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# System 6 Alternatives: An Economic Analysis

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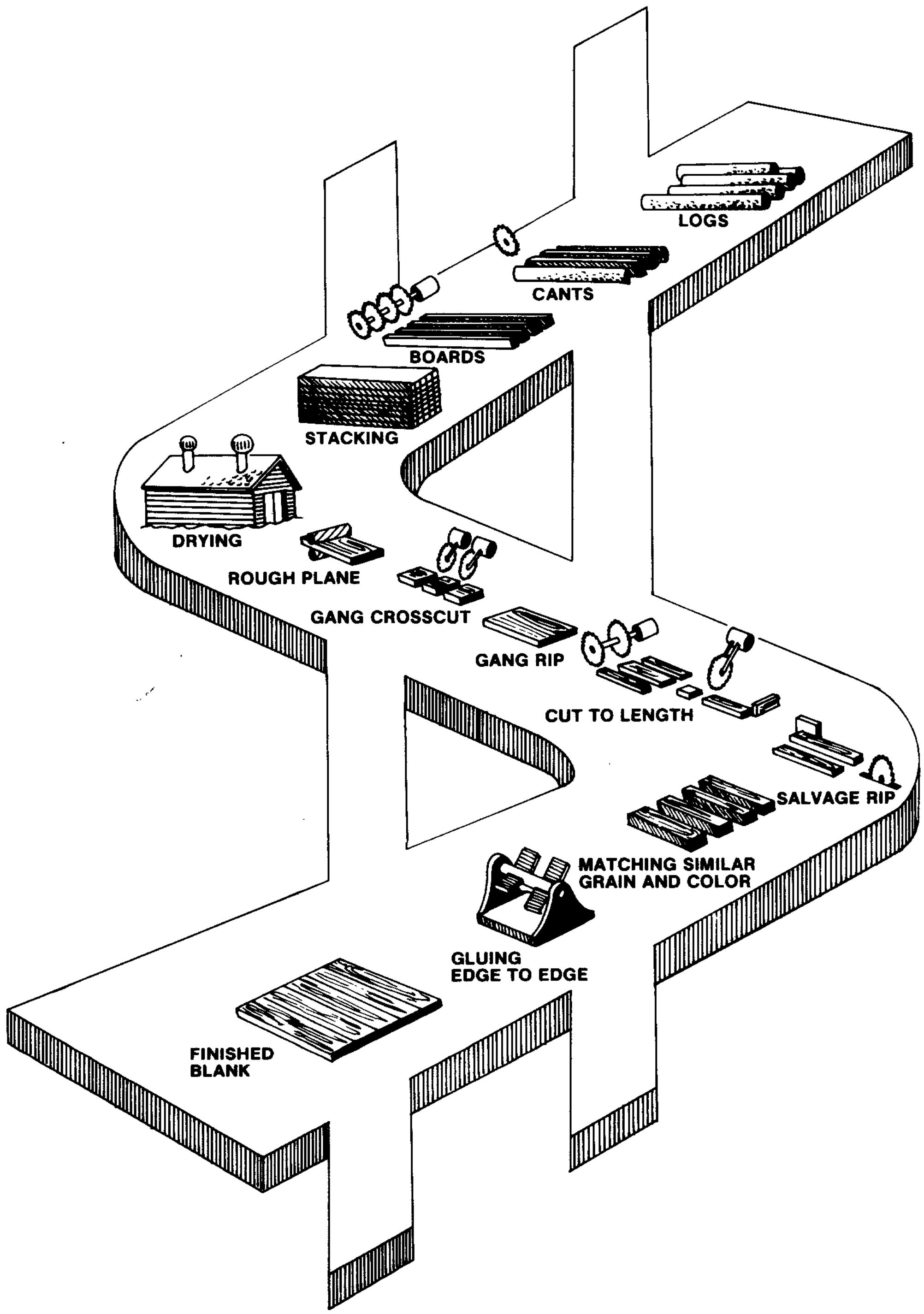

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## Abstract

Three System 6 mill-size alternatives were designed and evaluated to determine their overall economic potential for producing standard-size hardwood blanks. The study focused on developing standard discounted cash flow measures. Internal rates of return ranged from about 15 to 35 percent after taxes. Secondary effort was directed at providing accounting cost summaries to facilitate cost comparison of standard-size blanks with rough-dimension stock. Cost per square foot of blanks ranged from about $0.88 to $1.19, depending on mill size and the amount of new investment required.

## Introduction

System 6 is a new technology that, when combined with the production of standard-size hardwood blanks, provides a way to convert a low-grade resource into high-value products. A standard blank is a piece of solid wood (generally constructed from edge-glued pieces) of specified length, width, thickness, and quality. Specifications for standard-size blanks have been developed from an analysis of rough-dimension part sizes required by 32 major manufacturers of furniture and kitchen cabinets. Sizes have been determined so that rough-dimension parts can be processed efficiently from blanks with a minimum amount of loss in kerf and end trim. Several manufacturers have found System 6 blanks satisfactory in the production of fine solid-wood products.

System 6 production technology has been developed through numerous trials conducted at the Northeastern Forest Experiment Station's Forestry Sciences Laboratory at Princeton, West Virginia. However, a thorough economic analysis of System 6 is needed to see if investment is justified. In this paper we examine three alternative plant sizes that represent a range in investment and output by those who may wish to convert existing dimension operations to the manufacture of blanks, or by those who wish to produce blanks for sale on the open market. Also, we discuss the many general issues in investment analysis that affect results.

Additional information on System 6 technology and standard-size blanks is found in Araman et al. (1982); Reynolds and Gatchell (1982); Reynolds and Araman (1983); Reynolds et al. (1983); and Reynolds and Hansen (1984).

## Study Design

### Mill Alternatives

The three options for producing blanks with System 6 technology are referred to as the standard-mill, the mini-mill, and the maxi-mill alternatives. While all three were profitable, there were obvious economies associated with increased scale of operation.

The standard-mill was assumed to have a daily input of 16 Mbf (thousand board feet) of 6-foot cants. This resulted in production of about 7,200 $ft^2$ of blanks. Production of the mini-mill was one-half that of the standard-mill, while production of the maxi-mill was double that of the standard-mill. In each case, we assumed that the mill operated 240 days per year, and that each Mbf of input resulted in 450 $ft^2$ of blanks.

The standard-mill design is shown in Figure 1. This mill consisted of a resaw mill, a rough mill, and a glue room. The design included a forced-air predryer with a capacity of 250 Mbf, three kilns with a total capacity of 60 Mbf, and a boiler. This mill had a capability of sustained production of 16 Mbf of green cants into 7.2 Mbf of C1F (clear-one-face) panels (blanks) with a single shift. The initial investment required for this plant was $1.7 million excluding working capital (Table 1).

