An Input Factor Demand Model for the Sawmilling Industry of the Lake States

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Introduction

The purpose of this study is to derive own-price and cross-price elasticities for the major input factors of the sawmilling industry of the Lake States (Michigan, Minnesota and Wisconsin).

The motivation for this research came from the Montreal Process of 1993 which arose from the Rio conference of 1992. The Montreal Process entailed the development of criteria and indicators of sustainable forestry for temperate and boreal forests and in the end, six criteria and hundreds of indicators were developed. When reading through the criteria and indicators there is the realization that they are really a shopping list of factors that should be included in sustainable forestry. However, the important question what is the optimal value of each indicator? What is necessary to make that decision is an idea of the tradeoffs among the various criteria and indicators. The purpose of this paper is to help quantify the tradeoff between increased sawlog price and demand for labor in the sawmill industry. The next step in the research program would be to determine how changes in the level of other indicators will affect sawlog price. For instance, a political jurisdiction may decide that they support more wilderness or biodiversity and so timber harvests on public land may be reduced. This will affect sawlog price and consequently demand for labor in the sawmilling industry.

There are reasons other than environmental restrictions that timber supply may be restricted in the future. Changes in attitudes of private landowners in the future may restrict timber supply from non industrial private forest land (NIPF). More than one third of the forestland in the Lake States is NIPF. There is a trend toward preservation of forest cover on these lands by new landowners and this could affect availability. Overall, forest managers in the Lake States foresee a 8% decrease in area of available land for harvest by 2020 (Vasievich, Potter-Witter and Leefers 1997).

Literature Review

There have been a number of papers written on the production structure and demand for inputs in the sawmilling and pulp and paper industry of North America. Most focus on a specific region of the United States or Canada. Also, they tend to make comparisons among regions. This style of analysis was used by Caves et al (1981) in studying the railway industry of the U.S. and follows the duality relationship between production functions and restricted cost functions derived by Lau (1978).

It is typical in these analyses to use a cost function of some type but a profit function may also be used. The profit function route is more data intensive and may introduce some econometric problems due to the increased number of coefficients to estimate.

Abt (1987) and Meil and Nautiyal (1988), use translog restricted variable cost functions to estimate production structure and factor demands for several lumber producing regions of the U.S. and Canada respectively. It is assumed with this method that producers are efficient in that they minimize costs given an output level. It is also assumed that they are only able to minimize costs with respect to certain inputs. In the case of the above papers, log input and labor input are adjusted to minimize costs but capital is "quasi-fixed", that is, capital is not included in the variable cost of the firm but is included in the model estimating variable cost.

Methods

The input factor demands and the own-price and cross-price elasticities are derived through the estimation of a translog restricted variable cost function. The variable inputs include labor and logs and capital is treated as quasi-fixed. That is, variable cost is minimized by the choice of labor and sawlog input. The model includes the translog restricted variable cost function and a cost share equation for one of the variable inputs. By definition, the cost shares of the variable inputs add up to one so only one cost share equation may be used in order to avoid a singular matrix. It does not matter which input cost share equation is used. The labor cost share equation is used here.

So, the model to be estimated is shown below.

$$\begin{aligned}\ln VC &= \beta_0 + \beta_1 \ln LP + \beta_2 \ln SLP + \beta_3 \ln K + \beta_4 \ln LUMPROD \\ &+ \tfrac{1}{2}(\beta_{11} \ln LP^2 + \beta_{22} \ln SLP^2 + \beta_{33} \ln K^2 + \beta_{44} \ln LUMPROD^2) \\ &+ \beta_{12} \ln LP \ln SLP + \beta_{13} \ln LP \ln K + \beta_{14} \ln LP \ln LUMPROD \\ &+ \beta_{23} \ln SLP \ln K + \beta_{24} \ln SLP \ln LUMPROD + \beta_{34} \ln K \ln LUMPROD + \varepsilon\end{aligned}$$

$$\ln LCSTSHR = \beta_1 + \beta_{11} \ln LP + \beta_{12} \ln SLP + \beta_{13} \ln K + \beta_{14} \ln LUMPROD + \nu$$

Where:

Variable Name	Definition
VC	Variable cost = labor cost +sawlog cost
LP	Labor price in dollars per hour
SLP	Sawlog price in dollars per mbf
K	Capital stock in 1996 dollars
LUMPROD	Lumber production in mbf
LCSTSHR	Labor cost share

