital requirement before and after the payment of these dividends. Preferred stock dividends are based on the coupon rates of the issues outstanding. The coupon rates for any issues of variable rate preferred stock are calculated using projections of the appropriate index rate.

2. Common Stock—In the first year of the stress test, dividends on common stock in all four quarters are based on the trend in earnings at that Enterprise. If earnings are positive and increasing, dividends are paid based on the same percent dividend payout as the average payout of the preceding four quarters. If earnings are not positive and increasing, dividends are paid based on the preceding quarter's dollar amount of dividends per share. Common stock dividends are stopped after four quarters of payouts, except they are cut off earlier if an Enterprise's capital falls below the minimum capital requirement.

3. No other net capital distributions are made, i.e., no repurchases of common stock or redemption of preferred stock occur during the stress test.

(b) The Enterprise's minimum capital requirement is computed by applying leverage ratios to all assets (2.50 percent) and off-balance sheet obligations (0.45 percent), and summing the results.

3.10.3.3 Allowances for Loan Losses and Other Charge-Offs

(a) The stress test calculates a tentative allowance for loan losses monthly by multiplying current month mortgage default losses [19] by twelve, thus annualizing current month mortgage default losses. If the tentative allowance for loan losses for the current period is greater than the balance from the prior month plus charge-offs for the current month, a provision (e.g., expense) is recorded. Otherwise, no provision is made and the allowance for loan losses is equal to the prior period amount less current month charge-offs.

(b) Other charge-offs result from ''haircuts'' related to mortgage revenue bonds, private-issue MBS, and non-mortgage investments, described in their respective cash flow components. These haircuts result in receipt of less than the amount of principal contractually due. This lost principal is charged-off when due and not received.

3.10.3.4 Operating Expenses

The stress test calculates operating expenses, which include non-interest costs such as those related to an Enterprise's salaries and benefits, professional services, property, equipment and office. Over the stress period, operating expenses decline in proportion to the decline in the size of an Enterprise's mortgage portfolio (i.e., the sum of outstanding principal balances of its retained and sold mortgage portfolios). The stress test calculates the percentage of an Enterprise's mortgage portfolio at the start of the stress test that is remaining at the end of each month of the stress period. It then multiplies the percentage of assets remaining by one-third of the Enterprise's operating expenses in the quarter immediately preceding the start of the stress test. The resulting amount is an Enterprise's operating expense for a given month in the stress period.

3.10.3.5 Taxes

[a] Both Enterprises are subject to Federal income taxes, but neither is subject to state or local income taxes.

[b] The stress test applies an effective Federal income tax rate of 30 percent when calculating the monthly provision for income taxes (e.g., income tax expense). This tax rate is lower than the statutory rate because of tax exempt interest received, deductions for dividends received, and equity investments in affordable housing projects. OFHEO may change the 30 percent income tax rate if there are significant changes in Enterprise experience or changes in the statutory income tax rate.

[c] The stress test sets income tax expense for tax purposes equal to the provision for income taxes. The effects of timing differences between taxable income and generally accepted accounting principles (GAAP) income before income taxes are ignored. Therefore, Net Operating Loss (NOL) occurs only when the net income, before the provision for income taxes, is negative.

[d] Payments for estimated income taxes are made quarterly. At the end of each year, the annual estimated tax amount is compared to the annual actual tax amount. At that time, a payment of remaining taxes is made or a refund for overpayment of income taxes is received.

[e] A NOL for the current month is ''carried back'' to offset taxes in any or all of the preceding three calendar years. (The Enterprises' tax year is the same as the calendar year.) This offset of the prior years' taxes results in a negative provision for income taxes (e.g., income) for the current month. Use of a carry back reduces available carry backs in subsequent months. Any NOL remaining after carry backs are exhausted becomes a carry forward.

[f] Carry forwards represent NOLs that cannot be carried back to offset previous years' taxes, but can be used to offset taxes in any or all of the subsequent 15 years. Carry forwards accumulate until used, or until they expire 15 years after they are generated.

[g] Under the stress test, the Enterprises will not have a positive net income in future

[19] Current month mortgage default losses include the sum of what the Enterprises classify as ''provision for losses'' and ''foreclosed property expense.'' For both the retained and sold portfolios, this includes lost principal (net of recoveries from credit enhancements and disposition of the real estate collateral), and foreclosure, holding, and disposition costs.

years to utilize NOL carry forwards. A valuation adjustment is used to decrease the Federal income tax refundable to zero (e.g., the amount likely to be realized).