The mini-mill was designed to be built adjacent to an existing dimension facility. Another goal was to limit the initial investment to about $1 million. This goal was partially achieved by eliminating the following equipment:

| *Item* | *Number* |
|---|---|
| Defect saws | 2 |
| Sorting table | 1 |
| Salvage ripsaw | 1 |
| 40-clamp carrier | 1 |
| Cutoff saw | 1 |
| Stacker | 1 |
| Strapping machine | 1 |

Further reduction in the initial cost was obtained by eliminating separate kiln facilities and reducing boiler size. The prestickered packages of System 6 boards were dried with kiln facilities of the dimension mill at a marginal cost of $35 per Mbf. The mini-mill processed 8 Mbf of cants into 3,600 $ft^2$ of blanks daily. Maxi-mill production was achieved by running the standard-mill on two shifts per day. To support the doubling of production, additional drying capacity was necessary. This increased the initial investment by approximately $300,000 over that required for the standard-mill. The maxi-mill processed 32 Mbf of cants into 14,400 $ft^2$ of blanks daily.

### Methods of Analysis

*Discounted cash flow.* Our analyses of the System 6 standard-mill, mini-mill, and maxi-mill centered on the theoretically preferred measures of discounted cash flow (DCF): the internal rate of return (IRR) and the net present value (NPV). These measures assess the relationship between initial investment requirements and anticipated future after-tax cash flows (Appendix A).

Another measure closely associated with the NPV is the profitability index (PI), also known as the benefit/cost ratio. This measure expresses the NPV in terms of the investment base from which it results and allows the NPV from different-size investments to be compared.

*Accounting-based cost summaries.* In addition to the DCF analyses, we developed accounting-based manufacturing cost summaries for those who might use System 6 to replace existing dimension production facilities. In the case of replacement, we cannot account for all circumstances in which DCF analyses are used. For example, in developing data for such analyses, it is customary to

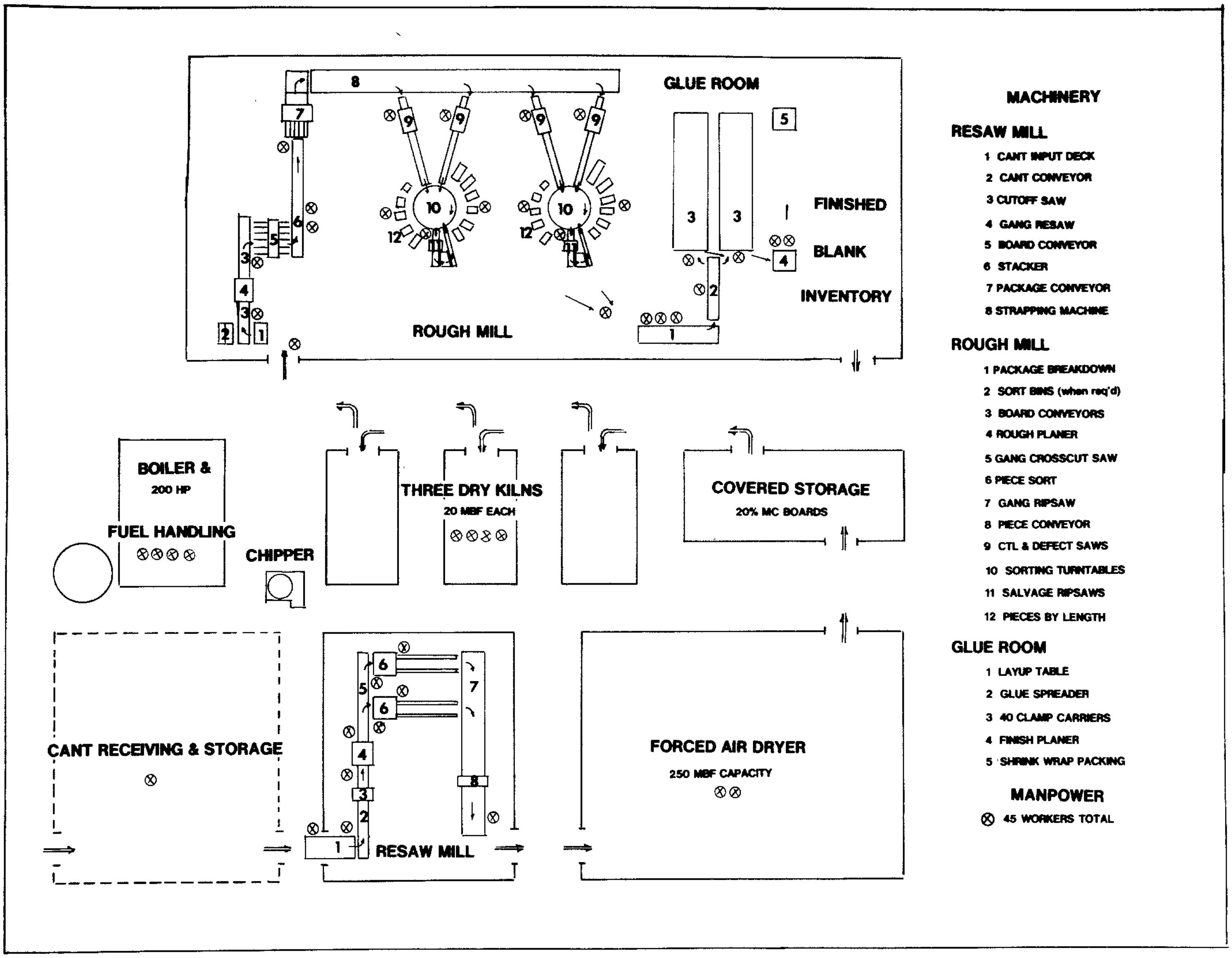


Figure 1.—The standard System 6 mill (input capacity: 16 Mbf per shift).

