REGIONAL DEPENDENCE AND LOCATION OF THE WOOD PRODUCTS SECTOR IN THE NORTHEASTERN UNITED STATES: UNIQUE ATTRIBUTES OF AN EXPORT-BASED INDUSTRY

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ABSTRACT

Natural resources have long been a source of both raw material supply and value added manufacturing in many rural regions across North America. Contemporary resource management and rural development planning increasingly emphasize the integration of raw material production with forward-linked processing activities. Empirical studies suggest that wood processors locate proximate to raw material supplies. Assessing the regional firm location decisions of wood processors, however, raises important and complex issues of sectoral heterogeneity. In this paper, we initiate analysis of firm location in three wood processing sub-sectors through descriptive location quotients of primary, secondary, and reconstituted wood products manufacturing sectors. Explanatory variables that support these sectoral specific location quotients include proxies for raw material inputs and output markets. Results suggest that important differences exist in locational dependency attributes between wood products sub-sectors.

Keywords: Wood products, primary processors, secondary processors, reconstituted processors, firm location, location quotient.

INTRODUCTION

Firm location decisions offer one basis for understanding regional economic vitality. In many respects, regions grow or decline based on their ability to attract and retain firms. The relative ability of regions to retain and attract firms is dependent, at least in part, on their unique comparative advantages. These unique comparative advantages relate to how firms perceive a location's conduciveness to allowing them to maximize profits. Important components associated with a firm's ability for maximizing profits relate to location as it affects cost minimization and/or

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demand maximization. Furthermore, the location and characteristics of industry clusters relative to the breadth of sectoral diversity determine the extent of regional dependency on any given industrial sector. This is particularly important for rural resource-dependent regions across the United States.

Regional science has a strong literary component that addresses regional resource endowments, primary industry location, resource dependency, and export base attributes of regions. The early work of North (1955) and the overview of economic base multipliers by Richardson (1985) identified the importance of raw material endowments and their processing as principal explanatory factors involved in an export-base concept of regional growth. Porter's work in regional competitive advantage (Porter 1990, 1994) clearly identifies factor resource conditions as critical in location decisions of a firm. While the extraction and processing of natural resources have the potential to provide a regional comparative advantage relative to other economic sectors by virtue of their ability to generate surplus resource rents above normal returns to other factors of production, large-scale dependency on resource extraction also can contribute to regional instability over time (Gunton 2003). The location of resource endowments and related firm activity represent an increasingly important component associated with the new economic geography (Fujita et al. 1999; Audretsch 2003) and in the analysis of spatial economic issues (Anselin 2003; Fingleton 2003).

The location of firms

The general problem facing a firm is a situation in which consumers and suppliers are scattered across a heterogeneous economic plane. Any given firm is faced with the locational choice that places the firm somewhere on the economic plane in a manner that maximizes profits. The firm does this by minimizing the transportation costs of shipping input supplies to the firm and finished goods to the market, and maximizing the potential market demand for their good or service. In other words, the profit maximization approach to location decisions declares that businesses select the site from which the number of buyers whose purchases are required for maximum sales can be served at the least possible total cost (Greenhut 1956; McCann 2002). This site need not be the lowest total cost site possible, but rather a site from which an individual business can offer a delivered price to buyers at lower than competitors' prices. This approach recognizes the interaction between demand (locational interdependence) and the cost of production in site selection.

The profit maximization approach examines both the total revenues and the total costs portion of the profit equation:

$$\text{Profit} = \text{Total Revenues} - \text{Total Costs} \quad (1)$$

The firm is faced with balancing two factors, the location of customers which drives the revenue side of the profit maximizing equation, and the location of suppliers, which drives the cost side of the equation. Typically, the firm believes one of these factors to be more important than the others, and the result is a focus on either maximized revenue or minimized costs. Other factors enter the decision only after that initial choice is made.

Formally we can state our problem outlined in Eq. (1) as:

$$\text{Profit} = \sum_{i=1}^{m} P_i D_i(P_i) - f - vq(x_i) - \sum_{i=1}^{m} t(s,s^i) D_i(P_i) - \sum_{i=1}^{n} d(s,s^i) x_i \quad (2)$$

where P_i is the price charged at market i (i = 1 . . . m), $D_i(P_i)$ is the demand for the firm's product at market i, s^i is the spatial location of market i, $t(s,s^i)$ is the cost of transporting one unit of the good from firm location s to market location s^i, f is the fixed costs facing the firm to produce the good, v is the constant marginal cost of producing one unit of the good, x_i is the production inputs from market i (i = 1 . . . n), $d(s,s^i)$ is the cost of transporting one unit of input x_i from market location s^i to firm locations, and $q(x_i)$ is the output level of the firm.

The firm selects location given a set of prices (P_i) that maximize demand at each market and a location (s) that minimizes transportation costs. Clearly, the number of output markets (m) need not be equal to the number of input markets (n), and the cost of transporting output ($t(s,s^i)$) need not be the same as the cost of shipping inputs ($d(s,s^i)$). We could make our problem even more general by allowing for multiple outputs (q_i) and multiple firm locations (e.g., multiple plants) (s^j).

Firm location and the wood products sector

The wood products sector has a long history of activity throughout rural North America. This is particularly true in rural regions endowed with significant forest resources (Webster and Chappelle 1989). The reliance of this sector on raw material inputs and its increasingly global linkages for both output demand and production inputs provides an interesting focus for applied empirical work.