3.10.3.6 Accounting

[a] The 1992 Act specifies that total capital includes core capital and a general allowance for foreclosure losses. For the Enterprises, this general allowance is represented by general allowances for loan losses on their retained and sold mortgage portfolios. The 1992 Act further defines core capital as the sum of the following components of equity:

- The par or stated value of outstanding common stock
- The par or stated value of outstanding perpetual, noncumulative preferred stock
- Paid-in capital
- Retained earnings

[b] In order to determine the amount of total capital an Enterprise must hold to maintain positive total capital throughout the ten-year stress period, the stress test projects the above four components of equity plus general loss allowances as part of the monthly pro forma balance sheets and income statements.

[c] Details of an Enterprise's actual balance sheet at the beginning of the stress test are recorded from a combination of starting position balances for all instruments for which other components of the stress test calculates cash flows and other starting position balances for assets, liabilities, and equity accounts needed to complete an Enterprise's balance sheet.

[d] After recording an Enterprise's balance sheet at the beginning of the stress period, the stress test creates monthly pro forma balance sheets and income statements by recording output from the cash flow components of the stress test; recording new debt and investments (and related interest), dividends, loss allowances, operating expenses, and taxes; and applying accounting rules pertaining to balance sheets and pro forma income statements.

3.10.3.6.1 Accounting for Positions and Cash Flows From Cash Flow Components

Balances at the beginning of the stress test and subsequent changes to related pro forma balance sheet and income statement accounts are obtained from data generated by cash flow components of the stress test for the following:

1. Retained whole loan mortgage interest cash flows in the first month of the stress period reduce accrued interest receivable at the beginning of the stress test. Subsequent months interest cash flows are recorded as accrued interest receivable and interest income in the month prior to its receipt. When the interest cash flows are received, accrued interest receivable is reduced. Monthly principal cash flows (including prepayments and defaulted principal) are recorded as reductions in the outstanding balance of the loan group. Net losses on defaults are charged off against the allowance for loan losses. Recoveries are cash inflows.

2. Retained mortgage-backed security interest cash flows in the first month of the stress period reduce accrued interest receivable at the beginning of the stress test. Subsequent months interest cash flows are recorded as accrued interest receivable and interest income in the month prior to its receipt. When the interest cash flows are received, accrued interest receivable is reduced. Monthly principal cash flows (including prepayments) are recorded in the month received as a reduction in the outstanding balance of mortgage assets.

3. Mortgage revenue bond monthly interest cash flows in the first month of the stress period reduce accrued interest receivable at the beginning of the stress test. Subsequent months interest cash flows are recorded as accrued interest receivable and interest income in the month prior to its receipt. When the interest cash flows are received, accrued interest receivable is reduced. Monthly principal cash flows are recorded as reductions in the outstanding balance of mortgage assets. Defaulted principal is charged-off when due and not received.

4. Principal repayments from non-mortgage investments (e.g., Federal funds sold; mortgage securities purchased under agreements to resell; commercial paper; eurodollar time deposits; asset-backed securities; U.S. Treasury securities; municipal obligations, other than mortgage revenue bonds; and auction-rate preferred stock) reduce the investment and increase cash. Interest payments received increase cash and reduce accrued interest receivable. Accrued interest receivable includes both amounts at the beginning of the stress period and subsequent monthly accruals (also recorded as interest income).

5. Sold portfolio cash flows include monthly guarantee fees, float, and principal and interest due MBS investors. Guarantee fees are recorded as income in the month received. Principal and interest due mortgage security investors does not affect the balance sheet; however, interest earned on these amounts (float) is recorded as income in the month the underlying principal and interest payments are received. Principal payments received and defaulted loan balances reduce the outstanding balance of the sold portfolio. Losses (net of recoveries) are charged off against the allowance for losses on the sold portfolio (a liability on the pro forma balance sheets) and reduce cash.

6. For each debt instrument in the starting position, interest is accrued monthly. Accrued interest (representing both amounts as of the beginning of the stress period and subsequent monthly accruals) and principal debt due investors are reduced when cash payments are made.

7. Issuance of discount notes increases cash by the amount of the new debt, net of discounts and issuance costs. Interest expense is accrued monthly and paid at maturity when the discount note is retired at par. Discounts and issuance costs are amortized on a straight line basis over the life of the discount note, increasing interest expense.

