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# Forest Resources, Government Policy, and Investment Location Decisions of the Forest Products Industry in the Southern United States

Changyou Sun and Daowei Zhang

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**ABSTRACT.** In this article, the results of an initial attempt to estimate the effects of state attributes on plant location and investment expenditure were presented for the forest products industry in the southern United States. A conditional logit model was used to analyze new plant births, and a time-series cross-section model to assess the total capital expenditure. Significant positive effects were found for personal income and forest inventory, and negative effects were found for population density. In the short run, tax and energy costs had negative impacts on new plant births in a state, while in the long run, stumpage price and environmental stringency had negative effects on the capital expenditure. Sensitivity of model specification was documented, and policy implications were discussed. *For. Sci.* 47(2):169-177.

**Key Words:** Industrial recruitment, forest-based economic development, tax, environmental regulatory stringency.

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INDUSTRY LOCATION HAS BEEN A SUBJECT of great interest to both corporate and government decision-makers. The forest products industry is one of the primary U.S. manufacturing sectors in many southern states. In Alabama, Louisiana, and Mississippi, for example, the forest industry is one of the largest manufacturing industrial groups in terms of gross state product, total value of shipment, and employment. Overall, the 13 southern states have about one-third of the forest inventory and nearly one-half of the timber harvesting in the United States (Powell et al. 1992). The forest products industry in these states produces about 45% of softwood lumber (Random Lengths, Inc. 1999) and accounts for about 56% of the total paper and paperboard production capacity and 72% of the wood pulp production capacity in the country (Miller Freeman, Inc. 1999).

The health and competitiveness of the forest industry in a particular state rely on continuous investment, which brings

new technology, enhances factor endowments, and thus improves the competitiveness of the industry (Porter 1991). More importantly, investment brings employment and economic growth. Therefore, state governments in the South have made great efforts in the last half century to attract forest industry investment to boost their industry production and employment. Various public policies have been used to recruit the industry, including financial incentives, such as tax abatements, low property tax, direct state loans, and industrial revenue bonds, and nonfinancial incentives, such as customized industrial training and provision of information to prospects. However, no study can be found that specifically examines the factors influencing the growth in the forest products industry in the southern states.

This study filled in this gap by examining the significance and magnitude of various factors in influencing the growth of the forest products industry in the southern United States.

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The availability of microeconomic data at establishment level allowed us to apply a conditional logit model (CLM) on the investment location decisions for new forest industry plants. In addition, a time-series cross-section model (TSCS) has been applied to the industry's total investment expenditure. The results showed that forest resource endowment, government tax policies, and other socioeconomic conditions affected the investment decisions in the forest products industry. The next section reviews previous investment location studies. This is followed by a demonstration of the CLM and TSCS model and by a description of the data used in this study. Finally, the empirical results from the two models are presented, and policy implications are discussed.

## Literature Review

Previous studies of industrial growth and investment location have taken many forms. The survey approach was once a widely used research method, and previous survey studies concluded that the location decision is a two-step process (Schmenner 1978). Firms first decide on a general multistate region and then choose a state or a city within that region, using different criteria in each step. More recently, empirical analysis using secondary data has gained its popularity in evaluating how state and local policies have influenced growth, branch plant location decisions, and new firm startup decisions (e.g., Bartik 1988, Levinson 1996). In this study the latter approach was adopted, and the following review concentrated on the related technical issues and empirical results.

### *Measurement of Variables and Estimation Methods*

Studies of industrial investment location have been focused on the possible causation between the economic characteristics of a region and its industry growth. On the one hand, economic growth and investment in a region can be measured fairly accurately in several ways, and different econometric techniques have been applied to analyze them. In some studies, employment rate was used to reflect the investment and economic growth in a region (Newman 1983, Duffy 1994). Investment expenditure within a region in a certain time period is a more direct measurement. In both cases, a linear regression method can be used. More recently, with the progress in econometrics, the number of firms that have invested in a region has been linked to the region's attributes using a conditional logit model (e.g., Bartik 1985, 1988; Levinson 1996). The latter approach presents a different way to look into business location decisions.

On the other hand, many economic characteristics for a region (independent variables) are difficult to measure and have been inadequately measured. For example, some studies have used the tax effort and capacity indexes from the Advisory Commission on Intergovernmental Relations (ACIR) (Bartik 1985, 1988). Lately, even this simple tax average at state level is no longer available—the ACIR was terminated several years ago. No federal statistical agency collects comparable data across states and local areas on business tax rates. Some research groups do publish data on business tax rates, but in many cases they fail to control for

differences across states and local areas in how the tax base is defined. Some studies used cross-sectional data and regression to avoid the lack of the continuous time series data (e.g., Duffy 1994).