Regional economic investigations of the wood products sector are limited. Important work has been done on the impact of timber production and the wood products sector on local economies; however, literature dealing with the regional economic effects associated with timber production and wood products sector activity either does not address or it glosses over important issues of firm location (Cox and Munn 2001; Aruna et al. 1997). Others have examined the environmental impacts of timber production and the wood products industry through regional comparisons without mention of firm location (McNulty et al. 2000; Lewis et al. 1996). Lohmander (1994) addresses cost minimization and firm location in the forest products industry from a transportation cost perspective; however, transportation is only one of many factors in the firm location decision process. It is important to note that minimizing transportation costs does not necessarily maximize profitability. It is the goal of transportation planning to optimize the expected present value of the firm where transportation is only one in a number of cost variables.

To more accurately model regional firm location, models should address additional factors such as demand market size, raw material availability, and labor markets. Abt (1987) examined the regional impacts of labor and raw materials in the United States lumber industry, while Smith and Munn (1998) examined labor and capital regional impacts of the logging industry. Both studies present interesting information but fail to address the spatial aspects of firm location. Leigh (2000) examined issues of foreign competition and competitiveness in the U.S. woodworking industry and suggests that the timber industry and construction activity may impact the location of woodworking producers. However, a detailed analysis of these two factors was not pursued.

The problem we address in this paper more clearly specifies attributes of firm location in the wood products sector. Specifically, the empirical questions we set out to answer are rather straightforward and fall into three basic categories. First, do the locations of subsectors within the wood products sector relate to one another? Second, if there is a correlation, to what extent does this correlation among alternative subsectors differ by subsector? Finally, what elements help explain why some regions have concentrations of the three forest products subsectors while others do not? This latter question moves us toward answering important issues related to firm location.

This paper is organized into four basic sections. Following this introduction, we describe the empirical modeling and data used to study firm location in the three subsectors of the forest products industry. Then we describe results generated from the empirical models and their relative limits. Finally, we summarize important findings, outline relevant policy issues, and lay out a framework for further research in this area.

METHODS AND DATA USED IN EMPIRICAL MODELS

In an effort to address the questions outlined above, we begin with a simple proxy that allows for identification of location choice as a regional phenomenon. Our work then moves into developing models that explain this location choice proxy. It is important to point out that our theoretical model identified above relates generically to the spatial profit maximization problem consistent with firm-level economic theory. Operationally, we step back and rely on an empirical model tempered by the realities of readily available secondary data.

A proxy spatial location metric

Location quotients are used as a proxy for spatial location. The location quotient represents an index that places the percent of local output in a given sector as a ratio to the percent of national output in same sector as follows:

$$LQ_s^i = \frac{\left(\frac{o_s^i}{o_s^t}\right)}{\left(\frac{o_n^i}{o_n^t}\right)} \quad (3)$$

where LQ_s^i is the location quotient for industry i in place s, o_s^i is the output in industry i in place s, o_s^t is total output in place s, o_n^i is a national reference for output in industry i, while o_n^t is the total national output.

These indices represent the level of sectoral dominance in regional economies and are sensitive to issues of economic diversity, size and economic scale. As such they are well-suited to the development questions raised here. They are limited, however, in measurements requiring an absolute incidence of sectoral activity. For instance, regions with large diverse economies may have a significant absolute level of activity in a given industry. But, if "other" sectors present in the economy are large, the industry in question may not show large location quotients because the relative importance of the sector is muted with respect to overall economic activity. Thus, our use of the location quotient as a proxy for firm location neglects to incorporate agglomerating influences and the pecuniary externalities of firm interaction. It does, however, capture the relative importance of firm location particularly evident in smaller rural counties. Also, it represents a useful proxy for identifying the extent to which export-base activity exists within these regions.

The empirical models

The operational models seek to explain these location quotient indices using a set of independent variables that mimic our generic model of firm location as outlined in Eq. 1. Namely, we construct models based on reasonable industry characteristics for inputs and outputs that reflect the sectoral cost structure (or supply) and its output markets (or demands). The latter represent proxies, for revenue, while the former represent costs. Operationally, this initial work is based on very gross measures of demand and supply driven by the available regional data.

Perhaps the most straightforward forest products subsector is what we identify as primary wood processors. This sub-sector is representative of firms that turn roundwood into dimensional material. Specific examples include sawmills and plywood mills. Output demand for primary processors includes both intermediate demands of the forward-linked processing sectors (e.g., furniture manufacturers) and final demands within the construction trades and general public consumption. Thus a more specific empirical model for the primary processing subsector includes the following:

$$LQ^{primary} = f\begin{pmatrix} D_{INT2}, D_{INT3}, D_{FIN}, \\ RM_{RW}, RM_{INT}, \text{control} \end{pmatrix} \quad (4)$$

where D_{INT2} is the demand from the secondary wood processing sub-sector (measured as regional sub-sector output), D_{INT3} is the demand from the reconstitituted wood processing sub-sector (again measured as regional sub-sector output), and D_{FIN} is the set of final demands. In these models, final demand is proxied by the county-specific USDA Rural-Urban Continuum classification. This represents a gross indicator of market proximity. Input costs on a regional basis are related to the availability and relative transport costs associated with raw materials used in the primary wood processing sub-sector. Namely, these include timber harvested from surrounding forests.

For our purposes in these initial models, we have two alternative forms of timber removals that represent removals from growing stock (RM_{RW}) that include all volumes (sawtimber and pulpwood) and what we term intermediate inputs representing timber removals that are merchandised as sawtimber alone (RM_{INT}).

