The Patterns of Pulpwood Trade within the US South
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Abstract

The Southern timber market is the major source of both softwood and hardwood pulpwood in the US. In 1997, three-fourths of total US pulpwood production was produced in the region. The locations of pulpmills and fiber sources determine the patterns of pulpwood trade between the states. Prediction of trade is important for understanding subregional pulpwood markets in the US South and for timber inventory projections on a subregional level. In this paper we estimate determinants of pulpwood trade flows among the states of the US South using a gravity model.

Keywords: Pulpwood, Interregional trade, Gravity Model, Tobit.

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1. Introduction

Recently, there is increasing interest in timber supply and demand projections on the subregional level in order to understand effects of changes in timber dependent industries, urbanization, and population growth on forest resources on the local level (Abt et al., 2000). Thus, accounting for the interregional aspects is an important part of timber supply and demand modeling.

It appears that, despite the fact it is uneconomical to transport raw materials such as wood long distances, significant volumes of wood in the U.S. South are transported across state boundaries. And, more pulpwood than sawtimber is traded between states in the region. Nearly 30% of the pulpwood consumed by the pulping industry in the region arrives at the mill from other states of the region (while less than 1% is imported from outside of the U.S. South). This is one of the reasons why we have restricted our study to the analysis of pulpwood trade. Most state level econometric studies of supply and demand take trade into account as an exogenous variable. Creation of a model capable of predicting timber supply and demand at the local level requires understanding factors influencing trade of timber products among the states.

Figure 1: Pulpwood Production and Pulpmills Located in the South
The main reason for the occurrence of cross-state pulpwood trade is the distribution of pulpmill locations and the location of timber harvest, which is determined by the location of mills and location of inventory (see Figure 1). Pulpwood consumption and production in each state occurs not at a single point, but in an area or group of points. Location of production areas and
concentrations of pulping industry do not obey state lines, which in some cases cross areas of concentration of consumption and production. At the same time the statistics are aggregated by states. As a result we observe the trade across state boundaries (often in both directions — “cross-hauling”). Most of such trade takes place between neighboring states, but some amounts are traded between the states which do not share a common boundary, while volume of trade between neighboring states greatly varies.

The objectives of this study are to identify factors affecting pulpwood trade between states of the U.S. South and estimate their influence.

2. Method

Several groups of methods exist for regional interdependence analysis. Among them are fixed trade coefficient models (multiregional input-output models), gravity models, and linear programming models.

Linear programming (LP) models require a large number of parameters behind the mechanism of interregional trade. For timber inventory modeling, LP was used in the Interregional Timber Supply Model (Holley et al., 1975). In this study we will apply a gravity model, that utilizes empirical trade relationships between industries in different regions.

Tinbergen (1962) and Pöyhönen (1963) independently had the idea of explaining bilateral trade flows by comparing it to the Newtonian law of gravity, where the attraction of two countries “masses” (size of economy represented usually by GDP or population or combination — \( Y \)) is weakened by the “distance” separating them (transportation costs — \( D \)) and influenced by other factors (\( X \)).

\[
T_{ie} = \beta_0 (Y_i)^{\beta_1} (Y_e)^{\beta_2} (D_{ie})^{\beta_3} (X_{i1})^{\beta_4} ... (X_{im})^{\beta_m} \epsilon_{ie} 
\]

This model is usually estimated using a log-log specification.

The gravity equation subsequently became a popular instrument of foreign trade analysis. Early on there was a criticism that it had no theoretical foundation, however a number of works followed (Anderson, 1979; Bergstrand, 1985) which showed that the gravity equation could be derived from the baseline model of trade.

While used widely to analyze various factors affecting trade, such as tariffs, quotas, and trade agreements (including trade of forest products, Kangas and Niskanen, 2003), some studies showed that cross-sectional gravity analysis can yield very wide forecast interval spans around the predicted values, which make it almost useless for estimating trade potentials (Breuss and Egger, 1999).

A number of recent studies suggest that the panel framework has many advantages over the cross-section approach and that the proper econometric specification of a gravity model would be a three-way fixed effect approach (Mátyás, 1997, 1998; Egger, 2000). Furthermore, Egger (2003) argued that proper specification of a panel-based gravity model should include exporter-by-importer bilateral interaction effects. However, the use of bilateral interaction fixed effects makes distance, border and other similar explanatory variables redundant.

In the present study, the following pooled cross-section and time-series gravity model was used:

\[
T_{iet} = \beta_0 (D_{ie})^{\beta_3} (B_{ie})^{\beta_4} (C_{ie})^{\beta_5} (I_{ie})^{\beta_6} (P_{ie})^{\beta_7} \epsilon_{iet} 
\]

where \( i, e, \) and \( t \) are importing state, exporting state, and year; \( T_{iet} \) is pulpwood trade quantity (thousand cords); \( D_{ie} \) is the distance between consumption and production centers of trading
states (kilometers); $B_{ie}$ is the dummy taking 1 if states share a border; $C_{it}$ and $C_{et}$ are the pulping capacities (tons per 24 hours); $I_i$ and $I_e$ are timber inventories (mcf); $P_{it}$ and $P_{et}$ are stumpage prices ($ per cord)

The border dummy ($B_{ie}$) was introduced because distance ($D_{ie}$) between supply and demand centers of the trading states is not capable of fully reflecting propensity to trade due to the proximity of the states. The border dummy is expected to have a positive regression coefficient. The “size of the economy” is represented by pulping capacities of the trading states. The expected signs of pulping capacities are positive.