### *Aggregate vs. Micro Data*

Statistical agencies often collect data from establishments and then aggregate them for publication based on industrial sectors and geographical regions. Many growth and investment studies have used this kind of aggregate data on employment, capital, or value added in a region (e.g., Newman 1983, Plaut and Pluta 1983, Helms 1985). However, the aggregate measures of regional economic activities reflect a number of different types of decisions: small business startup, new plant, expansion or contraction of production at existing plants, and plant closure. These different types of decisions are presumably made in different ways. For example, high unionization of the labor force may deter possible new investment in a region. But high unionization may also delay the closing of an existing firm and even may succeed in forcing the firm to enlarge its capacity. Thus, the ultimate effect of unionization on economic growth is uncertain (Crandall 1993, p. 57). This issue makes the specification of estimation equation difficult and may partly explain why many previous studies do not find significant effects for many attributes.

Problems with modeling aggregate business growth patterns make studies on particular types of business location decisions, such as a new branch plant, more attractive. For a specific type of business location decision, the appropriate specification of an estimation equation may be more apparent to researchers. Thus, a focus on a specific type of location decision using micro data makes coming up with a theory-based empirical specification easier (Bartik 1991, p. 32).

Unfortunately, in many cases, using micro establishment data is prohibitively expensive if not impossible. In fact, the relatively heavy use of aggregate data by researchers and policy analysts is more a reflection of supply rather than demand (McGuckin 1993). In light of data constraints, previous studies on industry growth suggest that a state is still the best unit of analysis when regional influences are being studied. With the state level data, variation in business investment has been explained by state attributes such as tax rate, wage rate, population density, and energy cost (Duffy 1994, Wheat 1986).

### *Change vs. Level*

A longstanding controversy in business location research is whether growth in business activity in a region should be seen as a function of levels of relevant state attributes or changes in state attributes, or both levels and changes (Sullivan and Newman 1988, Bartik 1985). A disequilibrium view of regional economic structure assumes that profit level differences exist among regions and that business growth responds to these profit level differences. Therefore, industry locations are indirectly related to the differences in the levels of state attributes that affect profits. A simplistic equilibrium view assumes that profits are initially equal across regions and that only changes in a region's characteristics can cause changes

in its economic activity. A more sophisticated equilibrium view would allow for the possibility that national or international economic forces may lead to expansions in certain industries and that this expansion need not be distributed equally across all regions.

Duffy (1994) criticized some studies that have used change variables where level variables are called for. However, deciding, *a priori*, whether to focus on changes or levels or both in modeling aggregate regional economic activity is difficult. Bartik (1985, 1988) argued that a focus on one specific type of plant location decisions will allow for a much cleaner and more plausible model. In both of his studies, Bartik (1985, 1988) focused on new plant births and used level variables.

### Empirical Results

Only a few of many previous investment location studies have briefly touched the forest products industry in cross-industry comparisons. Duffy (1994) analyzed 1954–1987 state manufacturing employment growth in 19 two-digit industries over 50 U.S. states. The market variables are found to have the strongest influence in 18 industries, followed by labor variables. As to the wood products industry (SIC 24), market, transportation, and income variables have significant influence on employment growth. For the paper industry (SIC 26), the unionization variable has a negative coefficient, while the effect of market is positive. However, no effect has been found for government policy and resource endowment factor, which is represented, perhaps erroneously, by commercial forest holdings. Levinson (1996) used establishment-level data to examine the effect of differences in the stringency of state environmental regulations on establishment location choice. Using the conditional logit model, he showed that interstate differences in environmental regulations do not affect the choice of location for most manufacturing plants. For the forest products industry (SIC 24 and 26), the model is estimated for new branch plants of large firms. No environmental variable has been found to be significant.

### Methodology

The conditional logit model (CLM) and the TSCS model were used in this study to evaluate the investment activities of the forest products industry in the southern United States. This was in accord with the two popular ways of measuring investment activities—the number of new plants and total investment expenditure. The development and estimation of the CLM were more complicated than that of the TSCS model, and most of the following description was devoted to the CLM.

#### Conditional Logit Model for New Plant Births

First developed by McFadden (1974), the CLM has been used in various economic analyses, especially the interregional studies of plant location. Following Carlton (1983), each new plant is assumed to have a latent (unobserved) profit function that is dependent on the attributes of the state in which it locates or it is intended to be located. Firms evaluate all relevant state attributes and

seek locations with the highest expected profits. Firm  $i$  selects state  $j$  if and only if the profit derived from the choice,  $\pi_{ij}$ , is at least as great as  $\pi_{ik}$  for all  $k$ , which are in the set of alternative choices (states) available to firm  $i$ . Thus, the profit  $\pi_{ij}$  that each individual firm derives from locating in a state can be written as a function of the attributes of that state and a disturbance term:

$$\pi_{ij} = \beta' X_j + e_{ij} \quad (1)$$

where  $X_j$  is a vector of observable attributes for state  $j$ ,  $\beta$  is a vector of coefficients,  $e_{ij}$  is a random disturbance term,  $i$  indexes firms, and  $j$  indexes states.

