A LOGISTICAL REGRESSION MODEL OF SOUTHERN HARDWOOD LUMBER EXPORT PARTICIPATION

A. L. Hammett, III

Adjunct Assistant Professor
D.B. Warnell School of Forest Resources
University of Georgia
Athens, GA 30602

Frederick W. Cubbage

Project Leader
Southeastern Forest Experiment Station
Box 12254, Research Triangle Park, NC 27709

and

William G. Luppold

Project Leader
Northeastern Forest Experiment Station
Forestry Sciences Lab, Box 562-B
Princeton, WV 24740

(Received May 1991)

ABSTRACT

A survey of nine hundred hardwood lumber manufacturers in seven southern states gathered information on mill production capabilities, marketing practices, equipment, and products. Models utilizing logistical regression were developed to assess mill characteristics and how they influence participation in export markets. Mill yearly rated production, lumber production of oak species, covered storage capacity, sales manager's education level, and public ownership all were found to have a positive influence on a mill's export participation. Sales to finished products manufacturers, production of grade three lumber, production of pallets or pallet parts, and private ownership were significant in inhibiting export participation. Expansion plans, number of species sawn, age of sales manager, and importance of sales calls to marketing effort were all found not to be significant predictors of hardwood lumber mills' export participation, or lack thereof.

Keywords: Hardwood lumber manufacturers, export market participation, logistical regression.

INTRODUCTION

Large volumes of southern wood products are sold to international markets. These exports have been due to a growing timber resource, access to many all-weather ports, and a well-developed infrastructure, including many timber processing facilities. Products manufactured from hardwood species, such as red oak, white oak, sweet gum and ash, are an important part of the region's forest industry.

In 1987, hardwood mills in the Southeast and South Central regions of the United States produced 2,308 and 2,748 million board feet of lumber, respectively (USDA Forest Service 1988). This represented increases of 51% and 80%, respectively, for these regions over 1986 (Luppold 1989). The South's hardwood timber resource contains many species highly valued both in domestic and foreign markets (Wisdom 1988). This resource is increasing in size (Araman 1988) and can support even higher domestic and international market demand (Tate et al. 1989). Increased production of hardwood lumber due to expanded exports would greatly benefit many areas in the South.

This study was initiated to quantify factors

Wood and Fiber Science, 24(3), 1992, pp. 315–329

important to hardwood lumber exports. The first section of this paper reviews literature on the export methods and relevant export studies. The next section describes a survey of southern hardwood lumber manufacturers we conducted to find characteristics associated with firms that did—and did not—export their products. Subsequent sections present an analysis of these factors and suggest means by which firms could initiate or expand export sales, and way policymakers might encourage hardwood exports.

LITERATURE REVIEW

The solid wood products industries, and most notably the lumber sector, have traditionally used overseas markets merely as an outlet for excess production when domestic markets are slack. Export markets have not been fully integrated into successful hardwood lumber marketing strategies.

Export methods

Before one can understand what factors might influence successful exporting, a clear understanding of export methods and marketing practices is necessary. For instance, the appointment of one person responsible solely for export sales is often necessary (Jones 1980). Timely response to inquiries from overseas buyers often requires the use of telex or facsimile machines (Evans 1990). Various specialized bank draft systems and in-transit cargo and credit risk insurance are frequently required for export shipments (Evans 1990). Hardwood lumber often needs to be end-coated, strapped in bundles with heavy duty straps, protected with corner guards, and covered during transit (Araman 1988).

Forest product export studies

Researchers in other industries have conducted numerous studies to determine factors common to exporting firms. A review of studies that analyzed exports of southern forest products was made to help determine which firm characteristics might influence hardwood lumber exporting efforts.

Firms must be reliable suppliers to overseas customers and must provide hardwood lumber of consistent quality, as overseas markets often have strict grade requirements. One barrier to exporting is that forest products required overseas are often different than those needed in U.S. markets (Walters 1982). Hardwood log exporters were shown to have higher sales volumes and numbers of employees than nonexporters and felt that they could increase overseas sales by expanding marketing efforts, shortening delivery times, and sending employees overseas to visit customers (Owens 1990).

For hardwood lumber exporters, firm size has been found not to be a significant factor in determining whether or not a firm had exported (Ringe et al. 1987). For nonexporting firms, lucrative domestic markets and an inability to produce enough export-quality lumber discouraged overseas sales. Red oak and white oak lumber of higher grades were popular with overseas customers (Ringe et al. 1987). Exporting firms emphasized the need to understand overseas marketing procedures and to have adequate international communication equipment.

In a survey of northeastern forest products manufacturers (Northeastern Forestry Alliance 1989), mills cited poor communication, difficulties in meeting lumber specifications, and lack of knowledge about customers as hindering exports. Nonexporters indicated exporting would jeopardize their ability to supply existing domestic markets.

Lumber exporters have been found to have larger sales and more employees than nonexporters. Firms tended to be of a minimum size before beginning to export, but above this threshold increasing firm size had little impact on export participation (Gottko and McMahon 1989). In contrast, Shinn (1989) found that smaller firms in the Northwest had a competitive advantage when entering export markets as they could shift species, products, and markets more quickly than larger firms.

SOUTHERN HARDWOOD LUMBER EXPORT DATA

In 1990 a mail survey of hardwood lumber mills was conducted in seven southern states: West Virginia, Virginia, South Carolina, North Carolina, Georgia, Tennessee, and Kentucky (Hammett et al. 1991). A sample of 890 mills was selected from the 2,225 hardwood sawmills listed in these states' most current forest industry directories. The number of hardwood lumber mills included by state was based on each state's share of the total hardwood sawtimber volume for the seven states, as reported in Haynes (1988).