Tests for homogeneity in prices and constant returns to scale in production show that we can reject the null hypothesis in both cases at the 5% level of significance. A major advantage of the translog functional form is that it is flexible and therefore does not hold the inputs at a fixed proportion at different output levels. Therefore, CRS was not imposed on the model. However, homogeneity in prices is a necessary property of a well behaved cost function and was imposed on the model through the following parameter restrictions:

$\beta_1+\beta_2=1$
$\beta_{11}+\beta_{12}=0$
$\beta_{22}+\beta_{12}=0$
$\beta_{14}+\beta_{24}=0$
$\beta_{13}+\beta_{23}=0$

The model was estimated using full information maximum likelihood (FIML) estimation method.

The own price and cross-price elasticities are calculated based on the following formulae:

$$E_{ii} = \mu_{ii} * S_i$$
$$E_{ij} = \mu_{ii} * S_j$$

Where S_i is the cost share for input *i* and μ_{ii} is given by:

$$\mu_{ii} = \frac{\beta_{ii} + S_i^2 - S_i}{S_i^2}$$

Once the estimation is complete it is simply a matter of plugging the values into the above formulae to calculate own-price and cross-price elasticities.

Data

The data required for the model include: quantity of labor and logs going into the milling process, the prices of those inputs, the value of the capital stock of the milling industry and the volume of output (lumber). Data were collected for three states (Michigan, Minnesota and Wisconsin) for the period 1980-1996. Following is a discussion of each data type.

Labor Quantity

Labor quantity is defined as man hours for production workers in SIC 242 (sawmills and planing mills) for each year. The data source is the Annual Survey of Manufactures (ASM) from the Census Bureau. The time series ends at 1996 because at that time the Census Bureau changed from the SIC system to the NAICS and there is poor correspondence between SIC 242 and the new classifications. For some years, data for SIC 242 was not available and so an approximation of the SIC 242 data was made from the SIC 24 (lumber and wood products) data. The same data source was used for all three states.

Sawlog Quantity

The quantity of sawlogs entering sawmills for the three states comes from several sources.

The first source is the periodic Timber Product Output (TPO) reports published by the North Central Forest Experiment Station. Sawlog receipts (volumes received) are given by species for sawmills in each state. However, these reports are published only every two years at best during the time frame of this study.

Volume of sawlogs entering mills had to be estimated for other years from available harvest data. National Forest and State Forest harvest data is available for all years and states by species. In Minnesota and Wisconsin, county and municipal land harvests are also available. For Michigan, county and municipal lands are not important in terms of volume produced.

Much of the Minnesota and Wisconsin harvest data comes from numbers compiled by the states' Department of Natural Resources. These data include private land harvests as well as public and Indian lands.

For certain years, only public land harvests of sawlogs were available. In these cases, an estimate of total harvest was made using the same proportion of public-private harvests as in nearby years where harvest from all lands was available.

Labor Price

Labor price is calculated easily from the ASM data for SIC 242. Labor price is calculated as dollars per hour for production workers. It is simply the payroll expense divided by the number of hours worked. Again, for years where SIC 242 data is not available, estimates were made using SIC 24 data.

Sawlog Price

Michigan sawlog price data comes mainly from Timber Mart North quarterly price reports for delivered logs measured in $/mbf. Wisconsin and Minnesota also have Timber Mart North price reports for 1995 and 1996. For years prior to 1995 Minnesota price data comes from the Minnesota Forest Products Price Report. For Wisconsin, price data other than that from Timber Mart North comes from the Wisconsin Forest Products Price Review. For years where none of these sources are available, stumpage prices were used plus an additive factor to account for logging and transportation costs.

Capital Stock

The capital stock of sawmills in each state was calculated based on new capital expenditures. Capital stock was calculated assuming a 25 year life of capital with straight line depreciation. New capital expenditures from 1955-1996 were collected from the ASM and the Census of Manufactures. The final values were then converted to 1996 dollars using the PPI.

Lumber Output

Output volumes come from the Census Bureau publication MA24T: Lumber production and mill stocks. Volumes are in MBF International 1/4" log rule.

Results and Discussion

The estimation results are shown below including coefficient values, standard errors, R^2 for each equation and the elasticities as calculated from the above formulae.