The other variables included in the model are pulpwood inventories and stumpage prices. It is expected that a higher stumpage price in the importing state ($I_i$) and a larger inventory in the exporting state ($P_{it}$) would increase trade quantity, while a higher stumpage price in the exporting state ($I_e$) and a larger inventory in the importing state ($P_{et}$) would negatively influence trade quantity.

3. Data

The data used in the study are the bilateral trade quantities among eleven states during the period 1994–2001. The trade between each pair of states in both directions was accounted for separately. This makes up 880 observations for the each of the traded products (softwood and hardwood pulpwood). The trade is the total quantity in thousand cords of, respectively, softwood and hardwood roundwood pulpwood traded among eleven states of US South. Pulping capacity is annualized daily pulping capacities of states’ pulp and paper industries in thousand tons. The sources of data on pulpwood trade and pulping capacity are the “Southern Pulpwood Production” reports, an annual report series from the USDA Forest Service Southern Research Station.


Euclidean distances between exporting states’ centers of inventory and importing states’ centers of consumption were determined using ArcGIS. Exporting states’ centers of inventory were calculated separately for hardwoods and softwoods as centers of mass of counties for each of the states weighted by, respectively, softwood or hardwood inventory from the latest FIA data. Importing states’ centers of consumption were calculated as centers of mass of pulpmills for each of the states weighted by mills’ daily pulping capacity (Johnson, 2003).

4. Estimation and Results

Nearly 60% of the observations represent zero trade. In analytical terms this means that the dependent variable is left-censored at zero, since the value of the quantity of trade cannot be negative OLS gives inconsistent and biased estimates in such cases (see Figure 2). The common method for analyzing censored data sets of this type is the Tobit model (Tobin, 1958):
\[
\tilde{Y}_i = \beta' x_i + \varepsilon_i, \\
Y_i = \begin{cases} 
0 & \text{if } \tilde{Y}_i \leq 0, \\
\tilde{Y}_i & \text{if } \tilde{Y}_i \geq 0,
\end{cases}
\]

where \(Y_i\) is the latent dependent variable, \(\tilde{Y}_i\) is an observed dependent variable, \(\beta\) is a coefficient vector, \(x_i\) is a vector of explanatory variables, and \(\varepsilon_i\) is an error term.

Figure 2: Tobit model vs. OLS
Consistent estimates of the parameters of the Tobit model may be obtained using maximum likelihood estimation procedures (Greene, 2000).

Coefficients of a Tobit regression determine both the probability of the dependent variable being above the censoring limit and the change in the dependent variable if it is above the censoring limit. Changes in the dependent variable due to changes in the explanatory variables, or marginal effects, are nonlinear and are not equal to the regression coefficients.

Tobit model estimation results for the gravity equations, as well as the marginal effects, are presented in Table 1.

Table 1: Tobit Estimates of Gravity Models
<table>
<thead>
<tr>
<th>Softwood</th>
<th>Hardwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ \text{Estimate} ]</td>
<td>[ P &gt; \chi^2 ]</td>
</tr>
<tr>
<td>Intercept</td>
<td>-14.00</td>
</tr>
<tr>
<td>(D_{i}e)</td>
<td>-7.31</td>
</tr>
<tr>
<td>(B_{i}e)</td>
<td>7.33</td>
</tr>
<tr>
<td>(C_{i}t)</td>
<td>3.48</td>
</tr>
<tr>
<td>(C_{e}t)</td>
<td>2.40</td>
</tr>
<tr>
<td>(P_{i}t)</td>
<td>2.04</td>
</tr>
<tr>
<td>(P_{e}t)</td>
<td>-1.52</td>
</tr>
<tr>
<td>(I_{i})</td>
<td>-1.11</td>
</tr>
</tbody>
</table>
Marginal effects are calculated at the sample mean.

As indicated by the values of the pseudo-$R^2$’s (Veall and Zimmermann, 1994), the gravity models explain 71% and 69% of the variation in the dependent variables (logs of, respectively, softwood and hardwood pulpwood trades between individual states). Coefficients of most explanatory variables are significant and all have the expected signs. As expected, the distance and border variables have the most explanatory power (as indicated by their marginal effects and $\chi^2$). The coefficient of the distance variable has a much higher absolute value than usually indicated in the literature on gravity models, e.g. Kangas and Niskanen (2003). This is due to the fact that roundwood products are uneconomical to transport long distances.

Coefficients of pulpwood inventory for exporting states are significant in both models, and marginal effects (elasticities) are close to unity, which is consistent with the theory. In the softwood pulpwood model, stumpage prices in importing and exporting states have effects of similar magnitude and opposite directions. In the hardwood pulpwood model, quantity of trade is elastic with respect to the stumpage price in importing state, however, it seems that quantity of trade is not effected by the stumpage price in exporting state. Pulping capacities in the hardwood pulpwood model were not found significant probably because of our inability to discriminate between hardwood and softwood pulping capacity.

5. Discussion and conclusion

The paper presents an econometric analysis of pulpwood trade among eleven states of the U.S. South. It estimates a gravity trade equation using a Tobit model and pooled cross-sectional–time series data.

The results indicate that geographic distance between importing and exporting states, size of timber economy, stumpage prices in importing states, and pulpwood inventories in exporting states have been important determinants of the quantity of pulpwood trade.

The next step in this analysis is to evaluate the predictive ability of the model, and compare it with predictive abilities of other models, such as a gravity model estimated with a fixed error component, a fixed coefficient gravity model, and simultaneous equations demand and supply model.

References


Holley, D.L., R.W. Haynes, and H.F. Kaiser. 1975. An interregional timber model for simulating change in the softwood forest economy. School of Forest Resources, NC State University, Raleigh, NC.


