ECONOMIC FEASIBILITY OF PRODUCING INSIDE-OUT BEAMS FROM SMALL-DIAMETER LOGS

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ABSTRACT

Previous work has shown that it is technically feasible to produce inside-out (ISO) beams by taking small-diameter (5 to 7 in.) logs, slabbing four sides, quartering the cant, and turning the quarters inside out and gluing them together. After drying, the beams were found to be straight, with no cracks, and of equal or better mechanical properties than solid sawn beams of the same material. The objectives of this study were to determine if it was economically feasible to produce IS0 beams and if interest rate or daily production level influenced economic feasibility. Present net worth (PNW) with a lo-year planning horizon was used in the analysis. The interest rates were 8, 12, 16, 20, and 24 percent and the daily production levels were 400,600, and 800 tree-length stems yielding 464,696, and 928 small-diameter logs, respectively. Results indicated that the constraining variable in determining feasibility was production level, although discount rate was also important in determining PNW. The PNW of a 400-stem production level was always negative, while it was always positive for the 600- and 800-stem production levels. The break-even point was indicated to be approximately 550 stems per day for the equipment and production facility used in this study.

Throughout the forests of the United States, there is an abundance of small-diameter trees that need to be harvested for various ecological and silvicultural reasons. In Appalachia, for example, small-diameter hardwood trees need to be removed to maintain the health of the forest and improve the growing conditions for the remaining trees. In the South, plantations of southern pine need to be thinned to optimize the return on the investment of planting the trees. In the Northwest, various stands of old suppressed trees and new regeneration growth need to be thinned to improve the health of the stands, to increase biodiversity, and to reduce fuel loading to lower the risk of catastrophic forest fires.

The problem is that, in many areas, there is limited economic incentive to harvest small-diameter trees, which are usually limited to uses such as pulpwood, oriented strandboard (OSB) raw material, or firewood. In many regions of the Northwest and Appalachia, the distance to market is too great to haul logs from small-diameter trees. In other regions such as the South, mill residues and plantation thinnings are available in excess of market need and quotas given to the suppliers control mill receipts. However, in these areas, many small-diameter trees still need to be removed.

Of the leading industrial raw materials, wood accounts for 25 percent of the value, and the demand is growing. More effective use of existing timber resources would extend supplies, reduce waste, and slow deforestation.[1] Therefore, new products and markets need to be developed for small-diameter material.

In 1991, a study was begun at West Virginia University to determine the feasibility of producing inside-out (ISO) beams from the small-diameter logs cut from these small trees. This study was limited to three species of hardwoods (yellow-poplar, red maple, and red oak) and to the technical feasibility of pro-

[1] National Research Council. 1990. Forestry research - a mandate for change. National Academy Press, Washington, DC. 84 pp.

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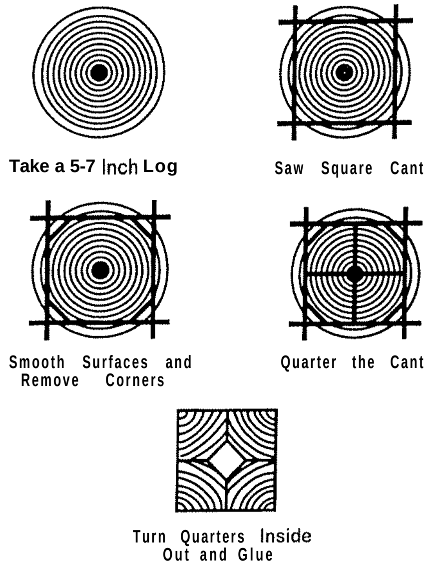

Figure 1. — The steps in making ISO beams.

TABLE 1. — The purchase costs and revenues (dollars) used in the economic analysis of producing ISO beams at each production level.