The mail survey was developed based on the Total Design Method (Dillman 1978), which suggests that several mailings follow the mailing of the initial survey. Information on nonrespondents was gathered from a telephone follow-up survey to a sample of 50 mills that had not returned forms (Raj 1972). *T*-tests yielded no statistically significant differences between the respondents and nonrespondents on any of the key questions in the survey (Hammett et al. 1991).

Responses from 488 mills were collected for an overall response rate of 54.8%. Mills found to be inactive, out of business, not cutting a significant percentage of total lumber production from hardwood species, no longer producing lumber products, or those mills that did not complete a major portion of the questionnaire accounted for 230 of the 488 and were not included in the analysis.

Export markets were defined as all international markets, including Canada and Mexico. If a mill had sold its products to foreign markets within the past five years, it was considered an exporter. All other responding active mills were considered nonexporters in the analysis. Of the 258 usable responses, 105 were from exporter mills and 153 from nonexporter mills. Table 1 explains the types of data collected and Table 2 gives summary statistics for each question.

MODELING EXPORT PARTICIPATION

Statistical methods were used to measure the relationships between firms' business and production characteristics and the likelihood that they had exported within the past five years. Traditional analytical methods such as Ordinary Least Squares (OLS) are unsuited for use with a binary dependent variable (Kachigan 1986)—in this case whether a firm had or had not exported within the past five years. Several problems prevent the use of OLS regression techniques with a binary dependent variable. These include violating the assumptions concerning the error terms, the failure of ordinary tests of significance and goodness of fit, and the possibility of OLS predicted outcomes outside the (0, 1) interval (Hodges and Cubbage 1990).

Multivariate methods were also considered, but these methods assume that the original profiles of data are normally distributed. Since the data include dichotomous variables, this assumption was violated, which would bias the significance test and estimated error rates in the analysis (Press and Wilson 1978). Hence, another method should be used that would have known distributional properties, would estimate the true relationship within the range of the data, and give probability estimates within the range of 0 to 1 (Aldrich and Nelson 1984).

Logistical regression

Models involving qualitative choice are especially applicable for survey data where individuals are asked opinions or are directed to indicate degrees of agreement or satisfaction (Stiefel 1990). Press and Wilson (1978) compared one such model, logistical regression, to discriminant analysis and found discriminant analysis not desirable, especially where normality assumptions were violated and when many independent variables were qualitative. However, logistical regression analysis is applicable for any combination of discrete and continuous variables (Afifi and Clark 1984; Royer 1985; Jamnick and Beckett 1988), and represents an alternative classification when the multivariate normal model is not justified (Hosmer and Lemeshow 1989).

The problem of having probabilities that lie

TABLE 1. *Summary of hardwood lumber exporting logistical regression variables.*

Variable acronym	Description	Measurement	Expected sign
MILLPROD	Rated yearly production capacity	Yearly rated production capacity in million board feet	+
PRODTHRE	Grade three lumber production	% of total lumber production	−
AGE	Sales manager's age	Years	−
BACHDEG	Sales manager's education	Bachelor's degree, 1 = yes, 0 = no	+
SALECALL	Importance of sales calls to potential customers on mill's marketing effort	where 1 = not important, 2 = somewhat important, 3 = important, and 4 = very important	+
PUBLCORP	Public owned firm	1 = yes, 0 = no	+
PRIVCOMP	Privately owned firm (sole proprietorship, partnership, or family owned firm)	1 = yes, 0 = no	−
CVSTCAP	Covered storage capacity	Covered storage capacity in million board feet	+
EXPAND	Mill has expansion plans	1 = yes, 0 = no	+
OAKHWLUM	Production of white and red oak lumber	% of total lumber production	+
NOSPEC	Number of species sawn	Number of species	+
PALPRODS	Production of pallet products	% of total lumber production	−
OTHMANUF	Sales to furniture, flooring, log home, flooring, and other manufacturers, and in-house use.	% of total sales.	−

outside the 0 to 1 range can be resolved by changing the estimated function form from a linear to a curved one (Stiefel 1990). This transformation has been called the logistic or logit, and is popular with economics researchers (Debertin et al. 1980; Neter et al. 1985), and in forest economics and other related disciplines.

This method has been used to help explain profit and loss on logging timber tracts (Hassler et al. 1986), to determine the likelihood that woodlot owners harvest timber (Jamnick and Beckett 1988), and to model the socioeconomic factors that affect timber supply from nonindustrial timberlands (Kuuluvainen et al. 1984). Royer (1987) used logistical regression to help predict reforestation investments, and Hodges and Cubbage (1990) used it to help determine the likelihood that foresters would adopt new management technologies. Extensions of this method have allowed for the measurement of the degree of participation explained by each of the factors studied (Hardie and Hasson 1986; Hodges and Cubbage 1990).

The conceptual model

Hardwood mills vary in production capabilities, marketing practices, equipment, and products. Any model of export participation for the hardwood lumber industry should include these and similar factors. Based on the observations gained through the survey, a model of hardwood mill export participation was hypothesized as:

$$EP = f(MC, MP, MPF, PPF) \qquad (1)$$

where,

EP = export participation by a mill
MC = mill characteristics
MP = marketing practices
MPF = mill production factors
PPF = product profile factors

The next step in the analysis involved applying the proposed conceptual model to the collected mill data. This required selecting operational variables to represent the structural parameters in the equation. Rather than try to interpret the significance of when a mill started exporting, or how much of a mill's total production was exported, it was decided to use whether a mill exported during the past five years as the dependent variable for this analysis. This was a dichotomous (yes/nor or 1/0) variable, thus appropriate for a logistical regression model and is explained by numerous independent variables. The probability of each variable explaining export participation falls between zero and one.