8. The amortized balance (e.g., the face amount of the debt less the unamortized discount) of zero coupon debt is recorded in the starting position. The unamortized discount is amortized monthly using the level yield method over the debt's term to maturity and recorded as interest expense. At maturity, the face amount of the debt is paid to investors and the balance of debt is reduced.

3.10.3.6.2 Accounting for Other Changes in Starting Position Balances

Cash flows, income, and changes in the pro forma balances for other parts of the Enterprise's balance sheet are recorded as described below.

1. Unrealized gains (losses) on available-for-sale investments included in the balance sheet at the beginning of the stress test are recorded as income during the first month of the stress test. Recognition of unrealized gains increases earnings; recognition of unrealized losses decreases earnings.

2. Unamortized balances of premiums, discounts, and fees from the acquisition of retained loans and retained mortgage-backed securities at other than par value are a component of the balance sheet at the beginning of the stress test. Unamortized balances related to retained whole loans are amortized in proportion to the decline in the size of an Enterprise's retained portfolio. Unamortized balances related to REMICs and strips are amortized over their lives using the level yield method, calculated using cash flows generated from the cash flow component of the stress test. Amortizing deferred balances at the beginning of the stress test reduces the deferred amounts on the balance sheet by simultaneously increasing interest income by amortizing discounts and decreasing interest income by amortizing premiums.

3. Low income housing tax credit investments at the beginning of the stress test remain constant over the stress test. No earnings or expenses are directly recorded.

4. The following receivables at the beginning of the stress test are converted to cash in the first month of the stress test:

- Amounts receivable from index sinking fund debentures and currency swaps
- Other miscellaneous receivables (e.g., fees receivable and accounts receivable)
- Federal income taxes

5. Real estate owned at the beginning of the stress test is converted to cash on a straight-line basis over the first six months of the stress test.

6. Clearing accounts as of the beginning of the stress test are converted to cash on a straight-line basis over the first twelve months of the stress test.

7. Fixed assets at the beginning of the stress test remain constant over the stress test. Depreciation is included in the base on which operating expenses are calculated for each month during the stress period.

8. Unamortized premiums, discounts and fees related to debt securities at the beginning of the stress test are amortized on a level yield basis over the remaining term to contractual maturity of the debt. Specifically, unamortized amounts are grouped by term to maturity and coupon bucket for debentures, zero coupon instruments, and all other debt. Unamortized amounts are amortized on a level yield basis using weighted average maturities and weighted average coupons for each of these groups.

9. Deferred balances relating to liability-linked derivatives at the beginning of the stress test are amortized using the sum of years digits method over three years.

Amortizing deferred balances increases or decreases interest expense, as appropriate.

10. Principal and interest payable to an Enterprise's mortgage security investors at the beginning of the stress test are paid during the first two months of the stress test (one-half in month one and one-half in month two).

11. The following liabilities at the beginning of the stress test are paid in the first month of the stress test, reducing cash:

- Payables from currency swaps
- Escrow deposits

12. Unamortized balances related to the sold portfolio are amortized in proportion to the decline in the size of an Enterprise's sold portfolio.

3.10.3.6.3 Other Accounting Principles

Additional accounting principles that affect the pro forma balance sheets and income statements over the stress period are also applied.

1. All investment securities are treated as held to maturity. As such, they are recorded as assets at amortized cost, not at fair value.

2. Enterprise REIT subsidiaries are consolidated. Specifically, REIT assets are treated as Enterprise assets. Preferred stock of the REIT is reflected as Enterprise debt. Dividends paid on the preferred stock are reported as interest expense.

3. Dividends are declared and paid simultaneously.

4. Treasury stock is reflected as a reduction in retained earnings.

3.10.4 Output

For each month of the stress period, the stress test produces a pro forma balance sheet and income statement. These pro forma financial statements are the inputs for calculating capital.

3.11 Treatment of New Enterprise Activities

[a] Given rapid innovation in the financial services industry, OFHEO anticipates the Enterprises will become involved with new mortgage products, investments, debt and derivative instruments, and business activities that the stress test will have to accommodate. OFHEO will monitor the Enterprises' activities and, when appropriate, propose amendments to this regulation addressing the treatment of new instruments and activities. However, the regulation is sufficiently flexible and complete to address new Enterprise activities as they emerge.