Cost item	Production level per day		
	400 stems, 464 logs or beams	600 stems, 696 logs or beams	800 stems, 92X logs or beams
	($)		
Land, building, scales	2 12,320	212,320	212,320
Lift trucks (2)	145,000	145,000	145,000
Log deck and conveyor	80,000	80,000	80,000
Debarker	170,000	170,000	170,000
Cut-off saw	25,000	25,000	25,000
Chipper	50,000	50,000	50,000
Skrag mill	175,000	175,000	175,000
Moulder (2)	100,000	100,000	100,000
Quartering saws	45,000	45,000	45,000
IS0 (clamping)	40,000	40,000	40,000
Boiler and kiln(s)	176,000	262,000	262,000
Pre-dryer (hardwoods)	215,833	323,750	431,831
Trim saw	25,000	25,000	25,000
Residue to boiler	33,000	33,000	33,000
Utilities/office	26,350	29,350	32,350
Salaries/wages	611,620	61 1,620	611,620
Logs	358,851	53X.276	717,701
Revenue (beams)	900,160	1,350,240	1,800,320
Revenue (chips)	220,168	330,250	440,334

ducing these beams. The objectives of the study were to determine if the beams could be made and how their properties compared to the properties of solid sawn beams.[2]

Small trees (6- to 9-in. diameter at breast height) were cut into S-foot logs. These logs were cut into 4-1/4-inch square cants with the sides parallel to the pith. The sides of the cants were smoothed on a moulder and the corners chamfered. The cants were then quartered, the exterior surfaces heat treated, resorcinol adhesive was applied, and the quarters turned inside-out and clamped together. After the adhesive cured, the new beams were kiln-dried and moulded to final size: 3-1/2 by 3-1/2 inches **(Fig. 1)**.

The results of the West Virginia study indicated that most properties of the ISO beams were superior to the properties of solid sawn beams. With IS0 beams, there is a hole in the middle of the beam because the comers of the cant are removed. This hole is advantageous in that it reduces the drying time, especially for oak, and improves treatability with preservatives. By turning the quarters inside out, the beam remains straight and has no drying cracks because the natural wood stresses work against each other. There is no significant difference in modulus of elasticity (MOE) or modulus of rupture (MOR) between the ISO beams and solid sawn beams. IS0 beams are technically a viable product.

Since the previous study determined that it was technically feasible to produce IS0 beams, this study was initiated with the objective of ascertaining if it was economically feasible to produce IS0 beams.

PROCEDURES

A study of the economic feasibility of producing ISO beams was initiated in Arkansas and included southern pine plantation thinnings as well as hardwoods. Engineering economic discounted cash flow procedures (present net worth [PNW]) with a IO-year planning horizon was used. Equipment suppliers were contacted for current costs, including purchase, shipping, installation, operating, and maintenance of each piece of machinery. Contractors and utility companies were asked to supply the costs of buildings, electric power, water, and waste removal. Wages, taxes, insurance, and other costs of doing business were included in the analysis. The analysis first looked at softwoods such as southern pine, which would require a kiln for drying the beams. The analysis then looked at hardwoods, which would additionally require a pre-dryer to reduce kiln residence time. **Table 1** shows the main purchase costs as well as the revenues from beams and chips.

The feasibility analysis was conducted using five discount rates (8, 12, 16, 20, and 24%) and three production levels (400, 600, and 800 stems delivered per day). The objective was to determine how these two variables influence the economic viability of producing IS0 beams. The discount rates varied from the current loan rate to the high-risk rate. Because a truckload of plantation thinnings contains approximately 100 tree-length stems, the production rates would require probably 4, 6, or 8 truckloads of stems per day.

To aid in detenninning raw material cost and estimating revenues, a visit was made to a local chip milt. Fifty pine stems were pulled from the stacks and spread on the ground. The diameter at each end, total length, and length to a 5-inch diameter top were recorded for each stem. Total stem volume was calculated for each stem and averaged for the 50 stems. The average value was multiplied by 0.03 tons per cubic foot

[2] Patterson, D.W. and X. Xie. 1998. Inside-out beams from small-diameter Appalachian hardwood logs. Forest Prod. J. 48(1):76-80.

and by $22.12 per ton, the 2-year average delivered pulpwood price[3], to determine the average delivered stem cost.