Logistical regression is used to transform the original model so that predicted outcomes will fall within the (0, 1) interval for all values of the independent variables (Pindyck and Rubinfeld 1981). Based on the cumulative logistic probability function, the logistic transformation is specified as:

$$P_i = F(\alpha + \beta X_i) = \frac{1}{1 + e^{-(\alpha+\beta X_i)}} \quad (2)$$

where,

P_i = probability of hardwood lumber export participation
e = base of natural logarithms
β = vector of coefficients to be estimated
X_i = vector of independent variables
α = intercept term

We were interested in the probability of a hardwood lumber mill's being a member in one of two categories—those mills that have exported, and those that have not exported. The linear equation, including explanatory variables from the groups described above, gives the probability that the binary dependent variable will equal one or that a mill had sold its lumber to overseas customers. The data were analyzed utilizing the Statistical Analysis System (SAS) PROC LOGIST procedure (Harrell 1986).

Variable selection

Stepwise regression has been used to select potential variables for models (Hassler et al. 1986; Jamnick and Beckett 1988) and to pick from large numbers of variables in other disciplines (Hosmer and Lemeshow 1989). However, this method of variable selection leads to biased estimation and is not reliable in variable selection (Kennedy 1987).

Because of incomplete responses, many observations contained unanswered survey questions. Substitutions of averages or estimates for missing values in the data were avoided in order to not to risk introducing bias.

Since there were too many variables for a one-step logistic regression, it was determined that utilizing a multi-level procedure for variable selection would better suit the data. Variables were grouped in classes similar to those found in the survey instrument. This format enabled separate analysis of each individual group, and allowed the selection of the best variables from each group for the final models. This method also allowed more information to be gathered by group and minimized the effect of missing values. Since each variable group was considered separately when choosing variables, analyses could then be conducted with minimal loss of observations, yielding the most accurate models possible.

The Statistical Analysis System PROC CORR procedure (SAS Institute 1982) was utilized to conduct collinearity tests at each level to eliminate highly correlated variables. Only one of any collinear variables at the level alpha <0.05 was retained in the selection process, leaving an unbiased data set.

At the first level, four main groups of variables—Mill Characteristics, Marketing Practices, Mill Production Factors, and Product Profile Factors—were divided into nine subgroups that were small enough to facilitate separate collinearity tests. Variables with the strongest correlation to the dependent variable were chosen; then *a priori* knowledge and the PROC CORR procedure were utilized to eliminate related variables. Variables not highly collinear in these subgroups were then combined in their respective original main groups for further screening. At this second level of screening, collinearity tests were conducted on these four main groups to find variables suitable for modeling hardwood lumber export participation.

This final group of variables derived from the second level was also screened for collin-

TABLE 2. *Summary statistics for selected hardwood lumber manufacturer data.*

	Number	Mean	Standard deviation	Minimum	Maximum
MILLPROD					
Total	258	6.71	6.45	0.02	62.00
Exporters	105	9.03	7.82	0.25	62.00
Nonexporters	153	5.13	4.73	0.02	30.00
PRODTHRE					
Total	223	11.81%	11.93%	0.00%	65.00%
Exporters	99	10.25%	10.11%	0.00%	50.00%
Nonexporters	124	13.05%	13.11%	0.00%	65.00%
AGE					
Total	224	43.63	10.90	24	70
Exporters	91	42.74	10.86	24	69
Nonexporters	133	44.24	10.92	25	70
BACHDEG					
Total	234	0.32	0.47	0	1
Exporters	96	0.48	0.50	0	1
Nonexporters	138	0.22	0.41	0	1
SALECALL					
Total	258	1.33	0.95	0	4
Exporters	105	1.44	0.93	0	4
Nonexporters	153	1.25	0.96	0	4
PUBLCORP					
Total	258	0.08	0.27	0	1
Exporters	105	0.11	0.32	0	1
Nonexporters	153	0.06	0.24	0	1
PRIVCOMP					
Total	258	0.90	0.30	0	1
Exporters	105	0.87	0.34	0	1
Nonexporters	153	0.93	0.26	0	1
CVSTCAP					
Total	249	0.19	0.49	0	5.0
Exporters	101	0.37	0.69	0	5.0
Nonexporters	148	0.06	0.19	0	1.2
EXPAND					
Total	258	0.32	0.47	0	1
Exporters	105	0.37	0.49	0	1
Nonexporters	153	0.29	0.45	0	1
OAKHWLUM					
Total	258	46.98%	21.55%	0%	100%
Exporters	105	51.52%	21.13%	0%	91%
Nonexporters	153	43.86%	21.34%	0%	100%
NOSPEC					
Total	258	6.11	2.13	1	11
Exporters	105	6.24	2.34	1	11
Nonexporters	153	6.03	1.98	1	10

TABLE 2. *Continued.*

	Number	Mean	Standard deviation	Minimum	Maximum
PALPRODS					
Total	254	18.80%	25.37%	0%	100%
Exporters	105	13.10%	19.47%	0%	100%
Nonexporters	149	22.82%	28.20%	0%	100%
OTHMANUF					
Total	249	88.10%	19.72%	0%	100%
Exporters	103	86.39%	18.13%	30%	100%
Nonexporters	146	89.32%	20.75%	0%	100%

earity before placing variables into logistical regression models. In order to produce the most useful models for hardwood lumber manufacturers, variables from each of the four groups were considered for each of the final models.