The probability of selecting a specific state depends on the attributes of the state relative to those of all other states in the choice set. If the  $e_{ij}$  is independently and identically distributed and has a Weibull density function (McFadden 1974), then the probability of a new firm  $i$  choosing state  $j$  will be given by

$$Prob(Y = j) = \frac{e^{\beta' X_j}}{\sum_{k=1}^m e^{\beta' X_k}} \quad (2)$$

where  $Y$  is the index of the choices made by firms,  $m$  is the total number of states, and both  $j$  and  $k$  index the states.

Estimates of coefficients  $\beta$  can be obtained by maximizing the following likelihood function:

$$L(\beta) = \prod_{j=1}^m Prob(Y = j) \quad (3)$$

The rather strong assumption in CLM is that the disturbance terms are independent across the alternatives. This is the so-called “independence of irrelevant alternatives (IIA),” meaning that the relative probability of choosing one of the two existing alternatives is unaffected by the presence of additional alternatives (Greene 1993, p. 671). If the alternatives are very similar, this assumption may be too restrictive.

Hausman and McFadden (1984) proposed a specification test for this model to test the inherent assumption of IIA. The procedure is to estimate the model with all choices and the alternative specification with a smaller set of choices. Then a statistic is constructed according to the estimators and covariance matrices. If the IIA test fails, a sequential logit model can be used instead.

The estimated coefficients in the above model could be transformed to the marginal effects by differentiating Equation (2) with regard to the vector of state attributes  $X$ . Furthermore, two types of elasticities can be obtained from the marginal effects. One is the direct elasticity  $\epsilon_{jn}$ , showing the percentage change in the probability that state  $j$  is chosen in response to a percentage change in the  $n$ th explanatory variable for state  $j$ . It has the same sign as the estimated coefficients. The other is the indirect elasticity  $\epsilon_{kn}$ , caused by the substitution effect that a change in one attribute of a state would cause a change in the likelihood of firms choosing other states. It shows the percentage

change in the probability that state  $j$  is chosen given a percentage change in the  $n$ th explanatory variable for alternative state  $k$  (where  $j \neq k$ ). The indirect elasticity has the opposite sign compared to the direct elasticities and estimated coefficients. Generally, both elasticities are calculated at the mean of the state attributes  $X_{jn}$  or  $X_{kn}$ . The direct and indirect elasticities can be calculated as the following (Greene 1993, p. 670):

$$\epsilon_{jn} = \frac{\partial \ln P_j}{\partial \ln X_{jn}} \beta_n X_{jn} (1 - P_j) \quad (4)$$

$$\epsilon_{kn} = \frac{\partial \ln P_j}{\partial \ln X_{kn}} = -\beta_n X_{kn} P_k \quad (5)$$

### TSCS Model for Investment Expenditure

When the investment activities in each year for each state were measured by investment expenditure, the data had a cross-sectional aspect and a time series aspect. The TSCS model could be used to estimate this kind of panel data as follows:

$$Z_{st} = \gamma' X_{st} + \mu_{st} \quad s = 1 \dots N, t = 1 \dots T \quad (6)$$

where  $Z$  is the investment expenditure,  $X$  is the vector of state attributes,  $\gamma$  is the coefficient vector,  $s$  indexes the states, and  $t$  indexes years. The coefficient vector was assumed to be constant over time and for all groups. There may exist groupwise heteroscedasticity, cross-group correlation, or within-group autocorrelation for the error terms. All of these can be statistically tested using the likelihood ratio (LR) test (Greene 1993, p. 486–492).

### Model Specification and Data

In constructing the CLM, one must first specify a set of alternatives that would have been considered by individual firms. The southern states form a well-defined choice set for the forest products industry as they have similar climate, culture, and forest resources (southern pine and hardwood). In this study, nine southern states were selected: Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas, and Virginia. Four southern states were excluded from the study, either due to data constraints (Florida, Tennessee, and Kentucky) or because the activities of the forest products industry were not intensive (Oklahoma). In addition, the forest products industry in this study referred to lumber and wood products (SIC 24) and paper and allied products (SIC 26) sectors.<sup>1</sup> The furniture and fixtures (SIC 25) sector was excluded because it includes metal and

plastic furniture, wood is just one of the raw materials in that sector, and firms' investment decisions in SIC 25 sector may be quite different from that in SIC 24 and 26 sectors.