**Table 1.—System 6 equipment costs for a standard-mill (prices current: October 1982)**

| Item | Cost |
|---|---|
| | *Dollars* |
| *Primary processing machinery* | |
| Cant gang resaw: 11 saw (100 hp) | 22,000 |
| Cant cutoff saw: 6 × 25 (15 hp) | 9,000 |
| Receiving deck, unscrambler and conveyors (25 hp total) | 36,000 |
| 2 manual board stackers at $7,500 each (10 hp total) | 15,000 |
| Board conveyors and strapping machine (25 hp total) | 30,000 |
| Hog/screen chip-pac and infloor sawdust/refuse conveyor (75 hp total) | 48,500 |
| Forklift, 4,000 pounds propane | 12,500 |
| | 173,000 |
| *Secondary processing machinery* | |
| Package breakdown hoist and 3-way sort conveyors (25 hp total) | 24,000 |
| Rough planer: 2-side, 4 × 12 spiral knives (50 hp total) | 30,000 |
| Gang crosscut saw: 5-saw, variable spacing (30 hp total) | 54,000 |
| Modified gang ripsaw (100 hp) | 60,000 |
| Piece conveyors and piece sort station (25 hp total) | 24,000 |
| 4 defecting saws at $8,500 each (20 hp total) | 34,000 |
| 2 rotary sorting tables at $4,500 each (10 hp total) | 9,000 |
| 2 salvage ripsaws with return conveyors at $8,500 each (50 hp total) | 17,000 |
| Forklift, 4,000 pounds propane | 12,500 |
| Glue spreader and conveyors and panel layup tables (15 hp total) | 15,000 |
| Clamp carriers: 80 section at $65,000; 40 section at $35,000 (air motors) | 100,000 |
| Panel trimsaw: 3-saw variable spacing (30 hp total) | 35,000 |
| Blank planer: 2-side, 2 × 30 spiral knives (75 hp total) | 40,000 |
| Dust collection system and bins (50 hp total) | 65,500 |
| Minicomputer with 250K memory | 10,000 |
| | 530,000 |
| *Dryers, kilns, and boilers* | |
| Boiler, 200 hp and fuel handling/storage | 300,000 |
| 250 Mbf dryer at $0.60/board foot capacity | 150,000 |
| 3–20 Mbf kilns at $2.70/board foot capacity | 162,000 |
| 2-forklifts, 4,000 pounds propane at $12,500 each | 25,000 |
| | 637,000 |
| *Land* | |
| Improved 8 acres at $12,500/acre | 100,000 |
| *Buildings* | |
| Primary plant 40 × 70 feet = 2,800 $ft^2$ at $24/$ft^2$ | 67,000 |
| Secondary plant 40 × 150 feet = 6,000 $ft^2$ at $24/$ft^2$ | 144,000 |
| Boiler 40 × 40 feet = 1,600 $ft^2$ at $12.50/$ft^2$ | 20,000 |
| Air-dry lumber storage 40 × 60 feet = 2,400 $ft^2$ at $12/$ft^2$ | 29,000 |
| | 260,000 |
| *Total investment* | |
| Primary plant machinery | 173,000 |
| Secondary plant machinery | 530,000 |
| Subtotal | 703,000 |
| Dryers, kilns, and boilers | 637,000 |
| Buildings | 260,000 |
| Subtotal | 897,000 |
| Land | 100,000 |
| Total | $1,700,000 |

assume that complete new facilities are to be constructed. This allows us to have access to relevant price information. By contrast, those who replace existing facilities will most likely convert some portion of their existing plant and equipment to the System 6 venture. Still other components of the existing facility may no longer be necessary; their sale can be used to further offset initial investment requirements. Therefore, the number of investment requirement possibilities can be as large as the number of possible investors.

Similarly, it is difficult to derive possible revenues when replacement is involved. If products are to be sold on the market, we generally can use the current market price of the same or substitute products to estimate revenues. But when conversion leads to "revenues" because of internal cost savings, we cannot account for the many likely possibilities among investors.

The manufacturing cost summaries follow general accounting practice and provide manufacturing costs on a square foot of output basis. Where costs are comparable to those of the process being studied for replacement, further individual DCF-based investigation of the actual costs and revenues involved should be undertaken. Help in undertaking a study of this nature generally is available from university forestry extension personnel and personnel in the various schools of business, the Small Business Administration, and private business consultants. The computer program by Harpole (1978) used in our analyses has been adapted to run on all major computer systems.

## Investment Parameters

### Initial Costs

Working capital is an important component of the initial cost of each alternative. Working capital refers to that required to purchase and maintain raw material, work-in-process, and finished goods inventories, and also to support credit sales to the extent that they were made. We assumed a 30-day inventory of raw material and a combined amount for finished-goods inventory and credit sales equal to 30 days' output. These requirements were proportional to the level of production.

### Variable Operating Costs

The cost of raw material was estimated at $180 per Mbf. This figure was based on a cost of approximately $45 per cord for low-quality hardwood bolts (or about $100 per Mbf). To this we added a cost of $50 for sawmilling into cants and $30 for transportation to the System 6 mill. Each Mbf of cants yielded 450 ft$^2$ of blanks. The cost of the raw material was independent of the volume purchased.

We found that the cost of System 6 raw material is unaffected by species, as species generally is not a consideration in the market for low-grade roundwood. Thus, the price for this material is related directly to the cost of manufacture. As a result, whether purchasing oak, cherry, or another species, the estimated price for cants of $180 per Mbf that we used in our analyses should hold firm.

Labor costs for millworkers were assumed to average $6 per hour. This is broken down into a wage of $4.60 per hour plus mandatory fringes of 30 percent of $1.40 per hour. We believe this figure is adequate since most jobs within the System 6 mill require only minimum skills and training. We included a 2-week vacation allowance. Another 2 weeks of lost time was assumed during which workers were not compensated. Supervisory employees average $10 per hour in wages and fringe benefits.

The standard-mill, including kilns, employed 47 people—45 production and 2 supervisory. Mini-mill employment consisted of 23 production workers and 2 supervisory personnel. The maxi-mill labor force was twice that of the standard-mill in both production workers and supervisory personnel.

Raw material and labor accounted for nearly 85 percent of the total variable cost of the standard- and maxi-System 6 alternatives. Remaining costs were accounted for by utilities, supplies, and selling expenses. Mini-mill raw material and labor costs accounted for about 80 percent of the total variable cost. The remaining 20 percent was utility, supply, selling, and dry-kiln contract costs. Table 2 includes a detailed breakdown of the variable operating costs for each alternative.

### Fixed Operating Costs

Fixed costs for each alternative were composed of management and administrative costs, insurance costs, and maintenance expenses (Table 2). In terms of the management and administrative staff, the standard-mill had an assumed staff of two administrators and one secretary; the mini-mill had a staff of one administrator and one secretary; the maxi-mill had two administrators and two secretaries.

For all alternatives, insurance and maintenance costs were based on a percentage of the total cost of plant and equipment. Insurance was estimated at 2½ percent annually. Maintenance was estimated at 10 percent annually and was based on initial machinery cost. This allowance would include expenditures for both parts and labor.

### Revenues

Revenue estimates were obtained from the assumed sale of blanks on the open market at a price of $1.60 per square foot (Table 3). This price was equal to about 90 percent of the price received for rough dimension of similar quality. While mill residues were used to fire boilers, about twice as much was produced as was used. Although we did not include their sale in our analyses, it is possible that some investors will find a market for this surplus material.

## Other Factors Affecting Investment

Besides the obvious factors that affect investment performance—initial amount of investment, operating costs, and revenues—others are not so obvious. These include the time period or useful life of investment; inflation; depreciation; sources and costs of funds; tax rates and tax credits; and the time required to reach full production. Appendix B includes a detailed discussion of these issues and of our treatment of these factors with respect to the System 6 investment opportunity.