The secondary wood products sub-sector represents those firms that use dimensional and reconstituted wood products to produce some final finished good. Specific examples include furniture manufacturers and cabinetmakers. For purposes of explaining firm location in the secondary wood products sub-sector, our logic rests on the notion that the primary sectoral output will be for final demands (D_{FIN}) with raw material inputs including output of primary processors (RM_{INT1}) such as dimensional wood members and the reconstituted sector (RM_{INT3}) such as fiberboard and wood-based laminates. In future models, we will also seek to include non-wood based inputs such as chemicals and textiles. Also important in these future models will be skilled labor supplies. Thus, our initial model for secondary wood products sub-sector location is as follows:

$$LQ^{secondary} = f\left(D_{FIN}, RM_{INT1}, RM_{INT3}, \text{control}\right) \quad (5)$$

The reconstituted wood products sub-sector represents those firms involved in using wood chips or wood pulp to produce some good that has both intermediate and final demands. Specific examples of firms included in this sub-sector are oriented-strandboard manufacturers and paper mills. Our model of firm location for the reconstituted sector rests on the logic that these types of firms are both closely tied to timber output (wood chips and pulpwood) and are inextricably linked to other downstream processors (secondary wood processors, publishers, etc.). Our model for reconstituted sector location quotients is represented as:

$$LQ^{reconstituted} = f\begin{pmatrix} D_{INT1}, D_{INT2}, D_{FIN}, \\ RM_{RW}, RM_{INT}, \text{control} \end{pmatrix} \quad (6)$$

where outputs are consumed by intermediate (D_{INT1}, D_{INT2}) and final (D_{FIN}) demands and raw material inputs include timber, both roundwood (RM_{RW}) and sawtimber (RM_{INT}).

Data used in the empirical models

Data for this study were obtained from three sources. The first source included data on forest growing stock and timber removals and was interactively accessed through the USDA Forest Service Forest Inventory and Analysis (FIA) database (USDA Forest Service 2003). The FIA database project collects data on forest area and tree volume down to the plot level which can be aggregated to county-wide estimates. Data within each state are collected on a rotational basis, which provides complete state coverage every 3 years. Data from the FIA database can be presented by county, state, and forest survey unit. A forest survey unit is a group of counties defined by the USDA Forest Service. Each state is divided into as many as nine forest survey units based on political and ecological criteria (see Figs. 1, 2, and 3 below for specification of forest inventory units).

Specific data from this source included volumes for four measures of raw material availability including *growing stock removal, sawtimber removal, growing stock volume,* and *sawtimber volume. Growing stock removal* is defined as the volume of harvested live timberland trees of commercial species that contain at least one 12-ft sawlog or two sawlogs 8 ft or longer, now or prospectively, and meet specified standards of size, quality, and merchantability. *Sawtimber removal* is defined as the volume of harvested growing-stock trees that contain at least a 12-ft sawlog or two noncontiguous sawlogs 8 ft or longer and meets regional specifications for freedom from defect. Softwoods must be at least 9.0 in. diameter and hardwoods must be at least 11.0 in. diameter. *Growing stock volume* is defined as the net volume in cubic feet of growing-stock trees at least 5.0 in. in diameter from a 1-ft stump to a minimum 4.0-in. top d.o.b. of the central stem or to the point where the central stem breaks into limbs. *Sawtimber volume* refers to the net volume