The dependent variable in the CLM was the number of new plants that had been established in the nine southern states from 1991 to 1996. Following the previous location studies, we concentrated on the new plants that allowed for better model specification and interpretation of the results. The number of the new plants was obtained directly from relevant state government agencies.<sup>2</sup> For each observation, 1 was assigned to the chosen state and 0 to the other eight states. For the TSCS model, the dependent variable was the "New Capital Expenditure" from the Census of Manufactures and Annual Survey of Manufactures. Due to government budget cutback for the survey, no data were available from "Statistics for Industry Groups and Industries" for the period from 1979 to 1981. Therefore, this study was roughly for the past two decades excluding those three years. For each state, there were 20 observations from 1974 to 1978 and then from 1982 to 1996.

The vector of explanatory variables included nine state attributes. Individual attributes were selected based on their relevance to the underlying profit maximization hypothesis, and they covered both demand-side variables as well as supply-side variables. The following explained the attributes in detail. A summary of the variables, including data sources and expected signs, was presented in Table 1.

### Market

The southern United States has been one of the fastest growing regions in terms of population in the last half century, and considerable growth of economic activity has been observed in this area. One of the incentives for this growth may be that the industries try to move closer to the established and emerging markets. In this analysis, two variables were selected to capture this possible effect. They were the state per capita income (INC) and the state population density per square mile of state land area (POP). INC was expected to have a positive effect on the investment decision. However, the effect of POP has not been determined in previous studies (Bartik 1985).

### Resource Endowment

In order to minimize production cost, firms often try to locate plants close to resources. This is especially relevant for the forest products industry because of the bulky nature of wood and the resulting high cost of transporting wood. The variable, *INVT*, which represents the total forest (both softwood and hardwood) inventory available to forest products firms, was included. The Forest Inventory and Analysis Group (FIA) reports *INVT* periodically (Harris 1997, Forest

Separate regressions had been estimated for SIC 24 and 26 using the TSCS model. The results for SIC 26 closely followed the aggregation results reported here while these for SIC 24 differed only for the environmental stringency variable (ENVR, which became statistically insignificant). Overall, the main results were the same as reported. For the conditional logit model, we did not have separate data for SIC 24 and 26 for several states and had to use the combined data.

<sup>2</sup> The new forest product plant establishments from 1991 to 1996 were obtained from the corresponding Department of Commerce for North Carolina and Texas; Department of Economic Development for Mississippi, Virginia, Louisiana, and Arkansas; Department of Industry, Trade & Tourism for Georgia; Forestry Commission for Alabama and South Carolina.

Table 1. Variable definition and data sources.

Variable	Variable construction	Expected sign	Source
<b>Dependent variable</b>			
	Number of new plants for each state		State economic development agencies (see footnote 2)
	New capital expenditure		USDC-BC, CM-GAS, ASM
<b>Independent variables</b>			
<i>INC</i>	State per capita income (\$)	+	USDC-BC, SA
<i>POP</i>	State population density (persons/mi <sup>2</sup> )	?	USDC-BC, SA
<i>INVT</i>	Forest inventory (10 <sup>6</sup> ft <sup>3</sup> )	+	Forest Service (1999)
<i>PULP</i>	Pulpwood delivered price, s. pine (\$/std. cord)	-	Timber Mart-South
<i>ELEC</i>	Average cost of electric energy, industrial users (\$/kWh)	-	USDC-BC, CM-GAS, ASM
<i>TAX</i>	Annual state tax revenue/gross state product	-	USDC-BC, SA
<i>ENVR</i>	Environmental stringency (index)	-	Levinson (1999)
<i>WAGE</i>	Average wage rate per hour, production workers, all industry (\$/hr)	-	USDC-BC, SA
<i>HIGH</i>	Percentage of persons 25 yr old and over who have completed high school education or more	+	USDC-BC, Current Population Reports

NOTE: ASM: Annual Survey of Manufacturers; CM: Census of Manufactures; GAS: Geographic Area Series; SA: Statistical Abstract of the United States; USDC-BC: U. S. Department of Commerce, Bureau of the Census.

Service 1999). For example, for North Carolina, FIA reported inventories, growth, and removals in 1976, 1984, 1990 and 1997. In order to fill in the intervening years for the standing inventory in a state, the following formula was used:

$$I_t = I_{t-1} + G^* - S \quad (7)$$

where  $G^*$  is the average net growth and  $S$  is the timber production between time  $t$  and  $t-1$ . Generally, annual growth of forest inventory is relatively stable, and  $G^*$  was assumed to be constant between two survey years. With the variation of removal rate, the net increment to inventory in any single year may be positive or negative. For some years, data on timber production were not available, and consequently  $S$  was assumed to be an average of timber production in years that data were available. *INVT* was expected to have a positive effect on location decisions.