## Comparative Cash Flow Summaries

The derivation of net after-tax cash flows in most years is straightforward. We subtracted operating costs and depreciation from revenues, computed taxes, and then added depreciation to the after-tax income. However, there are some instances where other considerations affect the net after-tax cash flows. First, additional working capital is required to cover inventories as the plants move to full production. Second, the maxi-mill requires additional capital investment in year 2 to cover increased kiln and boiler capacities. Third, Harpole's (1978) cash flow program allows for the complete writeoff of depreciation in the year it occurs whether or not there is sufficient income from the project itself. In such instances, it is implicitly assumed that there is additional income for the investor, allowing the complete and immediate writeoff to occur. This treatment enhances the net after-tax cash flow only to the extent of the tax benefit derived from depreciation. Finally, proceeds from the assumed sale of land and from real assets in an amount equal to their undepreciated value, plus the return of working capital, are added to the operating cash flows at the end of year 10. Once after-tax net cash flows have been determined, the DCF measures are calculated. Cash flow summaries for the three mill alternatives are included in Tables 4–6. The accounting-based summaries do not require cash flow summaries since they focus on the costs occurring in just 1 year at full production.

**Table 2.—Variable and fixed operating costs for the System 6 mill alternatives**

| Cost item | Year 1 | Year 2 | Years 3 to 10 |
|---|---|---|---|
| | *Dollars* | | |
| | | MINI-MILL | |
| Variable costs | | | |
| Raw material | 172,800 | 345,600 | 345,600 |
| Labor | 237,000 | 316,000 | 316,000 |
| Supplies | 15,000 | 20,000 | 20,000 |
| Utilities | 20,000 | 26,000 | 26,000 |
| Selling expense | 34,560 | 69,120 | 69,120 |
| Drying | 50,250 | 67,000 | 67,000 |
| Fixed costs | | | |
| Management and admin. | 50,000 | 50,000 | 50,000 |
| Insurance | 25,000 | 25,000 | 25,000 |
| Maintenance | 68,000 | 68,000 | 68,000 |
| Total | 672,610 | 986,720 | 986,720 |
| | | STANDARD-MILL | |
| Variable costs | | | |
| Raw material | 345,600 | 691,200 | 691,200 |
| Labor | 435,000 | 580,000 | 580,000 |
| Supplies | 31,250 | 41,500 | 41,500 |
| Utilities | 41,750 | 55,500 | 55,500 |
| Selling expense | 69,120 | 138,240 | 138,240 |
| Fixed costs | | | |
| Management and admin. | 80,000 | 80,000 | 80,000 |
| Insurance | 40,000 | 40,000 | 40,000 |
| Maintenance | 134,000 | 134,000 | 134,000 |
| Total | 1,176,720 | 1,760,440 | 1,760,440 |
| | | MAXI-MILL | |
| Variable costs | | | |
| Raw material | 345,600 | 691,200 | 1,382,400 |
| Labor | 435,000 | 580,000 | 1,160,000 |
| Supplies | 31,250 | 41,500 | 83,000 |
| Utilities | 41,750 | 55,500 | 111,000 |
| Selling expense | 69,120 | 138,240 | 276,480 |
| Fixed costs | | | |
| Management and admin. | 80,000 | 80,000 | 95,000 |
| Insurance | 40,000 | 40,000 | 48,000 |
| Maintenance | 134,000 | 134,000 | 165,000 |
| Total | 1,176,720 | 1,760,440 | 3,320,880 |

**Table 3.—Revenues for the System 6 mill alternatives**

| Mill type | Year 1 | Year 2 | Years 3 to 10 |
|---|---|---|---|
| | *Dollars* | | |
| Mini | 691,200 | 1,382,400 | 1,382,400 |
| Standard | 1,382,400 | 2,764,800 | 2,764,800 |
| Maxi | 1,382,400 | 2,764,800 | 5,529,600 |

**Table 4.—Standard-mill cash flow summary**

| Year | Facilities and working capital investment | Revenues | Operating costs | Depreciation | Net after-tax cash flow |
|---|---|---|---|---|---|
| | *Thousands of dollars* | | | | |
| 0 | 1,857 | | | | −1,857 |
| 1 | 156 | 1,382 | 1,177 | 168 | 32 |
| 2 | | 2,765 | 1,760 | 253 | 659 |
| 3 | | 2,765 | 1,760 | 237 | 652 |
| 4 | | 2,765 | 1,760 | 219 | 643 |
| 5 | | 2,765 | 1,760 | 210 | 639 |
| 6 | | 2,765 | 1,760 | 63 | 571 |
| 7 | | 2,765 | 1,760 | 54 | 567 |
| 8 | | 2,765 | 1,760 | 54 | 567 |
| 9 | | 2,765 | 1,760 | 54 | 567 |
| 10 | | 2,765 | 1,760 | 45 | 1,218 |

**Table 5.—Maxi-mill cash flow summary**

| Year | Facilities and working capital investment | Revenues | Operating costs | Depreciation | Net after-tax cash flow |
|---|---|---|---|---|---|
| | *Thousands of dollars* | | | | |
| 0 | 1,857 | | | | −1,857 |
| 1 | 468 | 1,382 | 1,177 | 168 | − 280 |
| 2 | 313 | 2,765 | 1,760 | 253 | 346 |
| 3 | | 5,530 | 3,321 | 259 | 1,312 |
| 4 | | 5,530 | 3,321 | 254 | 1,309 |
| 5 | | 5,530 | 3,321 | 242 | 1,304 |
| 6 | | 5,530 | 3,321 | 88 | 1,233 |
| 7 | | 5,530 | 3,321 | 76 | 1,228 |
| 8 | | 5,530 | 3,321 | 76 | 1,228 |
| 9 | | 5,530 | 3,321 | 73 | 1,226 |
| 10 | | 5,530 | 3,321 | 64 | 2,309 |

**Table 6.—Mini-mill cash flow summary**

| Year | Facilities and working capital investment | Revenues | Operating costs | Depreciation | Net after-tax cash flow |
|---|---|---|---|---|---|
| | *Thousands of dollars* | | | | |
| 0 | 1,175 | | | | −1,175 |
| 1 | 79 | 691 | 673 | 124 | − 11 |
| 2 | | 1,382 | 987 | 185 | 299 |
| 3 | | 1,382 | 987 | 175 | 294 |
| 4 | | 1,382 | 987 | 168 | 291 |
| 5 | | 1,382 | 987 | 165 | 290 |
| 6 | | 1,382 | 987 | 22 | 224 |
| 7 | | 1,382 | 987 | 19 | 222 |
| 8 | | 1,382 | 987 | 19 | 222 |
| 9 | | 1,382 | 987 | 19 | 222 |
| 10 | | 1,382 | 987 | 16 | 563 |

## Results of Analyses

### Discounted Cash Flow Performance

The results of the DCF analyses of System 6 investment alternatives indicate that they are economically justifiable. As seen in Table 7, the IRR ranged from about 15 percent for the mini-mill to 35 percent for the maxi-mill. This pattern was similar for NPV's and PI's; both increased with the scale of operation. With respect to the alternatives we have presented, there seemed to be a direct relationship between size and performance. And as was readily apparent, the returns to the maxi-mill were considerably better than those to the other two. However, we believe that increasing mill size and operation much beyond the parameters established for the maxi-mill would pressure the upper limits of the mill's technological and physical capabilities. Consequently, additional improvement in performance is unlikely.