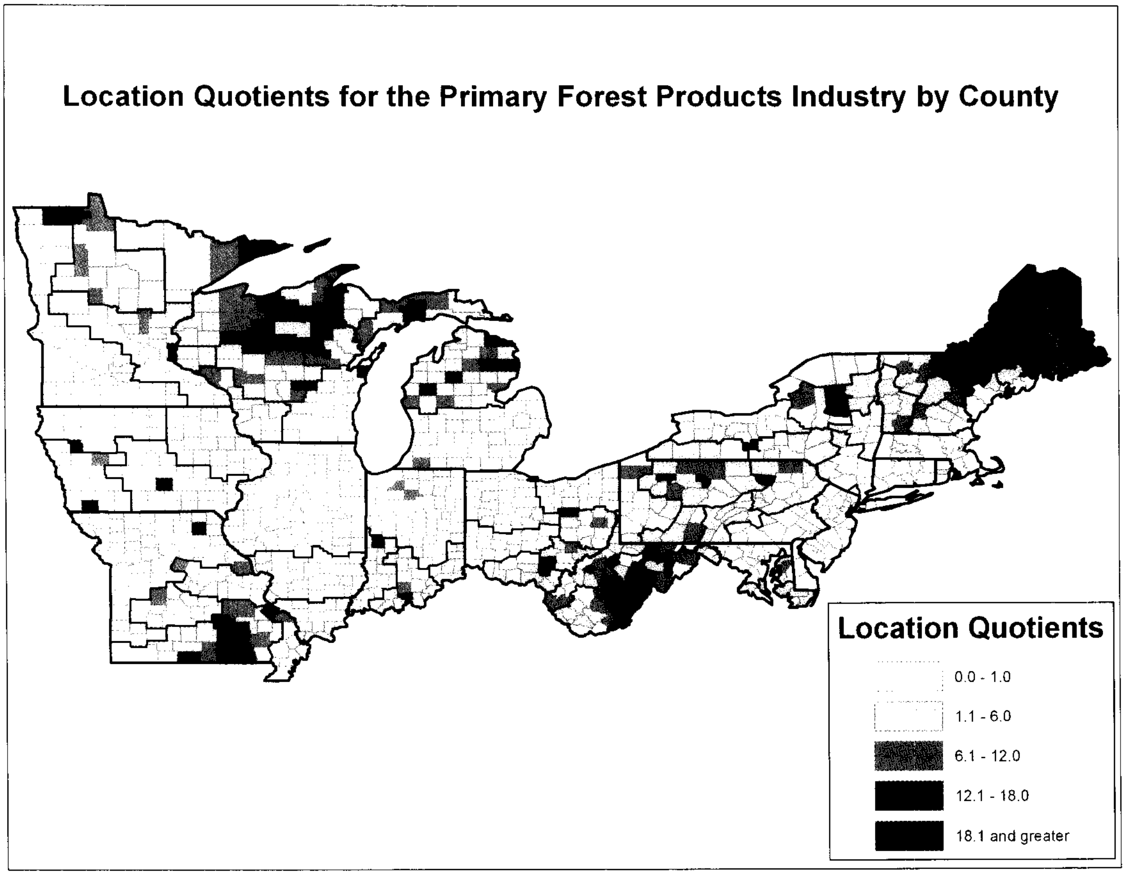

FIG. 1. Location quotients for the primary forest products sub-sector by county calculated using 1997 MicroIMPLAN data on industry output.

in board feet (International 1/4-in. rule) of the sawlog portion of sawtimber trees.

The second data source from which sectoral characteristics were identified was from the Minnesota IMPLAN Group (MIG 2001). Specifically, we used IMPLAN data to construct county-level estimates of sector output (in dollars), employment (in no. of jobs) and other components of value added such as employee compensation, other property type income, proprietors income, and indirect business taxes. For our purposes, Table 1 presents the aggregation template used for the various sub-sectors of the forest products industry.

Finally, county-level data on population and demographics were obtained from the United States 2000 Census (USDC 2002). At this point, the only Census data used in these forest products industry empirical models have been population. Other related work (Kim 2002; Dissart 2003) has incorporated data on socio-demographic conditions such as distributional income data, poverty rates, and unemployment. As future models are developed, these richer regional condition data elements will be incorporated.

As a conclusion to this section, we address issues of firm location in the forest products industry using regional explanatory models of locational attributes. Our proxy for spatial location is the sub-sector location quotient. Input costs are proxied by timber availability and, depending on the sub-sector, intermediate purchased in-

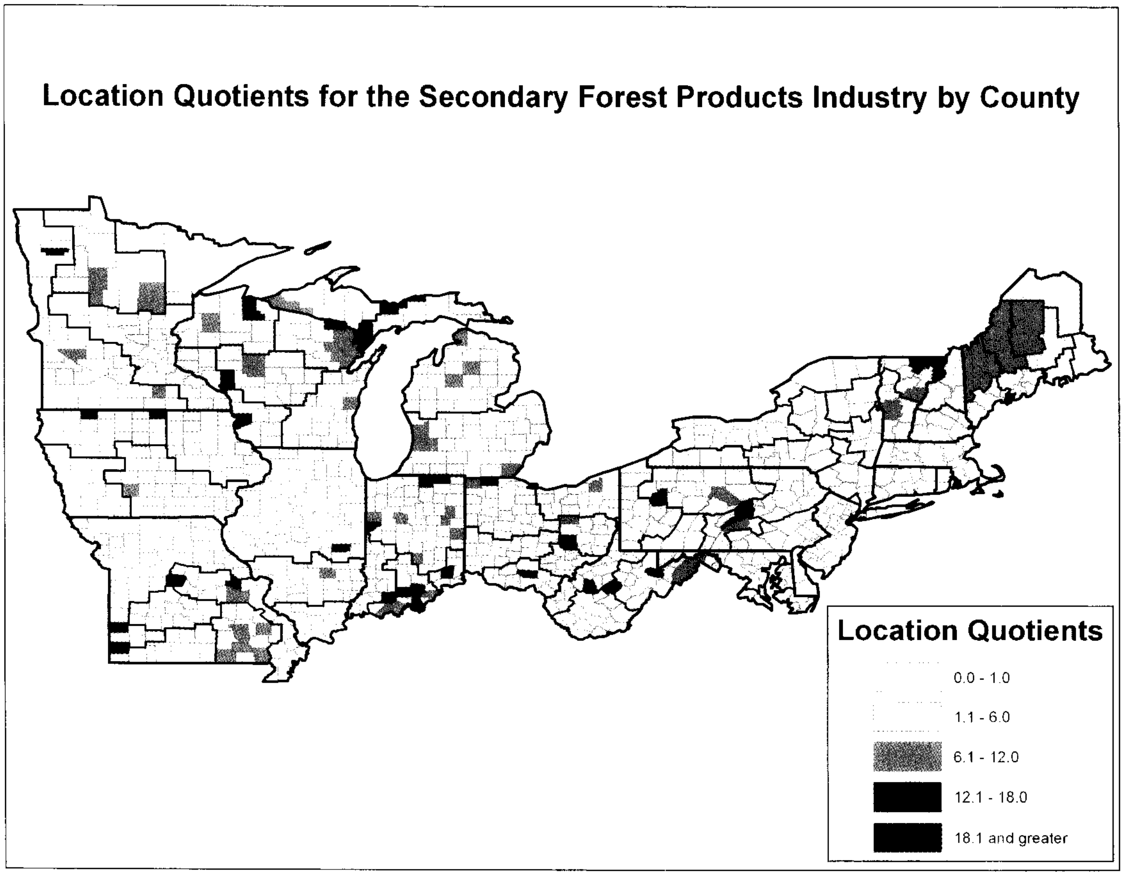

FIG. 2. Location quotients for the secondary forest products sub-sector by county calculated using 1997 MicroIMPLAN data on industry output.

puts from other sub-sectors of the forest products industry. Output demands include both intermediate and final demands. Data sources capture forest inventory characteristics, industry sectoral characteristics, and socio-demographic elements of counties in the 20 Northeastern United States.