Anticipated effects

The four main groups of independent variables include: *Mill Characteristics,* which quantify mill size and percentage of total lumber production in each grade; *Marketing Practices,* concerning marketing of lumber products and sales or advertising techniques; *Mill Production Factors,* which describe the number of workers, mill ownership, equipment, and expansion plans; and *Product Profile Factors,* which relate to species sawn, products produced, and markets. Table 1 gives the anticipated influence of each variable related to hardwood lumber exporting. A positive sign indicates that the variable would be expected to increase the probability of export participation; a negative sign, the reverse.

Mill characteristics.—Traditionally, sawmills have been reluctant to divulge actual production or sales figures. While our survey asked for sales and production information, respondents provided rated production data most consistently so we used it in our analysis. Rated production figures reflect a mill's capacity to produce lumber, and were closely correlated with actual production volumes. The MILLPROD variable is a mill's rated production capacity in million board feet per year. We hypothesized that larger mills can afford to cut and store enough high quality lumber to fill the traditionally large shipments foreign customers require. This variable should be positively related to the probability that a mill had exported.

Another factor thought to be related to a lumber manufacturing firm's competitiveness in foreign markets is the production of higher quality lumber. Lumber is usually graded based on color or appearance, and other product quality attributes, according to its intended eventual use. Grade three lumber is of lower quality, and often used in pallet production or other appearance insensitive products. We hypothesized that production of grade three lumber (PRODTHRE) would be negatively related to the probability of export participation.

Marketing practices.—While exporting is not a new concept, forest products managers do need to be innovative and willing to risk inventory and other resources when selling to foreign markets. Younger sales managers might be more aware of the potential benefits to be gained from exporting. Older sales managers might rely more on long-standing customers and be reluctant to commit to new, more distant markets. We hypothesized that older sales managers (AGE) would reduce the likelihood of exports.

Similarly, a more educated sales manager should be more knowledgeable about the intricacies and potential profits of exporting. Increased analytical and marketing skills would most likely help firms interested in selling in foreign markets. We hypothesized that mills having sales managers with bachelor's degrees (BACHDEG) would benefit from this education and their export potential would be enhanced.

Traditionally, lumber has been sold locally to established customers. Previous studies (Owens 1990) have confirmed that sales calls to potential customers help increase the probability of foreign sales. Many mills are too small to support extensive sales staff or travel. Thus, the SALECALL variable was developed to reflect how much importance each mill put on making sales calls to retailers, wholesalers, and contract lumber suppliers. Each response ranked 1 as not important to 4 as important to a mill's marketing effort. We hypothesized that exporting mills place heavy importance on soliciting new customers, and hence should do better in export markets.

Mill production factors.—The form of mill ownership would also seem important for determining export participation. Publicly owned larger firms tend to act slowly and are less likely to enter export markets (Shinn 1990). Privately owned firms tend to be smaller and therefore can move in and out of markets quickly. Hence, we expected that public ownership (PUBLCORP) would negatively affect the likelihood of exports; while the converse would be true for privately owned firms (PRIVCOMP).

Mills that produce for foreign markets often need to cut and store large volumes of lumber before reprocessing, drying in dry kilns, and concentrating in large enough shipments for export. CVSTCAP indicates a mill's covered storage capacity in million board feet. We expected that the ability to store larger volumes of lumber in protected areas would have a strong positive influence on export participation.

In an effort to quantify mill expansion plans, the variable EXPAND was developed. Mills having expansion plans, such as opening a new plant or adding new products, are presumably growing, economically sound, and have vision. Hence, we believed that this variable would have a positive link with export participation.

Product profile factors.—Lumber sawn from red or white oak has been in high demand in the 1970s and 1980s in foreign markets (Araman 1988). Those mills that produce more of their total lumber production from oak species should be more likely to export than those mills that cut lower percentages of oak lumber. The production of oak lumber, OAKHWLUM, was hypothesized to correspond positively with a mill's export participation.

The total number of species cut into lumber would also seem to be important to a mill considering export markets. Mills need to adjust to local timber supplies and to varying market needs. A varied product line offers flexibility to suit numerous domestic and foreign markets. Hence, we hypothesized that NOSPEC—the number of species sawn—would be positively linked to export participation.

Production of pallets and pallet stock (pieces) utilizes lower quality grades and species than those suitable for export markets. Pallet products have not been in high demand by foreign buyers because of their relatively low value and high cost of transportation. We hypothesized that a larger percentage of a mill's total production in pallet products (PALPRODS) would negatively influence export participation.

Lumber manufacturers that sell directly to end users or to planer mills would seem to be more likely to export since their lumber would be of higher quality. Planer mills offer further processing so that lumber is ready for customers. Conversely, it would seem that increased sales to other manufacturers, such as furniture, flooring, or other finished products, (OTHMANUF) would negatively influence export sales.

RESULTS

Based on our findings, the characteristics that are most likely related to determinants of export participation included thirteen independent variables representing all four major variable groups. These variables are: total rated

TABLE 3. *Results of logistical regression for Model I.*

Independent variable	Mean	Beta (T ratio)	Derivative prob @ mean	Elasticity @ mean
Intercept		−0.0926 (−0.11)		
MILLPROD	6.693	0.1644*** (4.34)	0.0406	0.61
PRODTHRE	12.103	−0.0375*** (−2.39)	−0.0093	−0.25
BACHDEG	0.355	1.0291*** (3.01)	n.a.[a]	n.a.
PUBLCORP	0.069	1.1230* (1.61)	n.a.[a]	n.a.
EXPAND	0.355	0.1318 (0.39)	n.a.[a]	n.a.
NOSPEC	6.261	0.0441 (0.56)	0.0109	0.15
PALPRODS	18.665	−0.0246*** (−3.04)	−0.0061	−0.26
OTHMANUF	87.921	−0.0124* (−1.51)	−0.0031	−0.61