While all three alternatives seemed economically justified under the conditions prescribed, we examined performance under changes in some of the key inputs: initial investment, sales, price, and fixed and variable operating costs. Keep in mind that we were not concerned so much with increases in sales and prices as we were with declines. Conversely, decreases in investment and operating costs were not of the same concern as were increases. Figures 2–4 were derived using Harpole's (1978) CFA program and depict what happened to the internal rate of return (IRR) when either a 10- or 20-percent increase or decrease was imposed on the selected input while all others remained unchanged. As can be seen, mini-mill IRR was sensitive to any increase in cost or decrease in either the level of sales or price of blanks. A 10-percent change in any one of these resulted in an IRR below 15 percent.

By contrast, the standard-mill offered some security against the adverse effects of changes in the selected revenue and cost items. For this alternative, only a 20-percent reduction in the volume of sales or in the price of blanks will cause the IRR to fall below 15 percent.

**Table 7.—Economic performance criteria for the three System 6 design alternatives**

| Mill type | IRR | NPV | PI |
|---|---|---|---|
| | *Percent* | *Thousands of dollars* | |
| Standard | 24.5 | 892 | 1.48 |
| Mini | 15.0 | 0 | 1.00 |
| Maxi | 35.0 | 2,763 | 2.47 |

The maxi-mill was the most certain to earn at least a 15-percent return. In fact, in no instance did the return fall below 15 percent. The lowest IRR (19 percent) resulted from a 20-percent drop in the unit price.

We did not measure compound effects. Certainly, in those instances where both volume and price were to fall or where several cost items were to increase in conjunction with a decline in revenues, all alternatives would be in jeopardy.

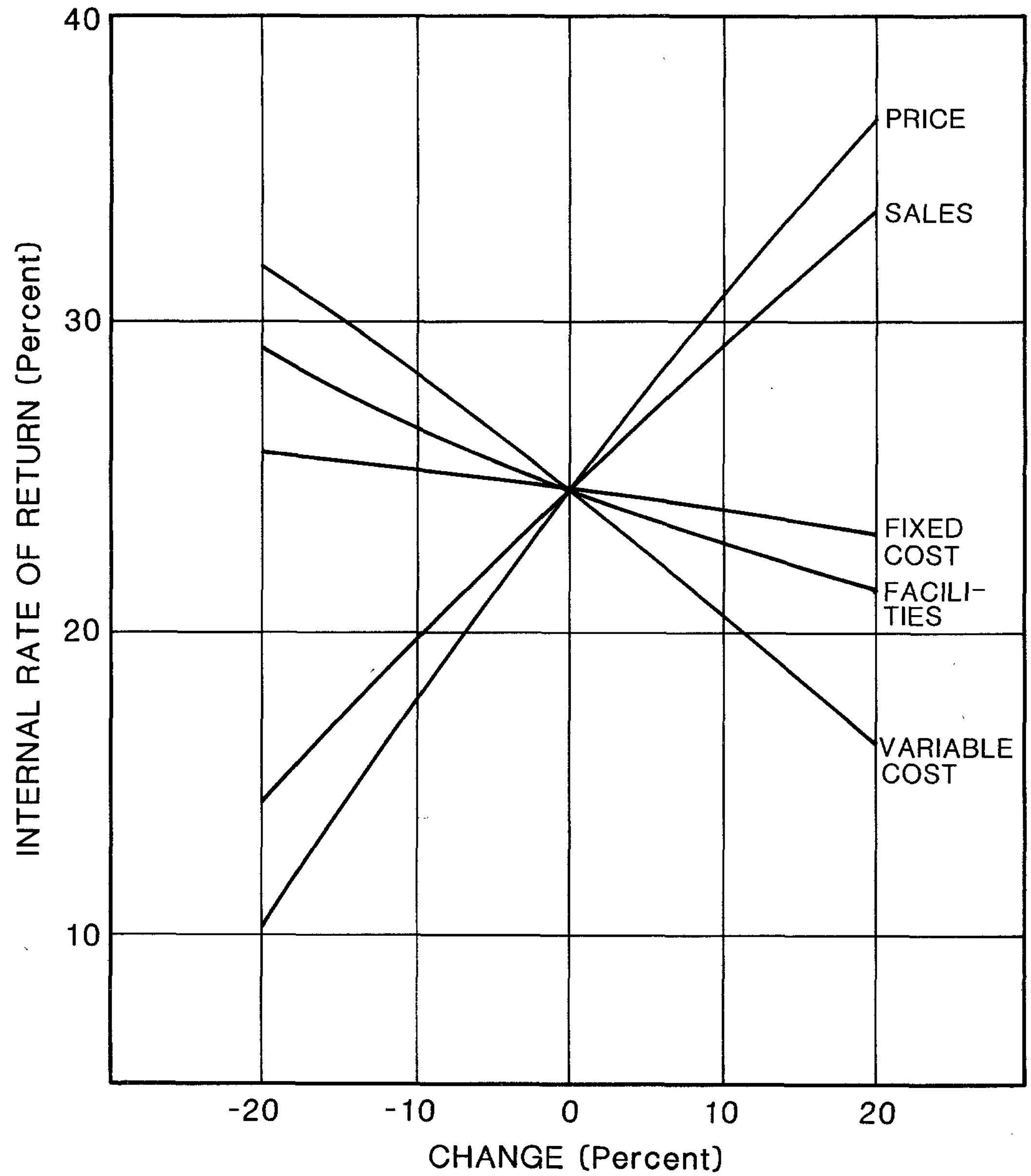


Figure 2.—Sensitivity of IRR to changes in selected inputs: standard-mill.