Results and limitations of the analysis

Results suggest that location issues for each wood products sub-sector are unique in-and-of-themselves but are also distinctly related to one another. In this section, we outline the descriptive and inferential results of our analysis. First, the location quotients for each sub-sector are spatially arrayed and briefly described. We then proceed into a discussion of the statistical correlations that exist in the dataset used for the empirical models. This is followed by a brief discussion of the empirical Ordinary Least Squares models used to develop an understanding of firm location in the forest products industry.

Descriptive results of spatial location

Location quotients were calculated for each forest products industry sub-sector. Calculations were generated for county, state, and forest survey unit levels. A location quotient greater than 1 indicates a higher local concentration of output than the national concentration of output for that given sector. A location quotient less than 1 indi-

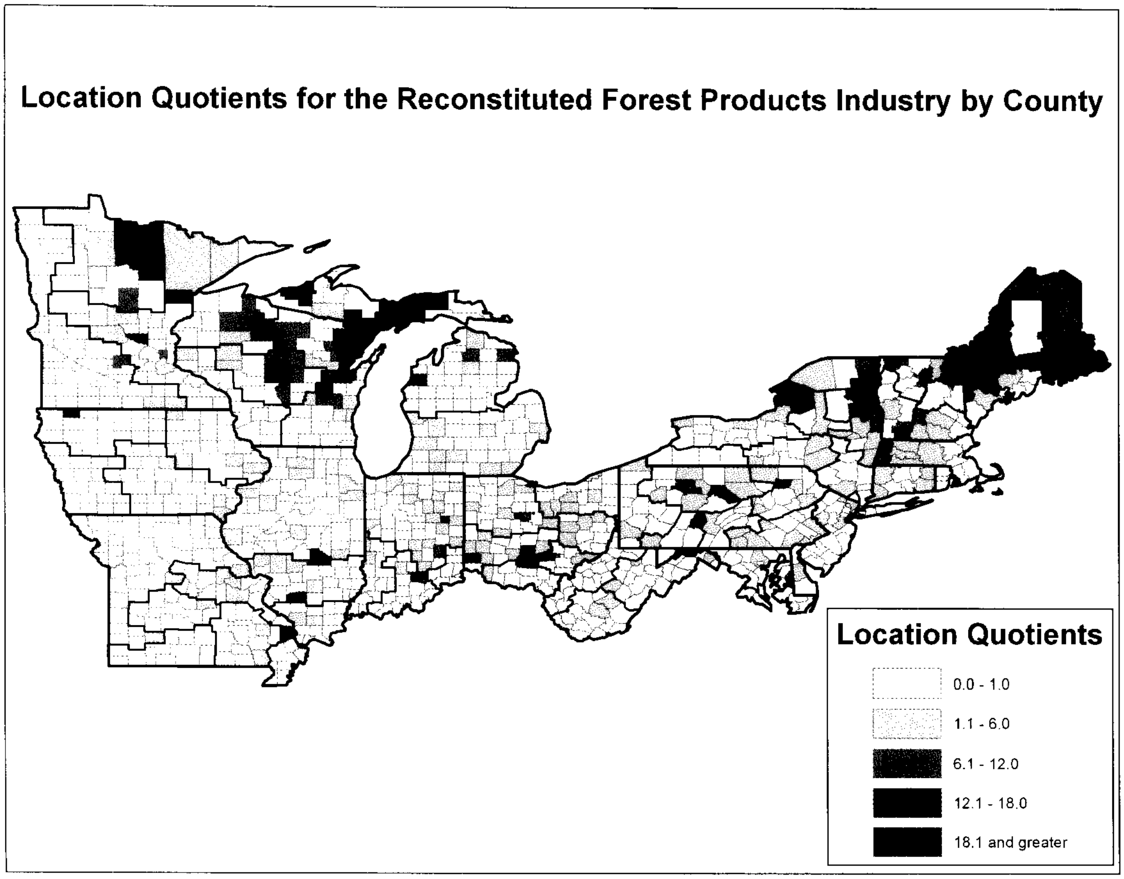

FIG. 3. Location quotients for the reconstituted forest products sub-sector by county calculated using 1997 MicroIMPLAN data on industry output.

cates a lower local concentration of output than the national concentration of output for that given sector. For example, a location quotient of 5 indicates that the region has 5 times the local concentration of output as the national output for that given sector.

Twelve of the 20 Northeastern states had location quotients greater than 1 for at least one sector on a statewide level. Three states had location quotients greater than 3. The analysis by forest survey unit proved useful. This level of analysis showed regional trends not visible with the state level analysis. Fifty-nine of the 74 forest survey units in the 20 Northeastern states had location quotients greater than one for at least one sector. Thirty-three forest survey units had location quotients greater than 3 in at least one sector. For purposes of detail, we present the spatial array of each sub-sector on a county basis.