Length of the possible beam of each tree length stem was determined from the distance from the butt to a 5-inch diameter. Since 16 feet would be the longest beam produced, those stems with possible beam portions longer than 16 feet would be cut into two shorter logs, such as an 8-foot log and a IO-foot log, or two 12-foot logs. From the sample of 50 tree-length stems, 58 logs/beams could be produced. Distribution of beam lengths was: 10 percent were S-foot; 38 percent were IO-foot; 16 percent were 12-foot; 15 percent were 14-foot; 21 percent were 16-foot.

Southern pine 4 by 4 prices[4] were used to estimate income. As depicted in Figure 2, the price varied by length and by season. A 2-year average price ($/beam) was determined for each length. The average price per beam was determined by a weighted average, which was the sum of the values of the average price for its length times its length distribution percentage ($7.76 per beam),

The tops of the tree-length stems and slabs would be chipped and sold to a pulpmill. Chip price reported by most surveyed sawmill managers was $22 per ton. The other residues would be used for boiler fuel to heat the dry kilns.

RESULTS

Results of the analysis showed that for both pine and hardwood logs, the PNW was negative for all discount rates at the 400 stems per day production level (**Figs.** 3 and 4). On the other hand, the PNW value was positive for all discount rates for the 600 and 800 stems per day production levels. The PNW value for the 800-stem level was approximately $2 million higher than the PNW value for the 600-stem level in all cases. As the discount rate increased, the PNW value decreased, but increases in discount rate never caused the PNW value to become negative for the three production levels studied. Output level appears to be the critical factor in the economic feasibility of producing ISO beams.

[3] Timber-Mart South. 2nd Quarter 1996 to 2nd Quarter 1998. Daniel B. Warnell School of Forest Resources, Univ. of Georgia, Athens, GA.

[4] Random Lengths. June 1996 to June 1998. Random Lengths Publications, Inc., Eugene, OR.

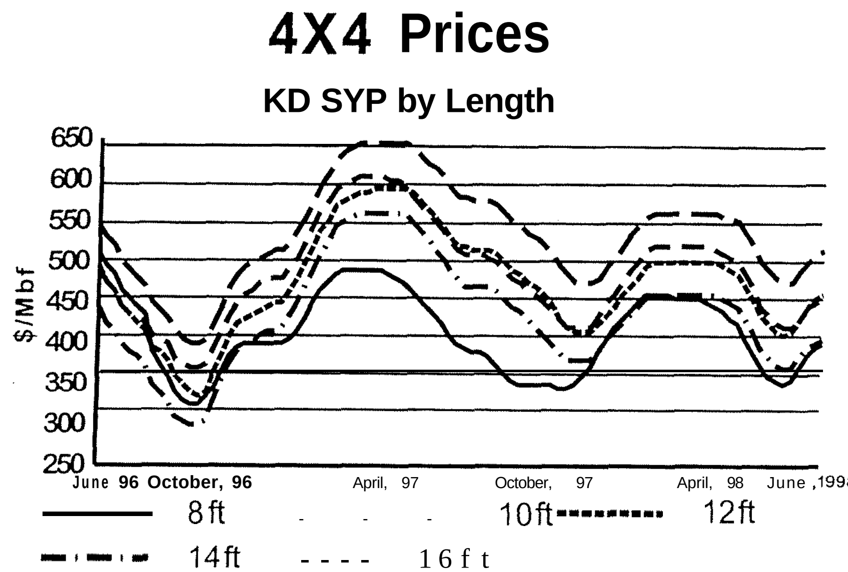

Figure 2. — Prices of southern pine 4 by 4 lumber by length.