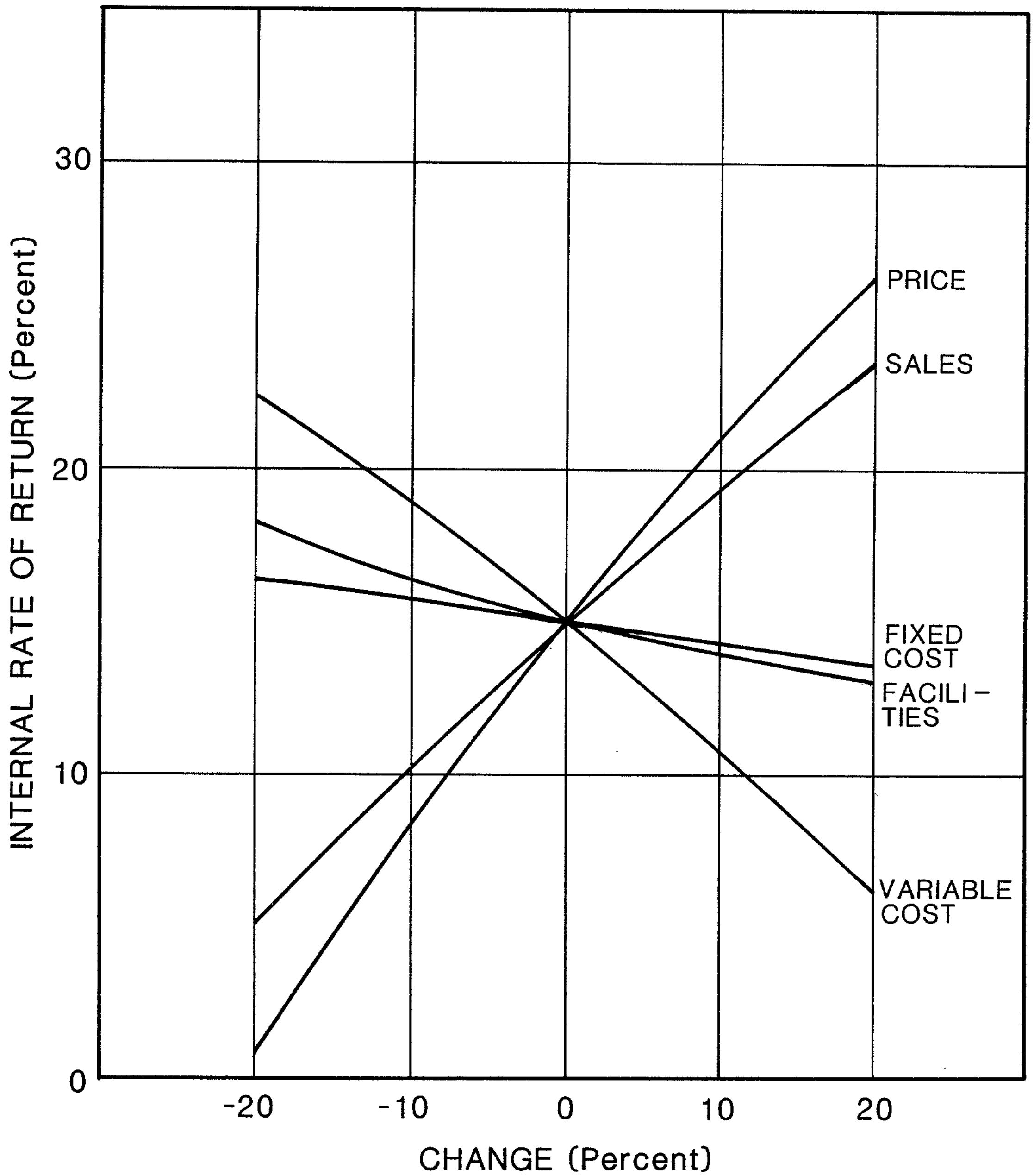

Figure 3.—Sensitivity of IRR to changes in selected inputs: mini-mill.

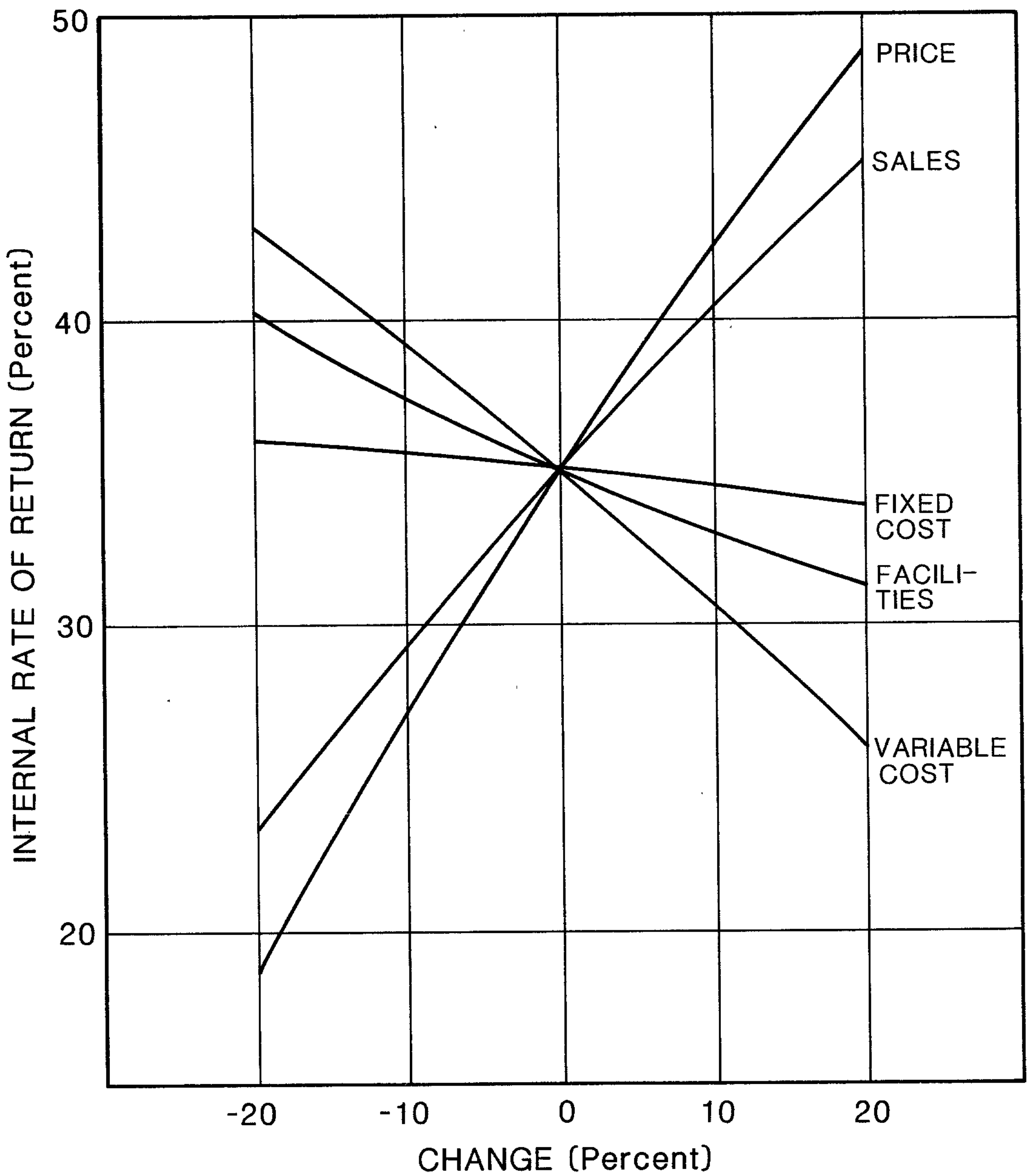


Figure 4.—Sensitivity of IRR to changes in selected inputs: maxi-mill.

## Accounting-Based Cost Estimates

The accounting cost summaries are provided for those investors who may look at blanks as a replacement for conventional dimension production. As stated earlier, we are unable to perform DCF analyses to cover all possible differences in the level of investment and potential "revenues" that might exist among individual investors.