To simplify this discussion, our presentation of the spatial distribution of forest products subsectors is provided graphically in Figs. 1, 2, and 3. Our first forest products subsector is termed "primary" and includes those firms involved in processing roundwood into dimensional products for use in construction or other forward-linked sectors. The county-level location quotient for this subsector is presented in Fig. 1. As shown in the figure, primary forest products firms dominate county economies in Northern Minnesota, Wisconsin, and Michigan as well as in Northern New England, the mid-Appalachian

TABLE 1. *Sectoral aggregation used in for industry subsector specification (MIG 2001).*

IMPLAN Sector	Sectoral Description	Aggregated Sector
24	Forestry Products	Primary wood processing
133	Logging Camps and Logging Contractors	Primary wood processing
134	Sawmills and Planing Mills, General	Primary wood processing
135	Hardwood Dimension and Flooring Mills	Primary wood processing
136	Special Product Sawmills, N.E.C.	Primary wood processing
137	Millwork	Primary wood processing
138	Wood Kitchen Cabinets	Secondary wood processing
139	Veneer and Plywood	Secondary wood processing
140	Structural Wood Members, N.E.C.	Secondary wood processing
141	Wood Containers	Secondary wood processing
142	Wood Pallets and Skids	Secondary wood processing
143	Mobile Homes	Secondary wood processing
144	Prefabricated Wood Buildings	Secondary wood processing
145	Wood Preserving	Secondary wood processing
147	Wood Products, N.E.C.	Secondary wood processing
148	Wood Household Furniture	Secondary wood processing
149	Upholstered Household Furniture	Secondary wood processing
152	Wood Tv and Radio Cabinets	Secondary wood processing
153	Household Furniture, N.E.C.	Secondary wood processing
154	Wood Office Furniture	Secondary wood processing
156	Public Building Furniture	Secondary wood processing
157	Wood Partitions and Fixtures	Secondary wood processing
160	Furniture and Fixtures, N.E.C.	Secondary wood processing
146	Reconstituted Wood Products	Reconstituted wood product
161	Pulp Mills	Reconstituted wood product
162	Paper Mills, Except Building Paper	Reconstituted wood product
163	Paperboard Mills	Reconstituted wood product
164	Paperboard Containers and Boxes	Reconstituted wood product
165	Paper Coated & Laminated Packaging	Reconstituted wood product
166	Paper Coated & Laminated N.E.C.	Reconstituted wood product
168	Bags, Paper	Reconstituted wood product
169	Die-cut Paper and Board	Reconstituted wood product
170	Sanitary Paper Products	Reconstituted wood product
171	Envelopes	Reconstituted wood product
172	Stationery Products	Reconstituted wood product
173	Converted Paper Products, N.E.C.	Reconstituted wood product

region, and the Ozark Mountains of Southeastern Missouri.

The secondary forest products sub-sector includes those firms involved in transforming dimensional wood into final products. A good example of these types of firms includes furniture and cabinet manufacturers. The county-level location quotients for this sub-sector are graphically presented in Fig. 2. Notice from the figure that there is much less concentration of these firms in the forested regions of the 20 Northeastern United States as compared to primary forest products firms. Notice also that the location quotients were generally smaller when compared to the previous grouping of firms. This perhaps represents the wider spatial distribution of secondary processors into more diverse and larger economies.

The reconstituted wood products sector includes those firms engaged in processing goods that are comprised of wood that has been either chipped or pulped. Two good specific examples include oriented strandboard manufacturers and pulp and paper plants. The county-level location quotients for this subsector are presented in Fig. 3. Note from the figure that the spatial pattern appears similar to the primary forest products sub-sector. This was expected since both the primary and reconstituted industries extract their raw materials from largely forested areas. Both sawlogs and pulpwood are often harvested in the same areas with sawlogs being sold to sawmills and pulpwood being sold to pulpmills.

Relationships among dependent and independent variables

Our initial empirical work focused on developing a better understanding of the relationships among the location indices for the three forest industry sub-sectors and the alternatively identified explanatory variables for each subsector. As an entry into this work, we analyzed the correlation among primary dependent variables (LQs of primary, secondary, reconstituted sectors) and the array of independent variables (outputs of each sub-sector, the county-level Urban-Rural Continuum code, and county population). Pearson's sample correlation coefficients were used to identify correlation between the location quotients for the three forest products industry sectors and the four measures of raw material availability.

For county-level data, correlation coefficients of 0.6 were identified as significant. All measures from the FIA data including growing stock removal, sawtimber removal, growing stock volume, and sawtimber volume were significant and positively correlated. This was not surprising since they all account for the location and availability of the raw material. Both the primary and reconstituted sectors use timber in roundwood and sawtimber as their raw material and are both typically located in forested regions. In addition, the primary, secondary, and reconstituted forest products industry sectors were positively correlated to one another and positively correlated to the FIA variables, although none were significant at 0.6. The control variable population was negatively correlated to all other variables in the model. A rural industry dependent upon natural resource extraction would not be positively correlated with large population concentrations.

Regression model results

In this paper, we present an initial look at empirical models of firm location in the forest products industry. These simple OLS models are presented in Table 2 by alternative dependent variable (location quotients by industry subsector). Prior to discussing the details of relationships within the models, we note that although all models are significant, the general lack of any explanatory power of the secondary wood products sub-sector model provides significant limitations to developing a story around its specific components. Future work will develop a broader respecified model hopefully to improve our results with respect to the secondary wood products sub-sector. Furthermore, there are several extensions to these models that we will continue to develop that should improve their ability to explain locational aspects of each sub-sector. These include respecification of the independent variables through a broader inclusion of components of regional economic structure, economic diversity, and socio-demographic characteristics.