Southern pine is the primary commercial species in this area and the delivered price of southern pine for pulpwood (*PULP*) was selected to reflect the conditions in the timber market and measure the wood cost to the forest industry. In addition, since electricity is the primary energy source for both sawmills and paper mills, the average cost of electric energy for industrial users (*ELEC*) was included. Both *PULP* and *ELEC* were expected to have negative signs.

### Tax

Economic theory suggests that, at least in the short-run, high taxes may deter investment and growth. Corporate income taxes, property taxes, and other corporate and individual taxes add to the cost to firms and may thereby discourage firms from locating in high-tax states. However, time series data for various taxes in a state are not readily available, and this study used the total annual tax revenue for a state to represent the tax level. Considering the difference in tax base in various states, the tax revenue was divided by gross state product, and the resulting ratio (*TAX*) measured the relative tax incidence in each state.<sup>3</sup> *TAX* was expected to have a negative sign.

### Environmental Regulatory Stringency

The question of whether firms' location choices are responsive to the stringency of environmental regulations in a state has been a controversial issue. The conventional intuition is that profit-maximizing firms, when seeking location for new plant and investment opportunity, will tend to avoid investing in states with stringent environmental regulations as regulations will cause them to increase production and transaction costs. However, previous empirical studies have found weak or insignificant effects of environmental regulations (Bartik 1988, Levinson 1996). One possible reason may be the low quality of the existing data on the environmental stringency. This study used a new, industry-adjusted index of state environmental regulatory stringency (*ENVR*), which has been created by Levinson (1999). The index is based on estimates of environmental compliance costs for all industrial sectors in each state, and therefore, it controls for states' industrial compositions. Not surprisingly, this cost index is negatively correlated with subjective indices compiled by various environmental organizations. *ENVR* was expected to have a negative effect on the location decisions.

### Labor

Two characteristics of the labor force most widely used in location studies are wage rate and education attainment. Average wage rate per work-hour for production workers in a state (*WAGE*) was included in this study. The education attainment was represented by the percentage of persons 25 years old and over who have completed high school or more (*HIGH*). *WAGE* was expected to have a negative sign, while *HIGH* was expected to be positive.

<sup>3</sup> Government financial and nonfinancial incentive programs such as tax abatements, direct state loans, industrial revenue bonds, and information service were relevant to this study as well. Unfortunately, data on various public incentive programs that have been used to recruit the industry were not available.

Table 2. Empirical results of the conditional logit model.

	Coefficient	t-ratio	Coefficient	t-ratio
<i>INC</i>				
<i>POP</i>				
<i>INVT</i>	0.00009**	4.40	0.00010**	4.67
<i>PULP</i>	-0.00919	-0.74	-0.00775	-0.62
<i>ELEC</i>	-66.26900**	-2.56	-57.36280**	-2.24
<i>TAX</i>	-33.81650*	-1.60 <sup>1</sup>	-63.62590**	-3.49
<i>ENVR</i>	-0.33943	-0.71	-0.68074	-1.48 <sup>2</sup>
<i>WAGE</i>	0.05520	0.52	-0.04735	-0.47
<i>HIGH</i>	-0.14486**	-2.91		
Log likelihood		-892.91		-897.20
Restricted log likelihood		-927.23		-927.23
Chi-squared		68.64		60.06
No. of observations		422		422

Note: \* = Significant at 10% level, \*\* = Significant at 5% level.

<sup>1</sup> P value is 10.9%.

<sup>2</sup> P value is 13.9%.

### Empirical Results from the CLM

#### Model Estimation and Fitness

The CLM was estimated using the data from 1991 to 1995 first. The results for the full model with nine state attributes and for the reduced model with eight are presented in Table 2. For the full model, four out of the nine coefficients were significant at the 5% level and two at the 10% level, and five of these six variables had the expected signs. Personal income and forest inventories had positive effects while population density, electricity cost, and tax had negative effects on investment location choices. The coefficient of pulpwood price had a negative sign but was not significant. Environmental regulation stringency did not show a significant negative effect, either. For the two variables related to labor force, the wage rate showed an insignificant positive effect, but the education attainment did show a significant negative effect, which was contrary to prior expectation. A possible explanation is that the forest products industry is basically a rural industry. An enhancement in labor quality in a state may stimulate the development of other industries but may cause a short supply of labor for the forest industry. The results of a reduced model without *HIGH* showed that except for the personal income becoming insignificant, all other variables showed similar significance and magnitude. The reduced model was chosen for the following analysis.