The cost data in Table 8 for the three alternative ventures were developed to be generally comparable to manufacturing costs information provided by the accounting profession. In these summaries, manufacturing costs were broken into three components—variable costs, fixed costs, and depreciation expense which was used to account for the building and equipment "used up" in the production process. If these costs are near those of an existing dimension manufacturer, a more thorough, individually tailored, DCF investigation of the System 6 opportunity might be warranted. This investigation would focus on the relationship between the added (marginal cost) investment required and the potential cost savings (marginal benefits) to be realized over the life of the investment.

In looking at the accounting cost summary, note that depreciation was calculated for each of five levels of investment, which ranged from zero to 100 percent of those estimated for a complete new plant and equipment. This was done for two reasons. First, it provides a means for more accurate comparison of the inflated depreciation costs of a plant placed in service today with the uninflated depreciation costs of one placed in service some time ago. Rough comparison can be facilitated by multiplying the total investment cost of a complete new facility by the ratio between the producer price index during the past investment and that of the present. Once determined, the row in Table 8 representing an investment nearest this amount (i.e., 0, 25, 50, 75, 100 percent) will be more accurate for cost comparison. Second, the different levels of investment can be used to evaluate prospective costs more accurately where a portion of existing plant and equipment are to be either used or sold; this reduces the amount of new investment required.

The costs per square foot of C1F standard-size blanks for the standard-mill ranged from about $0.94 assuming no capital investment was required to nearly $1.04 for a complete new facility. Mini-mill costs were considerably higher starting at about $1.06 per square foot and ending at $1.19. The maxi-mill had the greatest economies, with costs per square foot ranging from approximately $0.88 to $0.94. Whether or not these costs are attractive depends on the current costs of the individual dimension producer.

**Table 8.—Cost per square foot of C1F standard-size blanks for each System 6 alternative given different levels of capital investment**

| Item | Standard | Mini | Maxi |
|---|---|---|---|
| | Dollars | | |
| Variable cost | 0.792 | 0.897 | 0.792 |
| Fixed cost | .147 | .166 | .089 |
| Total operating cost | .939 | 1.063 | .881 |
| Capital investment cost | | | |
| 0 percent | .000 | .000 | .000 |
| 25 percent | .025 | .032 | .015 |
| 50 percent | .049 | .064 | .029 |
| 75 percent | .074 | .095 | .044 |
| 100 percent | .098 | .127 | .058 |
| Total cost | | | |
| Low | .939 | 1.063 | .881 |
| High | 1.037 | 1.190 | .939 |

## Conclusion

Each of the three alternative operations for producing standard-size blanks from low-grade hardwood material seems commercially viable. Our treatment of the many elements (Appendix B) considered in an economic analysis tended to impose the more stringent assumptions on anticipated costs and revenues. However, we could not allow for all situations and recognize that for some individuals the situation will differ from that which we have described. Sensitivity analyses provide an indication as to the most critical areas. Those who are contemplating an investment in System 6 will need to trace our steps in determining more exactly the costs and revenues they will incur.

To duplicate results in actual production, management will need to ensure that the production rates and costs established in the analyses are maintained, and that the operation is kept in production for the prescribed time once the mill is operating. The latter requirement can be best ensured by developing and maintaining a viable market for System 6 standard-size panels.

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## Appendix A

The mathematical formula of the IRR can be expressed as:

$$\sum_{i=1}^{N} \frac{NATCF_i}{(1 + IRR)^i} = I_o$$

In essence, the IRR is a rate of discount that when divided into the net after-tax cash flows (NATCF) of each period (i) during the life of the investment (N) reduces their sum to an amount equal to the initial investment ($I_o$). The IRR is found via an iterative process.

The IRR can be thought of as a rate of earnings similar to the simple interest earnings of a home mortgage loan. $I_o$ is essentially the same as the original amount of a mortgage loan or principal and the $NATCF_i$ is comparable to the periodic payments. The IRR is comparable to the annual percentage rate of the mortgage loan. With any mortgage loan, the payment generally contains an amount to cover interest on the outstanding balance plus a return of principal. At the end of (N) payments, the loan is completely amortized. So, too, is the case with regard to earnings stemming from investment.

In most mortgage situations, payments are equal and of an amount sufficiently large to cover interest cost plus a portion of principal. However, this need not be the case for the same principles of simple interest to apply. For example, innovative financing arrangements have evolved that are designed to keep payments lower during the earlier years of a mortgage than what they ordinarily would be if equal. This is accomplished through what are termed "negative" payments to principal. Many investment situations may result in cash flows patterned in this manner.

The simple interest concept of the IRR differs from the concept where the IRR is presumed to represent a "compound" or "growth" rate of return. This latter concept assumes that any intermediate cash flows occurring during the life of the investment are reinvested at a rate equal to the IRR for the project. Such reinvestment opportunities may not always be available. Thus, to the extent that the actual rate of reinvestment differs from the IRR calculated for the project, the overall rate of "growth" under this concept will be affected.

The NPV formula looks quite similar to the IRR, however, there are some important differences.

$$\sum_{i=1}^{N} \frac{NATCF_i}{(1 + r)^i} - I_o = NPV$$

In this formula, the rate used to discount cash flows (r) is assigned. As a result, when the initial investment is subtracted from the discounted sum of the cash flows, the difference may be positive, negative, or zero depending in part on the rate of discount used. If the NPV is zero, r is equal to the IRR. Usually, r represents the minimum risk adjusted rate of return acceptable for investment. Consequently, projects with a negative NPV should be rejected. Final acceptance of projects with zero or positive NPV's (meaning returns equal to or above the minimum required) depends on the availability of funds and alternative opportunities.

The discount rate should reflect the after-tax, weighted average cost of capital. By using a weighted average, implicit recognition is given to the overall debt/equity structure.

In our studies of System 6 alternatives, we used a discount rate of 15 percent when deriving the NPV for each investment. This rate is consistent with that generally used by industry during the early 1980's (Gitman and Mercurio 1982). Obviously, no two investments need have the same capital structure or the same component costs. Therefore, we recognize that 15 percent may not be appropriate to all investors; however, it is important to note that the IRR sets an upper limit for the cost of capital below which any rate of discount used will result in a positive NPV estimate.

The final measure used in our analyses is the profitability index (PI). This measure also is known as the benefit/cost ratio and is derived as:

$$PI = \frac{NPV + I_o}{I_o}$$

This measure provides a look at the discounted returns (NPV) in terms of the investment on which it is based.

## Appendix B

The following are less obvious factors involved in investment analyses that are not directly related to any particular investment, but that influence the results of such studies. In most instances, our approach in handling these factors resulted in a more conservative estimate of performance than had some other course been taken.

### Time Period

In our analyses we have assumed a 10-year period over which to evaluate the investment. This period is fairly standard and can be supported rather easily.