The results of these models suggest that timber availability is a key input to the primary and reconstituted wood products subsectors. Raw material input variables were significant in both models with interesting and predictable signs. Sawtimber removals were positively related to location of the primary wood products subsector location quotient, while the pulpwood component of removals emphasized in the roundwood raw material variable played a positive role in explaining location of the reconstituted wood products subsector. The primary sector output variable was significant for the secondary sector model. This result was expected, given the dependence of the secondary sector on the primary sector for its raw material inputs. The secondary sector also depends upon the reconstituted sector for raw materials such as particleboard, yet the reconstituted sector output variable was not significant. Since the reconstituted sector is heavily weighted to the paper in-

TABLE 2. *OLS regression analysis for location quotient by industry subsector.*

	Dependent Variables					
	$LQ_{primary}$		$LQ_{secondary}$		$LQ_{reconstituted}$	
	b	t-ratio	b	t-ratio	b	t-ratio
DFIN (Beale Code, 0 to 9)	0.814 (0.328)	10.136***	0.218 (0.132)	3.746***	0.07205 (−0.047)	1.372
DINT2 (Sec. sector output)	−6.024E-4 (−0.007)	−0.215			0.001616 (0.029)	0.870
DINT3 (Recon. sector output)	−0.000131	0.150				
RMRW (Growing stock removals)	−0.371 (−0.338)	−2.699**			0.386 (0.569)	4.282***
RMINT (Sawtimber removals)	0.271 (0.617)	4.926***			−0.08846 (−0.325)	−2.453*
RMINT1 (Primary sector output)			0.01001 (0.076)	2.420*	0.01057 (0.086)	2.577*
RMINT3 (Recon. sector output)			2.666E-5 (0.002)	0.042		
Population 2000	1.042E-6 (0.041)	1.092	−6.688E-7 (−0.04)	−1.024	−1.158E-6 (−0.074)	−1.993*
Constant	−2.277	−4.477***	0.783	2.148*	1.509	4.520***
R^2	0.193		0.028		0.097	
Adjusted R^2	0.188		0.024		0.092	
Model F	40.986***		7.354***		18.511***	

*p = 0.05, **p < 0.01, ***p = 0.001; Standardized beta coefficients in parenthesis.

dustry, the impact of particleboard producers may have been masked.

The Beale code (also known as the Rural-Urban Continuum Code), which represented our gross proxy for final demand, was significant and positive in explaining the location quotients for primary and secondary wood products sub-sectors. Other locational factors such as proximity to a water source may have a larger impact on the reconstituted sector than distance to the final market.

Important locational relationships exist between these sub-sectors. Of particular note is the importance of a primary wood products sub-sector in the location of secondary and reconstituted wood products sub-sectors. Interestingly, there was no significant relationship between the primary wood products sub-sector and the locational index for the reconstituted wood products sub-sector. One might explain this one-sided relationship by noting that the reconstituted sector depends upon the primary mills for sawdust and shavings for a portion of their raw material input, but sawmills don't need to sell their sawdust and shavings to the reconstituted sector since they can sell their sawdust and shavings in the fuel and animal bedding markets.

DISCUSSION, CAVEATS, AND FURTHER RESEARCH NEEDS

In this paper, we constructed regional location models for three wood products sub-sectors. Although lacking specific firm-level profit components, our empirical models contained significant explanatory variables that served as gross proxies to the generic location decision framework. Results suggested that the location of two of the three wood products sub-sectors were significantly related to timber removals with intra sector location important as both intermediate demand and input suppliers.

The theoretical linkages between the primary, secondary, and reconstituted wood products sub-sectors are straightforward. The primary and reconstituted sectors depend upon an abundant forest resource to supply their raw material needs. The secondary sector depends upon the primary (lumber) and reconstituted (panel products) sectors for its raw material needs. The models developed here address these raw material demands. The final demand for the primary sector can be explained by the secondary and reconstituted sectors. The final demands for the secondary and reconstituted sectors are more difficult to measure; however, the Beale Code performed well as a general indicator of final demand.

Our models do a fair job of providing empirical evidence in support of raw material dependency and intra-sectoral linkages among the three sub-sectors. The broader determinants of firm location in these three sectors involve raw material availability, transportation costs (dependent on infrastructure), demand market conditions, and more qualitative aspects of locational decisions. Indeed, this latter component includes issues such as behavioral, historic, cultural, social, and quality-of-life factors that could be particularly important and are not captured in our initial modeling efforts.

Institutional aspects are another locational attribute that could potentially be important and are not included in these initial models. Locational incentives available to a particular firm in a particular county or municipality were not considered in the models discussed in this paper. Although very much a part of the decision process utilized by firms in establishing their location, the inclusion of incentives such as tax incremental financing, discounted property values, community-based economic development grants, and industrial revenue bonds are issues to be considered by a much more defined and specific model.

Future efforts will focus on improving the fit of the models. Other variables such as a more accurate measure of final demand or the availability of trained workforce may have a positive impact, especially in the secondary sector model. Separating the paper product producers from the panel product producers in the reconstituted sector should improve the model. Both have similar raw material demands; however, final product demand for each sub-sector differs greatly.