In addition to most coefficients having the correct signs, the model fitted the data well. Overall, the regression was significant according to the chi-square test of the log-likelihood ratio, which was similar to an F-test in ordinary least

regression. The model also passed the Hausman and McFadden test about independence of irrelevant alternatives. An additional, more intuitive, measure of goodness of fit appears in Table 3. It shows the actual and estimated number of new plants in each state along with the percentages. In order to aid in the interpretation of how the model fitted the data further, a mean absolute percentage error (MAPE) statistic was created. The MAPE was the average of the absolute difference values between the sample and predicted percentages for each state. In this case, the actual MAPE value implied that the average error of the model in placing an investor's choice of state was only about 2.0%.

#### Elasticity Estimates

From a policy perspective, the estimated elasticities are likely to be more useful because they allow policy makers and industrial executives to identify quantitatively the sensitivity of investment in a particular state to changes in the state attributes. Both the direct and indirect elasticities calculated with Equations (4) and (5) are presented in Table 4. The elasticity estimates showed, for example, that if forest inventory (*INVT*) increased by 10% in Alabama, the probability of it being chosen would increase by 19.2%, and the probability of other states being chosen would decrease by 3.5%.<sup>4</sup>

In terms of mean magnitude of the direct elasticity estimates (1st column of Table 4), tax, with the mean value as high as -2.95, was the most important state attribute that affected new plant location of forest products industry firms.

Table 3. Analysis of the Conditional Logit Model fitness: 1991-1995

	AL	AR	GA	LA	MS	NC	SC	TX	VA	Total
Sample number										
Predicted number										
Sample percentage (%)	20.4	7.8	17.1	10.2	7.1	11.8	4.7	14.7	6.2	100.0
Predicted percentage (%)	15.6	10.7	18.0	11.4	8.5	10.0	4.3	12.8	8.8	100.0
Mean absolute percentage error 2.0%										

<sup>4</sup> This was an average of the impacts across all other states.

Table 4. Elasticity estimates of state attributes on new plant births of the forest products industry.

Attributes	Mean	AL	AR	GA	LA	MS	NC	SC	TX	VA
<b>Direct elasticity</b>										
INC	-0.88	-0.80	-0.80	-0.88	-0.82	-0.75	-0.93	-0.90	-0.92	-1.10
POP*	-1.45	-1.13	-0.68	-1.59	-1.42	-0.84	-2.10	-1.88	-0.98	-2.43
INVT*	1.97	1.92	1.80	2.49	1.64	1.84	2.94	1.55	1.16	2.39
PULP	-0.39	-0.38	-0.38	-0.41	-0.41	-0.39	-0.35	-0.43	-0.37	-0.37
ELEC*	-2.21	-1.98	-2.31	-2.26	-1.97	-2.28	-2.56	-2.19	-2.10	-2.25
TAX*	-2.95	-2.88	-3.53	-2.47	-2.53	-3.66	-3.25	-3.44	-2.21	-2.61
ENVR	-0.45	-0.45	-0.45	-0.41	-0.53	-0.45	-0.45	-0.49	-0.39	-0.44
WAGE	-0.58	-0.65	-0.72	-0.53	-0.90	-0.92	-0.50	-0.67	-0.91	0.58
<b>Indirect elasticity</b>										
INC	0.11	0.15	0.10	0.19	0.11	0.07	0.10	0.04	0.14	0.10
POP*	0.18	0.21	0.08	0.35	0.18	0.08	0.23	0.08	0.14	0.23
INVT*	-0.25	-0.35	-0.22	-0.55	-0.21	-0.17	-0.32	-0.07	-0.17	-0.23
PULP	0.05	0.07	0.05	0.09	0.05	0.04	0.04	0.02	0.05	0.04
ELEC*	0.28	0.37	0.28	0.50	0.25	0.21	0.28	0.10	0.31	0.21
TAX*	0.36	0.53	0.42	0.54	0.33	0.34	0.36	0.15	0.33	0.25
ENVR	0.06	0.08	0.05	0.09	0.07	0.04	0.05	0.02	0.06	0.04
WAGE	0.09	0.12	0.09	0.12	0.12	0.09	0.05	0.03	0.14	0.06

\* The related coefficient estimates are significant at 5% level as shown in Table 2.

Except for Georgia, tax had the biggest value for all other states. Although there was some variation in the effect of state attributes in each state, energy price (-2.21), forest inventory (1.97), and population density (-1.45) were the second most important variables for all states and had the same sequence of importance except for Georgia, South Carolina, and Virginia. Consistent with their insignificant coefficients, the state per capita income, timber price, environmental stringency, and wage rate all had low direct elasticities, indicating that these factors had small effects on location decisions. Indirect elasticities showed a similar pattern.