*** Significant at alpha = 0.01; ** significant at alpha = 0.05; * significant at alpha = 0.10.
R^2 = 0.211; Normalized R^2 = 0.633; Chi square w/8 df = 54.230 @ alpha < 0.001.
Fraction of concordant pairs = 0.781.
Model: Export participation (Y) = f (independent variables).
Estimated Y = −0.228; P(Y = 1) @ means = 0.443.
[a] Derivatives and elasticities cannot be calculated for non-continuous variables.

mill production, production of grade three lumber, age of sales manager, whether the sales manager has a bachelor's degree, importance of sales calls, public ownership, private ownership, covered storage capacity, expansion plans, production of oak lumber, number of species sawn, production of pallet products and sales to finished product manufacturers. The models show the relationships between these variables, and which are important indicators of export participation or nonparticipation. For instance, a positive beta value for the regression coefficient implies that a variable increases in importance as the probability of exporting increases. With a negative beta value, the converse is true.

Results for two final logistical regression models—Model I and Model II—are shown in Tables 3 and 4, respectively. Two models were developed to avoid problems of collinearity among important variables in each model. Three variables in both models are the same; the others are different.

Validity of regression

Collinearity diagnostics indicated that the assumption of independence of the variables for regression was not violated for either of the models selected. None of the thirteen variables for consideration were correlated at the level of alpha <0.05 when placed into the two proposed models. The model chi-square goodness of fit statistics for both models were significant at the level of alpha <0.001.

Variables were evaluated for significance, utilizing the two-tailed test. Many of the individual variables in the final models were significant at the 0.10 level. Significance levels and the T-ratio values (beta values/standard deviations) for each variable are also given. Those variables found not significant were retained as they add informational value to the models.

Though no direct R^2 statistic is generated by the logistical regression model, many possibilities have been offered. Aldrich and Nelson

TABLE 4. *Results of logistical regression for Model II.*

Independent variable	Mean	Beta (T ratio)	Derivative prob @ mean	Elasticity @ mean
Intercept		0.7493 (0.55)		
PRODTHRE	12.130	−0.0379*** (−2.38)	−0.0094	−0.25
AGE	43.448	−0.0009 (−0.50)	−0.0002	−0.02
SALECALL	1.370	0.1262 (0.66)	0.0312	0.09
PRIVCOMP	0.911	−1.3924** (−2.30)	n.a.[a]	n.a.
CVSTCAP	0.211	2.4476*** (3.88)	0.6059	0.28
OAKHWLUM	49.594	0.0179** (2.06)	0.0044	0.49
PALPRODS	19.219	−0.0149** (−1.92)	−0.0037	−0.16
OTHMANUF	87.750	−0.0053 (−0.62)	−0.0013	−0.26

*** Significant at alpha = 0.01; ** significant at alpha = 0.05; * significant at alpha = 0.10.
R^2 = 0.196; Normalized R^2 = 0.588; Chi square w/8 df = 46.740 @ alpha < 0.001.
Fraction of concordant pairs = 0.769.
Model: Export participation (Y) = f (independent variables).
Estimated Y = −0.198; P(Y = 1) @ means = 0.451.
[a] Derivatives and elasticities cannot be calculated for non-continuous variables.

(1984) proposed the following pseudo-R^2, which should be appropriate here:

$$R^2 = \frac{C}{N + C} \tag{3}$$

where,

C = chi-square statistic for overall fit
N = total sample size.

This measure has two advantages: it is easily computed from readily available information, and its range is between 0 and 0.33, approaching zero as the quality of fit diminishes. Based on this formula, the model R^2 values for Model I and Model II are equal to 0.211 and 0.196, respectively. Royer (1985) notes that the R^2 for a dichotomous choice model can be normalized to the usual 0–1 range by dividing by 0.333. Hence, the normalized R^2 values would then equal 0.633 for Model I and 0.588 for Model II (Tables 3 and 4).

However, a more appropriate criterion for judging a model's goodness of fit, the fraction of concordant pairs of predicted probabilities and responses, was introduced by Harrell (1986). This method measures the predictive ability of logistical models by considering all pairs of observations having different values for the dependent variable. It then computes the proportion of the cases in which the predicted probabilities are higher for the member of the pair with the higher value of the dependent variable (in this case 1)—that is, it measures the concordance between the probabilities predicted for each individual using the maximum likelihood estimators and the actual responses of individuals measured simply as 0 or 1. The fraction takes on a value of 0 when there is no concordance and a value of 1 when there is perfect concordance. The models had a fraction of concordant pairs of 0.781 and 0.769 for Model I and Model II respectively, indicating excellent predictive capabilities.

Significant variables

The presence of many significant variables in both of the models demonstrates that they accurately describe hardwood lumber export participation. Mill characteristics, marketing factors, and products of sawmills all appear to influence the probability of export participation. The beta coefficients generated in logistical regression measure the effects of the respective independent variables on the logarithm of the odds, in this case that a mill will have exported. Mills with variables exhibiting a positive sign were more likely to export. Similarly, mills without such factors were less likely to have exported.

Mill characteristics.—A sawmill's rated production in million board feet per year (MILLPROD) was found to be important, as larger mills were more likely to have exported. Increases in the production of grade three lumber (PRODTHRE) as a percentage of total lumber production were shown to decrease the likelihood of exports. Both variables were significant at the alpha = 0.01 level.