In addition to satisfying theoretical curiosities, research addressing firm location and regional dependency has several practical applications. A basic understanding of where and why forest products firms locate is of interest to rural economic development specialists and natural resource managers. States with significant forest resources have a unique comparative advantage in attracting and retaining forest products firms. This manufacturing base can be the economic foundation for many rural communities. In recent years, economic pressures and public perceptions have brought change upon the forest products industry. Competition from foreign manufacturers has impacted many firms. Differing values on the use of our forest resources has caused disputes between various interest groups. A clear understanding of location factors can help address the array of issues facing the forest products industry today.

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REFERENCES

ABT, R. C. 1987. An analysis of regional factor demand in the U.S. lumber industry. Forest Science 33(1):164–173.

Anselin, L. 2003. Spatial externalities, spatial multipliers, and spatial econometrics. Int. Reg. Sci. Rev. 26(2): 153–166.

ARUNA, P. B., F. CUBBAGE, K. J. LEE, AND C. REDMOND. 1997. Regional economic contribution of the forest-based industries in the South. Forest Prod. J. 47(7/8):35–45.

AUDRETSCH, D. B. 2003. Innovation and spatial externalities. Int. Reg. Sci. Rev. 26(2):167–174.

COX, B. M., AND I. A. MUNN. 2001. A comparison of two input-output approaches for investigating regional economic impacts of the forest products industry in the Pacific Northwest and the South. Forest Prod J. 51(6):-39–46.

DISSART, J. C. 2003. The role of outdoor recreation facilities in remote rural economic development planning: An exploratory approach. Unpublished Ph.D. dissertation.

Department of Urban and Regional Planning, University of Wisconsin, Madison, WI.

FINGLETON, B. 2003. Externalities, economic geography, and spatial econometrics: Conceptual and modeling developments. Int. Reg. Sci. Rev. 26(2):197–207.

FUJITA, M., P. KRUGMAN, AND A. VENABLES. 1999. The Spatial economy: cities, regions, and international trade. MIT Press, Cambridge, MA.

———. 1956. Plant location in theory and practice. University of North Carolina Press, Chapel Hill, NC.

GREENHUT, M. L. 1963. Microeconomics and the space economy. Chicago: Scott Foresman & Co.

GUNTON, T. 2003. Natural resources and regional development: An assessment of dependency and comparative advantage paradigms. Econ. Geogr. 79(1):67–94.

KIM, K. K. 2002. Effects of natural amenities in the great lakes states: An application of exploratory spatial data analysis (ESDA) and spatial econometrics. Unpublished Ph.D. dissertation. Department of Urban and Regional Planning, University of Wisconsin, Madison, WI.

KRUGMAN, P. 1994. Peddling prosperity: Economic sense and nonsense in the age of diminished expectations. W.W. Norton and Company, New York, NY.

LEIGH, N. G. 2000. Planning, spatial, and technological considerations of restructuring in the U.S. woodworking industry. Economic Devel. Quar. 14(2):204–220.

LEWIS, D. K., D. P. TURNER, AND J. K. WINJUM. 1996. An inventory-based procedure to estimate economic costs of forest management on a regional scale to conserve and sequester atmospheric carbon. Ecological Economics 16(1996):35–49.

LOHMANDER, P., 1994. Adaptive transportation and production in a multi factory forest company—with regionally distributed stochastic roundwood volumes and product prices. *In*: F. Helles and M. Linddal, (eds.), Proc. biennial meeting of the Scandinavian Society of Forest Economics, Gilleleje, Denmark, Nov. 22–25, 1993. Scand. Forest Econ. 35:131–140.

MCCANN, P., 2002. Classical and neoclassical location—Production models, in Industrial Location Economics. P. McCann, ed. North Hampton, MA: Edward Elgar: 3–31.

MCNULTY, S. G., J. A. MOORE, L. IVERSON, A. PRASAD, R. ABT, B. MURRAY, R. A. MICKLER, AND J. D. ABER. 2000. Application of linked regional scale growth, biography, and economic models for southeastern United States pine forests. World Resource Rev. 12(2):298–321.

MIG. 2001. MicroIMPLAN county-level datasets for 1997. Available from Minnesota IMPLAN Group, Inc., 1725 Tower Drive West, Suite 140, Stillwater, MN 55082, Telephone: 651-439-4421.

NORTH, D. C. 1955. Location theory and regional economic growth. J. Political Econ. 63(3):243–258.

PORTER, M. E. 1990. The competitive advantage of firms in global industries. The competitive advantage of nations. The Free Press, New York, NY.

———. 1996. Competitive advantage, agglomeration economies and regional policy. Int. Reg. Sci. Rev. 19(1): 85–94.

RICHARDSON, H. W. 1985. Input-output and economic base Multipliers: Looking backward and forward. J. Reg. Sci. 25 (November 1985):607–661.

SMITH, P., AND I. A. MUNN. 1998. Regional cost function analysis of the logging industry in the Pacific Northwest and Southeast. Forest Science 44(4):517–525.

USDA FOREST SERVICE. 2003. Forest Inventory and Analysis Data Base Retrieval System. USDA Forest Service. http://www.srsfia.usfs.msstate.edu/scripts/ew.htm. May 12, 2003.

USDC CENSUS BUREAU. 2002. County-level 2000 Census Data. Available at the U.S. Department of Commerce, Census Bureau website—http://www.cencus.gov.

WEBSTER, H. H. AND D. E. CHAPPELLE. 1989. Community and regional economic growth and development. Ellefson, P. V., ed. Forest resource economics and policy research: Strategic directions for the future. Westview Press, Boulder, CO. Pp. 263–275.