First, and perhaps most important in supporting this choice, the discounted value of the dollar at current interest rates after 10 years makes up a relatively small percentage of the total revenue resulting from investment. For example, if we were to receive a dollar each year for the next 20 years and were to discount the value to the present using a discount rate of 10 percent, the dollars received after the tenth year would account for just 28 percent of the total. If a 20-percent rate of discount were used, the dollars received after the tenth year would be worth even less, only 14 percent of the total.

A second point that may be used to support the 10-year period relates to obsolescence. While it is possible that many plant facilities will last well beyond 10 years, they may become outmoded by advancing technology.

Third, the longer the period forecast for investment, the less reliable are the estimates made of the costs and revenues to be expected, and the greater is the degree of uncertainty that enters into the evaluation.

Finally, revenues lost by assuming the cessation of business activity in 10 years are partially offset by the assumed sale at the end of year 10 of land, real assets at their remaining undepreciated value, and the return of working capital resulting from the liquidation of inventories.

### Inflation

Inflation has proven to be persistent, highly volatile, and unpredictable. Consequently, it is an extremely difficult issue to deal with. While it might be prudent to expect a continuation, we can only guess at the rate of inflation over the next 10 years. It is near impossible to accurately predict individual increases in the various cost and revenue items. An alternative sometimes used is to assume a uniform rate of increase in both costs and prices. Yet, this actually has the effect of accenting performance. And if the rate is overspecified, predicted performance may not be realized, the consequences of which may be extremely detrimental. Recognizing these difficulties, we have chosen to disregard inflation in costs and revenues and to assume constant costs and prices (i.e., constant net revenues) over the life of investment.

It is argued that if inflation is disregarded in determining future costs and revenues, the inflationary component of the cost of capital or discount rate should be similarly disregarded. We believe that to do this may be dangerous, especially if an investment is made today using a fixed inflated financial obligation and, subsequently, inflation is brought under control. Also, even what is referred to as the "real" rate of interest has itself become increasingly unstable in recent years. By using current capital cost estimates against the likelihood of constant costs and revenues, we better protect the investor against the negative risks of investment. And if a uniform rate of inflation does prevail, the consequence is that investment performance will exceed our estimates.

### Depreciation

Depreciation, or capital recovery, is recognized in discounted cash flow analyses as it provides a shield from taxation for a portion of income equal to the amount of investment in buildings and equipment. DCF techniques recognize the time value of money; thus, the more accelerated the depreciation writeoff, the greater the benefits in tax-sheltered income. We use the recently legislated Accelerated Cost Recovery schedules for building and equipment capital cost recovery. Consequently, the full value (basis) of equipment is written off in 5 years. Building recovery during the first 10 years is based on full value and is allotted according to the 15-year schedule allowances for real assets placed in service during the sixth month of the tax year. The remaining value of these assets (27 percent of their cost) is recaptured through their assumed sale at the end of the tenth year.

Conversely, accounting theory recognizes depreciation as an expense and as a means to apportion that part of the building and equipment investment "used up" in the manufacturing process. Therefore, in constructing the accounting-based manufacturing cost summaries, we have chosen to apportion building and equipment costs equally over the 10-year period through depreciation calculated on a 10-year straight-line basis.

### Sources of Funds

Confusion can sometimes arise as to the earnings potential of an investment vis-a-vis other alternatives available to an investor because of the inclusion or exclusion of debt and equity considerations in the investment analysis. Consequently, it is necessary that we clarify our approach. We do not directly consider the sources of capital that might make up the initial investment because of the likelihood that each investor will have a different set of financial arrangements, that is, different amounts of debt and equity and different component costs. Rather, our analyses focus on the returns to the *overall sum* of investment dollars.

This is not to say, however, that the results of individual financial arrangements cannot be discerned or used to evaluate the results of the System 6 analyses. To the contrary, by using the concept known as "weighted average cost of capital"

(WACC), individual investors can determine the overall return on investment (discount rate) that would be required to repay debt plus interest costs and equity plus a desired profit. Likewise, knowing the IRR of an investment and the proportion and cost of debt used, the return to equity (profit) can be approximated.

The WACC takes the following form:

$$WACC \cong P_d C_d (1 - t) + (1 - P_d) C_e$$

where $P_d$ = the proportion of the total investment financed by debt capital
$C_d$ = the interest cost of debt capital
$t$ = the tax rate
$(1 - P_d)$ = the proportion of the total investment financed by equity capital
$C_e$ = the desired return (profit) to be earned by equity capital.

To use the WACC in determining the returns to equity, the following is used:

$$C_e \cong \frac{IRR - P_d C_d (1 - t)}{1 - P_d}$$

Generally, if the IRR exceeds the after-tax cost of debt, then the return to equity will exceed the IRR. This is due to the leverage effect gained by employing debt capital. Conversely, if the IRR should lie below the after-tax cost of debt, the returns to equity will be less than the overall returns (IRR) to the project.

Theoretically, returns to equity can be quite large in cases where the IRR exceeds the after-tax cost of debt and where debt is a significant proportion of the overall investment. In reality, overall indebtedness usually is kept at reasonable levels and rarely exceeds 50 percent of the total capitalization of a particular firm.

In calculating the NPV, we used a discount rate based on an annual WACC of 15 percent. The WACC was based on a hypothetical financial arrangement calling for equal parts of debt and equity financing. The before-tax cost of debt was set at 18.5 percent and the desired rate of earnings on equity at 20 percent.

**Taxes and Investment Tax Credits**

For taxable income, we apply the Federal corporate maximum rate of 46 percent. However, we do not include state and local taxes. Even so, we believe this approach generally will overstate the tax burden of most corporate investors.

We chose to exclude the investment tax credit from our evaluations because it has a history of change, and because it is dependent on the past and current earnings of individual investors. By not including the investment tax credit, we have understated the return likely to be realized by most investors.

**Phase In to Full Production**

We believe it is realistic to assume that full production will not be reached in the first year of operation. Mechanical difficulties, problems stemming from labor and supervisory inexperience, and a host of other factors undoubtedly will arise. To account for these eventualities, we have constructed DCF analyses to allow for a gradual move to full production. For each alternative, full one-shift production is not reached until the second year. First-year revenues are determined at one-half the full one-shift level, and cost generally at three-fourths the full one-shift level. Maxi-mill full two-shift production is not reached until year 3. If you, the potential investor, can accelerate the move to full production, so much the better. But if full production is not achieved in the period used in our studies, performance will fall short of our estimate.

Hansen, Bruce G.; Reynolds, Hugh W. **System 6 alternatives: an economic analysis.** Res. Pap. NE-551. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1984. 14 p.

Three System 6 mill-size alternatives were designed and evaluated to determine their overall economic potential for producing standard-size hardwood blanks. Internal rates of return ranged from about 15 to 35 percent after taxes. Cost per square foot of blanks ranged from about $0.88 to $1.19, depending on mill size and the amount of new investment required.

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