Marketing practices.—Characteristics of the person in charge of sales at each hardwood sawmill were also important. While most mills had at least one person responsible for sales, in many cases smaller mills had just the owner, as the sole salesperson. The older the person supervising lumber sales (AGE), the less likely that mill had participated in exporting. This variable, however, was not significant in distinguishing between exporters and nonexporters. The sales manager's completion of a bachelor's degree (BACHDEG) was found to be significant.

The variable describing sales visits (SALECALL) indicates the average importance placed by mill managers on sales visits to retailers, wholesalers, and contract lumber suppliers relative to a mill's overall marketing effort. Surprisingly, our analysis indicated little importance on sending mill personnel to call on potential customers. Thus exporting mills appear to rely more on long-standing customer relationships or referrals from current customers than on actively selling their lumber products in all markets.

Mill production factors.—The type of ownership of the mill was found to be the most important indicator for export participation or lack of it, but not in the direction we hypothesized. Private ownership including sole proprietorships, partnerships, and family-owned firms (PRIVCOMP) was negatively related to export participation. Public ownership (PUBLCORP) was found to have a positive influence on export participation.

Several survey questions related to expansion plans were consolidated in one variable (EXPAND). Our analysis indicated that the presence of expansion plans was not significantly related to export participation. The variable quantifying covered storage capacity (CVSTCAP) did exhibit a significant positive correlation with export participation.

Product profile factors.—The number of different species sawn into lumber (NOSPEC) was not significantly linked to export participation. Mills that exported did tend to have produced a greater proportion of red and white oak lumber (OAKHWLUM). This link has been shown in other studies (Araman 1988).

Sales of pallets and pallet parts (PALPRODS) as a percentage of total sales were negatively related to exporting. Our analysis showed that this variable had a significant negative influence on export participation.

Percentage of total sales to customers that manufactured finished products such as furniture, flooring, and millwork (OTHMANUF) was also important. This variable exhibited a negative beta sign, at a slight significance level, indicating its negative influence on participation in foreign markets. Hardwood lumber mills that export were more likely to sell to planer mills or end users, while nonexporters were more likely to sell to customers who would reprocess lumber into finished products.

Magnitude of variables

In order to judge the magnitude of a variable's influence on export participation, derivatives and elasticities were also calculated. The derivative of an independent variable indicates how a change in that variable will affect the probability of a change in a dependent variable, in this case exporting. By examining the partial derivatives of the model, the impact of each independent variable on the dependent variable can be isolated (Pindyck and Rubinfeld 1981). The change in the dependent variable caused by the independent variables depends on the initial value of the dependent variable. The value at the means has often been utilized to reflect the impact of a change in each independent variable on the dependent variable (Royer 1985).

Based on methods presented by Aldrich and Nelson (1984), the partial derivatives were calculated for each independent variable (Tables 3 and 4). This differentiated the probability of export participation with respect to each continuous attribute variable in the linear equation utilizing the following formula:

$$\frac{\delta p}{\delta X_i} = f(X_i{}^1\beta_i) = p(1 - p)\beta_i \qquad (4)$$

where,

p = probability of export participation
β_i = estimated parameter of the independent variable
$X_i{}^1$ = independent variable at the mean

For example, the probability of export participation expressed in Model I is 0.443. Inserting this value and the beta for the influence of mill production (0.1644) into the formula listed above yields the derivative of export participation with respect to MILLPROD. The result, 0.0406, means that an increase of one million board feet of yearly mill production increases the probability of export participation by 4.06%. However, using the same process for the variable PRODTHRE indicates that each percentage increase in production of grade three lumber decreases the probability of export participation by 0.93%.

As in other studies (Royer 1987; Hardie and Hasson 1986), elasticities were computed for each continuous independent variable, and indicate the percentage change in probability of the dependent variable due to a percent change in the independent variable. The elasticity shows the effect of this one unit change in a hardwood lumber mill business or production factor on the total probability of export participation. Elasticities were calculated for the independent variables utilizing the following formula:

$$\text{Elasticity} = \bar{X}_i(1 - p)\beta_i \qquad (5)$$

where,

p = probability of export participation
β_i = estimated parameter of the independent variable
$\bar{X}_i$ = mean value for the independent variable

For example, for Model II the probability of export participation is 0.451, while the mean production of grade three lumber (PRODTHRE) is 12.13% and its beta value is −0.0379. Using these values in the above formula, we found a 1% increase in the production of grade three lumber (at the mean) decreases the likelihood of export participation by 25%. However, an increase of one million board feet in covered storage capacity results in approximately a 28% increase in the probability of export participation.

DISCUSSION

Our analyses demonstrate that hardwood lumber mill production factors and marketing practices can be quantified and linked to export participation. Hardwood lumber mills that have sold lumber to international markets typically produced more lumber, had more highly educated sales managers, produced lumber from a greater number of species, and were publicly owned. The following variables were significant in assessing export participation in descending order of their importance: rated yearly mill production (MILLPROD), production of oak lumber (OAKHWLUM), covered storage capacity (CVSTCAP), sales manager's possession of a bachelor's degree (BACHDEG), and public ownership of mill (PUBLCORP). The following variables were significant in inhibiting export participation: private ownership of mill (PRIVCOMP), sales to finished products manufacturers (OTHMANUF), production of grade three lumber

(PRODTHRE), and production of pallet products (PALPRODS). Lastly, variables that described mill expansion plans (EXPAND), number of species sawn (NOSPEC), age of sales manager (AGE), and importance of sales calls to marketing effort (SALECALL) were not significant predictors of a hardwood lumber mill's export participation or lack thereof.

Exporting mills had large enough sawmill capacity to cut lumber volumes sufficient to fill export orders. Traditionally export orders have to be loaded and shipped within a short time because of the dependence on shipping schedules. Hence, lumber mills that export must carry larger inventories of lumber or produce higher volumes of lumber in short periods of time.