[b] Credit and interest rate risk of new Enterprise activities and instruments will be reflected in the stress test by simulating their credit and cash flow characteristics using approaches described throughout this Appendix. Simulating new activities and instruments will require that the Enterprises provide complete data, and full explanations of their operation. To the extent that approaches described herein are not applicable directly, OFHEO will combine and adapt them in an appropriate manner. For example, the stress test might employ its mortgage performance components and adapt its cash flow components to accurately simulate the loss mitigating effects of credit derivatives. Where there is no reasonable approach using existing combinations or adaptations within the timeframe for computing a quarterly capital calculation, the stress test will employ an appropriately conservative treatment, consistent with OFHEO's role as a safety and soundness regulator. Such treatment will continue until such time as sufficient information is made available to justify an alternative treatment, which may be subsequently incorporated as a specific provision in this Appendix.

[c] Procedurally, the Enterprises are expected to notify OFHEO of proposals related to new products, investments or instruments before they are purchased or sold or as soon thereafter as possible, but in any event no later than in connection with submission of the risk-based capital report provided for in § 1750.12. OFHEO will provide the Enterprise with its estimate of the capital treatment as soon thereafter as possible. The Enterprise will also be notified of the capital treatment in accordance with the notice of proposed capital classification provided for in § 1750.21.

3.12 Calculation of the Risk-Based Capital Requirement

3.12.1 Overview

[a] The stress test determines the minimum amount of total capital that an Enterprise must hold at the start of the stress test in order to maintain positive total capital throughout the ten-year stress period. Once the stress test has determined this amount of starting capital, the final calculation in the regulation is the Calculation of the Risk-Based Capital Requirement.

[b] The first step in calculating the minimum amount of total capital is to compute the discounted present value (as of the start of the stress test) of the projected month-end total capital amounts for each month of the stress period for both interest rate scenarios. The second step is to identify the lowest of the resulting 240 monthly discounted values and subtract from it the capital amount required for ''other'' off-balance sheet guarantees. If the resulting net amount is positive, the Enterprise has more than enough capital to maintain positive capital during the stress period. If the resulting net amount is negative, the Enterprise's capital at the start of the stress test is not sufficient. The third step is to subtract this net amount from the capital the Enterprise holds at the start of the stress test. This step effectively subtracts the extra capital or adds the shortfall to obtain the minimum amount of capital that the Enterprise needs at the start of the stress test.

[c] The final step in the regulation is the calculation of the Enterprise's risk-based capital requirement. The risk-based capital requirement equals the adjusted capital amount times 1.3 to account for management and operations risk.

3.12.2 Inputs

[a] The above calculations use outputs from three components of the stress test to make the final two capital calculations. These components include section 3.3, Interest Rates; section 3.8, Other Off-Balance Sheet Guarantees; and section 3.10, Operations, Taxes, and Accounting, of this Appendix.

[b] For each month of the stress test, the following inputs are from pro forma financial statements projected by the Operations, Taxes, and Accounting component:

- Total capital (the par or stated value of outstanding common stock, the par or stated value of outstanding perpetual, noncumulative preferred stock, paid-in capital, retained earnings, and allowance for losses on retained and sold mortgages)
- Provision for income taxes (income tax expense)
- Valuation adjustment that reduces benefits recorded from net operating losses when no net operating loss tax carrybacks are available
- Discount notes (amount outstanding)

[c] For present-value calculations, the stress test uses either the six month Federal agency cost of funds or the six month Treasury yield generated by section 3.3, Interest Rates of this Appendix.

[d] The input for the capital amount for other off-balance sheet guarantees is obtained from section 3.8, Other Off-Balance Sheet Guarantees, of this Appendix.

3.12.3 Procedures

The following steps are used for determining the minimum total capital an Enterprise needs to maintain positive capital during the stress test and the risk-based capital requirement for the Enterprise.

1. Determine whether taxes are owed or tax refunds will be received. If the provision for income taxes is positive (reflecting taxes owed) or negative (reflecting tax refunds to be received), then the effective tax rate is 30 percent. If the provision for income taxes is zero (after valuation adjustments, implying that income is negative, but no net operating loss tax carrybacks are available), then the effective tax rate is zero.

2. Determine whether an Enterprise is an investor or a borrower in each month of the stress period. In months where an Enterprise has outstanding six-month discount notes that were issued during the stress test, then the Enterprise is a borrower. Otherwise, the Enterprise is an investor.