**Prediction**

In order to assess how well the model could predict outcomes, an out-of-sample test was performed with the 1996 data. Using the estimates reported in Table 2 and substituting the state attributes in 1996 into Equation (2), the predicted probabilities for investments in 1996 were computed. In Table 5, the actual and the model's predicted investment number are presented, along with the percentages and MAPE. Alabama actually received 18 new plants compared to the predicted 16 from the model. Similarly, the model underpredicted the number of new plants in MS, NC, and SC. On the other hand, the model exactly predicted for TX, but overpredicted for AR, GA, LA, and VA. The MAPE was 3.4% and revealed that the model predicted new plant births well.

**Empirical Results from the TSCS Model**

The TSCS model was estimated with the 20 yr investment expenditure for the nine southern states using the maximum likelihood method. According to the LR test, the model

adjusted to incorporate groupwise heteroscedasticity and group specific autocorrelation was the best.<sup>5</sup> The results for the full model with nine state attributes and for the reduced model with eight are presented in Table 6. With the full model, personal income, population density, pulpwood price, and environmental stringency had expected signs and were significant at the 5% level while forest inventory was significant at the 10% level. Electricity, tax, and education attainment did not show significant effects. However, contrary to conventional wisdom, wage rate showed a positive sign and was significant at the 5% level in the full model. This might be partly because the variation in wage rate among states was not large. In the reduced model that excluded the wage rate variable, the forest inventory became insignificant while other variables had similar magnitude at the 5% level of significance.

To understand the magnitude of the effects, the elasticities were calculated by using the coefficient estimates and the average value of the investment expenditure and state attributes (Table 6). The personal income showed a high elasticity of 0.90. The elasticity was about -0.4 for population density, -0.5 for pulpwood price, and -0.2 for environmental stringency.

<sup>5</sup> The estimator produced nine sets of results with the combination of various specifications. On the disturbance covariance side, there may be no correlation or heteroscedasticity (S0), groupwise heteroscedasticity (S1), and cross group correlation and groupwise heteroscedasticity (S2). On the autocorrelation side, there might be no correlation (R0), autocorrelation and same  $\rho$  for all groups (R1), and autocorrelation but different  $\rho$  across groups (R2). The likelihood statistics from each two models were used to construct the LR test.

Table 5. Out-of-sample predictions: 1996.

	AL	AR	GA	LA	MS	NC	SC	TX	VA	Total
Sample number	18	6	14	7	12	12	4	11	4	88
Predicted number	16	12	15	10	5	8	3	11	7	88
Sample percentage (%)	20.5	6.8	15.9	8.0	13.6	13.6	4.5	12.5	4.5	100.0
Predicted percentage (%)	18.2	13.6	17.0	11.4	5.7	9.1	3.4	12.5	8.0	100.0
<u>Mean absolute percentage error 3.4%</u>										

Table 6. Empirical results of the TSCS regression.

	Coefficient	t-ratio	Elasticity	Coefficient	t-ratio	Elasticity
<i>INC</i>	0.02*	4.56	0.88	0.02*	4.08	0.82
<i>POP</i>	-2.01*	-3.45	-0.53	-1.30*	-2.43	-0.34
<i>INVT</i>	0.01**	1.59	0.33	0.00	0.14	0.03
<i>PULP</i>	-5.31*	-3.97	-0.69	-3.35*	-2.62	-0.43
<i>ELEC</i>	-345.57	-0.26	-0.04	835.48	0.62	0.09
<i>TAX</i>	-322.20	-0.19	-0.05	663.69	0.37	0.10
<i>ENVR</i>	-84.19*	-2.26	-0.28	-73.14*	-1.94	-0.24
<i>WAGE</i>	23.31*	2.80	0.55			
<i>HIGH</i>	-1.67	-0.50	-0.32	2.83	0.90	0.54
No. of observation		180			180	

Note: \* Significant at 5% level.  
 \*\* Significant at 10% level.

### Summary and Policy Implications

This study was an initial attempt to measure the effect of state attributes on plant location and investment expenditure for the forest products industry in the southern United States. A conditional logit model was used to estimate the revealed preference of new plant births, and TSCS regression to estimate new capital expenditure. Based on the similarity and difference in results generated from the two models (Table 7), some general conclusions can be drawn.