Table-1 Estimation Results

Coefficient	Variable	Value	Standard Error
β_0	constant	-10.73	10.24
β_1	lnLP	-0.499	1.00
β_2	lnSLP	1.499	NA
β_3	lnK	1.72	3.64
β_4	lnLUMPROD	0.513	3.25

β_{11}	$lnLP^2$	1.058	NA
β_{22}	$lnSLP^2$	1.058	NA
β_{33}	lnK^2	-0.521	1.64
β_{44}	$lnLUMPROD^2$	-0.467	0.59
β_{12}	lnLPlnSLP	-1.058*	0.32
β_{13}	lnLPlnK	0.518*	0.12
β_{14}	lnLPlnLUMPROD	0.0117	0.119
β_{23}	lnSLPlnK	-0.518	NA
β_{24}	lnSLPlnLUMPROD	-0.0117	NA
β_{34}	lnKlnLUMPROD	0.508	1.07

Cost Function R^2 0.47
Share Equation R^2 0.48
*indicates significance at the 5% level
NA=not applicable as coefficient is calculated from other coefficients

Table-2 Elasticities

Own-price elasticity of demand for labor	-3.1
Own-price elasticity of demand for sawlogs	1.8
Cross-price elasticity for labor/sawlogs	5.5
Cross-price elasticity for sawlogs/labor	-1.0

The first thing the economist will notice is that it appears we have discovered a Giffen good. The sign on the own-price elasticity of demand for sawlogs is positive. In a cost function model this does not make sense but one needs to keep in mind the process by which sawlog prices are determined.

On public land, sawlog price is partially determined by the stumpage value of the timber. Stumpage value in turn in partially determined by lumber price. Therefore, as lumber price increases, sawlog price automatically increases. On private land the price discovery process is a little more familiar in that as lumber price increases, competition for timber will increase and sawlog prices rise. It is possible for sawlog prices to increase and yet producers can increase their margins on the lumber they produce from those sawlogs. For example, lumber price may increase by $30/mbf but this translates into only a $10/mbf increase in sawlog price. Producers are then earning an extra amount on every mbf of sawlogs they convert to lumber. Of course, one mbf of sawlogs does not convert to one mbf of lumber so the conversion efficiency of the sawing process is important. Another point to keep in mind is that the lumber price is determined exogenously . The major factor affecting lumber price is housing starts for which the Lake States play a minor role. On the supply side, events in the Southeast, Northwest and Canada will have a much larger effect on lumber price than anything in the study region.

Another thing the economist will notice is that only two variables are significant at the 5% level. However, this is not unusual for models of this type. For the hardwood region, Abt (1987) also has only two variables significant at the 5% level. What is more relevant is the overall significance of the model.

The results show that the sawmilling industry in the Lake States is very sensitive to price changes compared to other regions. Much of the region, particularly the southern areas, is characterized by smaller hardwood mills. These mills may find it easier to increase or decrease output and consequently labor and sawlog input than their larger, unionized counterparts in the Northwest for instance. Also, the fact that much of the hardwood timber comes from private land contributes to the volatility of timber supply.

As for the collinearity between sawlog price and lumber price, an alternative to the cost function is the profit function. This will explicitly take account of the effect of output price on production decisions.

Conclusions

In order to draw conclusions on the effect of sawlog price increases on labor demand it will be necessary to distinguish between sawlog price increases due to scarcity and sawlog price increases due to increased output price. Again, a way of doing this is to include output price in the model via a profit function. As it stands, the region shows itself to be sensitive to input price changes. Further to that, future research will need to identify the effect of environmental regulations or other supply side factors on sawlog price.

Literature Cited

Abt, R.C. 1987. An analysis of regional factor demand in the U.S. lumber industry. Forest Sci. 33:164-173.

Caves, D.W., L.R. Christensen, and J.A. Swanson. 1981. Productivity growth, scale economies, and capacity utilization in U.S. railroads, 1955-1974. Am. Econ. Rev. 71:994-1002.

Lau, L.J. 1978. Applications of profit functions. *In* Production economics: A dual approach to theory and applications, Vol. I, Fuss and McFadden (eds.). North-Holland. 469 p.

Meil, J.K., and J.C. Nautiyal. 1988. An intraregional economic analysis of production structure and factor demand in major Canadian softwood lumber producing regions. Can. J. For. Res. 18:1036-1048.

Vasievich, J.M., K. Potter-Witter and L.A. Leefers. 1997. Timber supply and market trends in the Lake States. *In* Lake States regional forest resources assessment: technical papers, Vasievich and Webster (eds.). General Technical Report NC-189. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 314 p.