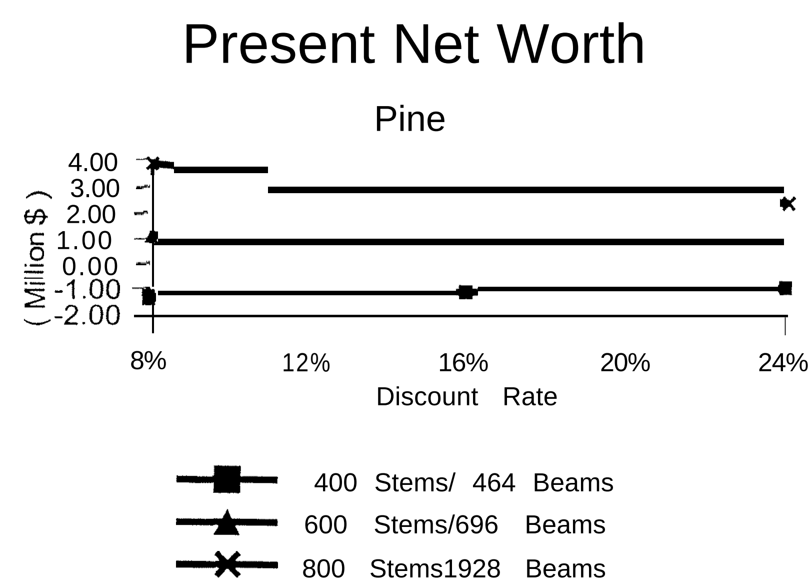

Figure 3.— PNW analysis of a southern pine ISO beam manufacturing facility using a 1 O-year planning horizon

In analyzing the variable costs and fixed costs for the operation, the revenues exceed the variable costs for all production levels. It is the fixed (capital) costs that affect the profitability of producing ISO beams. As the fixed costs are spread over increasing levels of output, average fixed cost drops. The economic break-even point in our analysis was between 500 and 550 stems per day. At 550 stems per day, approximately 638 beams were produced per day (10,208 board feet per day). This would total 159,500 beams or about 2.552 million board feet annually. Reducing fixed costs by buying used equipment, leasing forklifts or other rolling stock, or other capital reductions could decrease the break-even point,

SUMMARY

This feasibility study demonstrates that ISO beams can be produced economically given these costs and prices. Prior work showed that ISO beams are straighter, had no cracks, required less

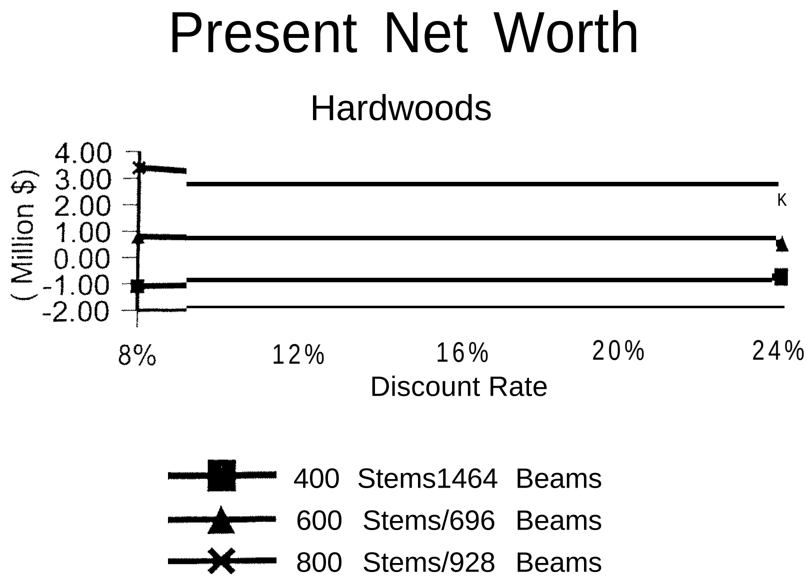

Figure 4. — PNW analysis of a hardwood ISO beam manufacturing facility using a 1 O-year planning horizon.

drying time, and had the same or greater strength than solid sawn beams of the same material. This analysis showed that it is economically feasible to produce IS0 beams.

Southern pine 4 by 4 prices were used to estimate revenue for this analysis. However, this does not imply that IS0 beams can only be used to replace 4 by 4's. There are a wide range of uses for these beams. For example, several IS0 beams could be glued together to produce decorative laminated beams. Additionally, tension rods could be placed in the voids in the center of each IS0 beam in the laminated beam to produce structural beams. Also, the beams could be used for light standards with the wires running through the hollow center. The potential uses of these beams are limited only by the imagination.