First, both models reached a similar conclusion about the significant effects of three state attributes: two on the market side and one about the resource. Specifically, both the personal income and population density were significant factors in affecting the investment location decisions of the forest products industry. The positive effect from personal income was reasonable and consistent with expectation. The negative impact of the population density was consistent with a few previous studies. Therefore, it was concluded that the market demand side was twofold: an increase in personal income in a state made it more attractive, but an increase in population density had the reverse effect. The results from

both models showed that forest inventory, as the indicator of availability of raw material, played an important role in attracting industry's investment to a state. This was contrary to the findings in Duffy (1994) that resource availability, measured as commercial forest holdings, has no effect on the growth in the forest products industry. However, the measures of resource availability in these two studies were different.

Secondly, two models produced opposite results for two other resources variables (stumpage price and electricity cost) as well as tax and environmental regulation stringency. This could be attributed to the two different aspects of the models. One was that the CLM covered only 6 yr investment activities since 1991, while the TSCS model covered the past two decades. These different time periods may represent short- and long-run linkage between state attributes and investment activities in the forest products industry, respectively. The other was the difference in measuring the investment activities: number of new plants with the CLM and total new capital expenditure with the TSCS model. In CLM, no consideration was given to the amount of capital investment, since data

Table 7. Comparison of the results from the CLM and the TSCS regression.

	CLM		TSCS		Conclusion
	Sign	Rank <sup>1</sup>	Sign	Rank	
<i>INC</i>	Yes <sup>2</sup>	5	Yes	1	Yes, positive effect
<i>POP</i>	Yes	4	Yes	3	Yes, negative effect
<i>INVT</i>	Yes	3	Yes <sup>2</sup>	4	Yes, positive effect
<i>PULP</i>	No		Yes	2	Opposite effect
<i>ELEC</i>	Yes	2	No	—	Opposite effect
<i>TAX</i>	Yes		No		Opposite effect
<i>ENVR</i>	No		Yes	5	Opposite effect
<i>WAGE</i>	No	—	NC <sup>2</sup>	—	Uncertain
<i>HIGH</i>	NC <sup>2</sup>	—	No	—	Uncertain

<sup>1</sup> The rank is sorted by the magnitude of the elasticities and does not include the insignificant variables and the WAGE and HIGH. "Yes" indicates that the variables have the expected and significant effects. "No" indicates that the variables have no significant effects. "NC" indicates that the effects of the variables are significant but not consistent with expectation.

<sup>2</sup> The variables are sensitive to model specification.

from some states did not include all the plant-specific investment expenditures. On the other hand, the total capital expenditure included investment in new as well as in existing firms. Therefore, although similar results from the two models were expected, the inherent difference of the two models might well tell us the different sides of the story. In the short run, tax and electricity cost had negatively affected the investment decisions of new plants in a state, while in the long run, the stumpage price and environmental stringency had negative effects on the investment expenditure.

Thirdly, neither model had reached a conclusion about the effects of the characteristics of the labor force. The wage rate and education attainment variables showed unexpected significant positive and negative effects, respectively. In addition, it was noticed that both variables exhibited sensitivity to the model specifications. Nevertheless, as endogenous growth has become an important part of corporate and industry expansion, the role of human capital in the growth of forest products industry cannot be ignored.

Attention had been paid to other factors that might have some influence on the investment activities in a state. For example, existing in-state competition might have some effects in forest industry investment location. On one hand, new plant location might be attracted to locations near potential consumers or suppliers or near other plants in similar industries (economies of agglomeration). On the other hand, new firms or investment will compete with existing firms in the market (labor, raw material, consumers, etc.). We had included the total manufacturing hours of forest industry in a state with and without the adjustment of land area. We also tried some other state attributes relevant in this study, including land area, unionization percentage of the labor force, and the outstanding per capita debt of state government.<sup>6</sup> However, the main results were similar to these reported here.

The limitations of this study may be inadequate measurements of independent variables used in this analysis. Proxies or aggregate measurements that may not capture the subtleties involved in individual plant location were used. Future efforts may be directed into improving the quality of data and model specification.

The policy implication of this study is straightforward. The competitiveness of forest industry in a particular state depends on the strengths of the interconnected elements, such as resource endowment, domestic demand, supporting industries, as well as government policy. State governments can be more successful in recruiting forest industry by reducing tax and energy costs and increasing forest resources. Attracting capital investment is the first step towards resource-based economic development.

<sup>6</sup> In addition, the wage rate of all workers in forest products industry had been used in both models instead of the wage rate of the production workers. The two series of wage rates had correlation coefficients around 0.98. Another educational attainment, the percentage of the persons who are 25 yr old and over and have completed Bachelor's degrees or more, had been tried, and sawtimber delivered price had been used instead of the pulpwood price. Again, no trial changed the main results. Water resource and industrial land prices have been considered, but no appropriate measurement or data were found.

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