Production of grade three lumber had a negative influence on export participation. Foreign customers most often require higher grades of lumber such as FAS (firsts and seconds) and #1 common. Lack of domestic markets for lower grade lumber may cause mills without enough total production capacity to ship their higher quality, exportable lumber to domestic markets. This production characteristic was found to be linked to the likelihood of export participation.

The analysis revealed that sales managers with a college education did positively influence the mill's likelihood of export participation. The variable describing the age of the person supervising lumber sales was found not to be a significant indicator of export participation. Neither were sales calls demonstrably important influences on export participation.

Mill ownership was found to be an important indicator of a mill's potential to enter foreign markets. Publicly owned mills were more likely to have exported than privately owned mills. Private ownership was found to negatively influence export participation. Larger covered storage capacity appears to help mills to concentrate and protect lumber while waiting for overseas shipments to be organized.

Production of red and white oak lumber was a significant determinant of export participation. The number of species sawn was not. Production of pallets and pallet stock hampered export participation, in both models. Sales directly to furniture, flooring, and other value adding manufacturers were also not significant.

CONCLUSIONS

This study was undertaken to determine hardwood lumber manufacturer's characteristics that are and are not related to export participation, and to provide useful information to policymakers and export promotion personnel. Pre-export conditions, such as types and amount of mill equipment owned and species sawn, were found to be important indicators of export participation.

Access to marketing knowledge seems vital to those who wish to increase exports of southern hardwood lumber. Promotional programs should focus on specific hardwood lumber products for specific overseas markets and increase efforts to educate mills about the benefits of expanding sales territories, not just in overseas markets but throughout the U.S. market. Increased exports will help stabilize and provide additional demand, stimulate local and regional economic growth, and help relieve the trade deficit.

Shinn (1989) maintained that response to policy initiatives can be predicted based on lumber mill attributes. International trade has received policy attention as an economic development tool. However, community stability, employment in family businesses, and impacts on forest management also need to be explored. We know little about how sawmills enter foreign markets and the basis for that involvement (Shinn 1990). Until recently, most research has been at the forest products industry level, and has focused on its involvement as a whole in exporting. However, trade data reveal that increasing volumes of hardwood lumber have been exported over the last decade. Reasons for this by firm should also be explored.

It was hypothesized that marketing would play an important role in determining export participation. However, only the completion of a bachelor's degree by the sales manager was found to be significant. Those sales managers having completed bachelor's degrees were more likely to be knowledgeable of the advantages of having a well-balanced and diverse marketing effort. While Rich (1986) has said that there is an increased interest in marketing by the forest products industry, this may not be true for the more localized hardwood lumber sector. Our study also revealed the negative influence on export participation of producing lower quality lumber and lumber products, thus confirming a previous study that stresses that higher quality lumber is essential to gaining market share overseas (Wiseman 1990).

The interaction between domestic markets for some lumber products and foreign consumer market preferences is also an important consideration. If a mill has few local markets for lower quality lumber, then often it cannot produce and concentrate enough higher quality lumber suitable for foreign markets. Smaller mills without markets for such lower quality lumber and the ability to cut and store large volumes of higher quality lumber would have problems shipping to overseas markets.

Knowledge of export logistics would also help hardwood lumber manufacturers assess the feasibility of entering foreign markets. In our study, a well-educated sales manager was found more qualified to interpret complicated export procedures, helping to influence a firm's ability to export lumber.

Most importantly, efforts to promote exporting should be product- and market-specific, and need to educate mills about foreign markets. Nonexporters must first realize the benefits that can be garnered from overseas sales before they will attempt entering export markets. Increased availability of information on foreign markets is also needed for exporters to increase their overseas sales.

REFERENCES

AFIFI, A. A., AND VIRGINIA CLARK. 1984. Computer-aided multivariate analysis. Lifetime Learning Publications, Belmont, CA. 458 pp.

ALDRICH, JOHN H., AND FORREST D. NELSON. 1984. Linear probability, logit, and probit models. Sage Publications, New York, NY. 95 pp.

ARAMAN, PHILLIP A. 1988. Pacific Rim and Middle East markets for hardwood products. Pages 45–58 *in* Proceedings of The Global Advantage of the South in Forestry and Forest Products, Atlanta, GA. Southern Rural Development Center, Mississippi State, MS.

DEBERTIN, D. L., A. PAGOULATOS, AND E. D. SMITH. 1980. Estimating linear probability functions: A comparison of approaches. Southern Agric. Econ. 12(2):65–69.

DILLMAN, DON A. 1978. Mail and telephone surveys. John Wiley and Sons, New York, NY. 325 pp.

EVANS, CYNTHIA. 1990. A guide to exporting solid wood products. USDA Foreign Agricultural Service. Agriculture Handbook No. 662. Washington, DC. 116 pp.

GOTTKO, JOHN, AND ROBERT MCMAHON. 1989. Oregon lumber producers: Evaluating exporting in the 1980s. Forest Prod. J. 39(11/12):29–32.

HAMMETT, A. L., F. W. CUBBAGE, AND W. G. LUPPOLD. 1991. Southern Appalachian hardwood lumber manufacturers: Characteristics of exporters and nonexporters. Forest Prod. J. 41(7/8):70–76.

HARDIE, IAN W., AND AZIZ ABU HASSON. 1986. An econometric analysis of residential demand for fuelwood in the United States, 1980–1981. Forest Sci. 32(4):1,001–1,015.

HARRRELL, F. E., JR. 1986. The logist procedure. Pages 269–293 *in* R. P. Hastings, ed. SUGI supplemental library user's guide, version 5 edition. SAS Institute, Inc., Cary, NC.