3. Determine the appropriate monthly discount factor for each month of the stress period. In months where an Enterprise is an investor, the monthly discount factor is based on the yield of short-term assets:

$$\text{Monthly Discount Factor} = \left[1 + \frac{(1 - \text{Effective Tax Rate}) \times \text{6-month Treasury yield}}{2}\right]^{1/6}$$

In months where an Enterprise is a borrower, the monthly discount factor is based on the cost of the Enterprises' short-term debt:

$$\text{Monthly Discount Factor} = \left[\frac{1 + \left[(1 - \text{Effective Tax Rate}) \times \left(\frac{\text{6-month Federal Agency cost of funds}}{2} \right) \right]}{1 - \left[(1 - \text{Effective Tax Rate}) \times 0.00025 \right]} \right]^{1/6}$$

where:

.00025 is the factor that incorporates the issuance and administrative costs for an Enterprise's new discount notes.

4. Compute the cumulative discount factor for the total capital amount for each month in the stress period—The cumulative discount factor for a given month of the stress period is the monthly discount factor for that month multiplied by the cumulative discount factor for the preceding month. (The cumulative discount factor for the first month of the stress period is the monthly discount factor for that month.) Thus, the cumulative discount factor for any month incorporates all of the previous monthly discount factors.

5. Compute discounted total capital for each month of the stress period for both interest rate scenarios. Divide the total capital for a given month by the cumulative discount factor for that month.

6. Compute the amount of capital necessary to maintain positive capital throughout the stress period. Identify the lowest discounted total capital amount from among the 240 monthly discounted total capital amounts. Subtract the capital required for ''other'' off-balance sheet guarantees as calculated in section 3.8, Other Off-Balance Sheet Guarantees, component of the stress test from the lowest discounted amount. Then subtract the resulting difference from the Enterprise's total capital at the start of the stress period. This subtraction effectively reduces the starting capital amount by any extra capital that remains at the end of the stress period or increases starting capital by any shortfall. The resulting number is the starting capital amount that the Enterprise must hold in order to maintain positive total capital throughout the stress period.

7. Compute the risk-based capital requirement. Multiply the capital amount calculated in Step 6, by 1.3 for management and operations risk.

3.12.4 Output

The output of the above calculations is the risk-based capital requirement for an Enterprise at the start date of the stress test.

5. Add new subpart C to read as follows:

Subpart C—Capital Classification

Sec.
1750.20 Definitions.
1750.21 Notice of capital classification.

Subpart C—Capital Classification

§ 1750.20 Definitions

All of the terms defined at § 1750.2 shall have the same meaning for purposes of this subpart C.

§ 1750.21 Notice of capital classification

(a) Pursuant to section 1364 of the 1992 Act (12 U.S.C. 4614), OFHEO is required to determine the capital classification of each Enterprise on a not less than quarterly basis.

(b) The determination of the capital classification shall be made following a notice to, and opportunity to respond by, the Enterprise.

(1) Not later than 60 calendar days after the date for which the minimum capital report required by § 1750.3 and the risk-based capital report required by § 1750.12 are filed, OFHEO will provide each Enterprise with a notice of proposed capital classification. The notice shall contain the following information:

(i) The proposed capital classification;

(ii) The proposed minimum capital requirement;

(iii) The summary computation of the proposed minimum capital requirement;

(iv) The proposed risk-based capital level; and

(v) The summary computation of the proposed risk-based capital level.

(2) Each Enterprise shall have a period of 30 calendar days following receipt of a notice of proposed capital classification to submit a response regarding the proposed capital classification. The response period may be extended for up to 30 additional calendar days at the sole discretion of the Director. The Director may shorten the response period with the consent of the Enterprise, or without such consent if the Director determines that the condition of the Enterprise requires a shorter period.

(3) The Director shall take into consideration any response to the notice of proposed capital classification received from the Enterprise and shall issue a notice of final capital classification for each Enterprise not later than 30 calendar days following the end of the response period.

(c) From [insert date of publication of the final rule in the **Federal Register**] until [insert date twelve months after date of publication of the final rule in the **Federal Register**], the Director shall determine the capital classification of the Enterprise, based solely on the proposed minimum capital requirement.

Dated: April 5, 1999.

Mark A. Kinsey,

Acting Director, Office of Federal Housing Enterprise Oversight.

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