HASSLER, C. C., S. A. SINCLAIR, AND E. KALLIO. 1986. Logistic regression: A potentially useful tool for researchers. Forest Prod. J. 36(9):16–18.

HAYNES, RICHARD W. (editor). 1988. An analysis of the timber situation in the United States: 1898–2040, Part I, (Draft). USDA Forest Service, Washington, DC. 281 pp. (plus appendices).

HODGES, DONALD G., AND FREDERICK W. CUBBAGE. 1990. Adoption behavior of technical assistance foresters in the southern pine region. Forest Sci. 36(3):516–530.

HOSMER, DAVID W., AND STANLEY LEMESHOW. 1989. Applied logistic regression. John Wiley and Sons, New York, NY. 307 pp.

JAMNICK, M. S., AND D. R. BECKETT. 1988. A logit analysis of private woodlot owner's harvesting decisions in New Brunswick. Canadian J. Forestry Res. 18(3):330–336.

JONES, H. RALPH. 1980. Organizing your firm for export. Pages 55–61 *in* Proceedings of Exporting for Small and Medium-sized Businesses: Key Decisions and Proven Approaches. Jan 29–30. Georgia World Congress Center, Atlanta, GA.

KACHIGAN, SAM KASH. 1986. Statistical analysis. Radius Press, New York, NY. 589 pp.

KENNEDY, PETER. 1987. A guide to econometrics. The MIT Press, Cambridge, MA. 238 pp.

KUULUVAINEN, J., H. A. LOIKKANEN, AND J. SALO. 1984.

On the timber supply behavior of private nonindustrial forest owners in Finland. Pages 151–162 *in* M. Tervo and J. A. Selby, eds. Proceedings of Symposium on Forest Products and Roundwood Markets. November 14–16, 1983, Hanasaari, Finland.

LUPPOLD, W. G. 1989. The shifting demand for eastern hardwood. USDA Forest Service, Northeastern Forest Experiment Station, Princeton, WV. (mimeo) 16 pp.

NETER, J., W. WASSERMAN, AND M. H. KUTNER. 1985. Applied linear statistical models. 2nd Edition. Richard D. Irwin, Inc., Homewood, IL. 1,127 pp.

NORTHEASTERN FORESTRY ALLIANCE. 1989. Export survey executive summary. Augusta, ME. (mimeo) 47 pp.

OWENS, RAY. 1990. Logging, *in* District exporters respond to survey. (Federal Reserve Bank's Fifth District) Cross Sections 6(4):2–3.

PINDYCK, ROBERT S., AND DANIEL L. RUBINFELD. 1981. Econometric models and economic forecasts. 2nd edition. McGraw-Hill Company, New York, NY. 630 pp.

PRESS, JAMES, AND SANDRA WILSON. 1978. Choosing between logistical regression and discriminant analysis. J. Am. Statist. Assoc. 73(364):699–705.

RAJ, DES. 1972. The design of sample surveys. McGraw-Hill Company, New York, NY. 390 pp.

RICH, STUART U. 1986. Recent shifts in competitive strategies in the U.S. forest products industry and the increased importance of key marketing functions. Forest Prod. J. 36(7/8):34–44.

RINGE, J. M., D. H. GRAVES, AND B. G. HANSEN. 1987. Exporting hardwood lumber from Kentucky: Species, grades, and markets. Forest Prod. J. 37(10):72–76.

ROYER, JACK P. 1985. The effects of markets and public policies on the reforestation behavior of southern landowners. Southeastern Center for Forest Economics Research, Research Triangle Park, NC. SCFER Working Paper No. 12. 35 pp.

———. 1987. Determinants of reforestation behavior among southern landowners. Forest Sci. 33(3):654–667.

SAS INSTITUTE. 1982. SAS user's guide: Basics, 1982 edition. SAS Institute, Inc., Cary, NC. 923 pp.

SHINN, CRAIG W. 1989. Sawmill decisions to produce for export markets: impact on local development in the Pacific Northwest. Pages 379–383 *in* Proceedings of Society of American Foresters National Convention. September 24–27, Spokane, WA. SAF, Washington, DC.

———. 1990. U.S. Pacific Northwest sawmills and international trade: Implications of a three type model of sawmill strategy. Presented at the Third Symposium on Social Science in Resource Management. Texas A&M University, College Station, TX. (mimeo) 16 pp.

STIEFEL, LEANNA. 1990. Statistical analysis for public and nonprofit managers. Praeger Publishers, New York, NY. 209 pp.

TATE, R. A., J. V. WHITWORTH, J. CASTRO, AND A. N. O'NEILL. 1989. Assessment of markets for remanufactured hardwood lumber. Georgia Tech Research Institute, Economic and Marketing Services Branch, Atlanta, GA. 106 pp.

USDA FOREST SERVICE. 1988. The South's fourth forest: Alternatives for the future. Forest Resource Report No. 24. USDA Forest Service. Washington, DC. 499 pp.

WALTERS, PETER G. P. 1982. Export operations in the Georgia forest products industry. International Business Series No. 7. Georgia World Congress Center, Atlanta, GA. 65 pp.

WISDOM, H. W. 1988. The competitiveness of southern forest products in world trade. Pages 21–29 *in* Proceedings of The Global Advantage of the South in Forestry and Forest Products. August 23–24, Atlanta, GA. Southern Rural Development Center, Mississippi State, MS.

WISEMAN, A. CLARK. 1990. Recent international developments impacting United States forest products trade. Discussion Paper No. ENR90-06, Energy and Natural Resources Division, Resources For the Future. Washington, DC. 55 pp.