MODEL

Merging Areas in Timber Mart South Data

by

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Abstract

For over twenty years, Timber Mart-South (TMS) has been distributing prices of various wood products from Southern forests. These long-term price series have been a critical resource for research into timber price and supply trends in the southern United States. Such analyses rely on consistent temporal and spatial reporting units, but these units have not always been consistent for many TMS reporting unit series. In the beginning of 1988 the reporting frequency changed from monthly to quarterly, a change readily addressed through a variety of established statistical techniques. A more significant statistical challenge is Timber Mart-South's change in 1992 from (typically) three reporting regions per state to two. We developed a conversion technique to address this change in reporting areas, permitting longitudinal analyses of the current two regions per state but extending back to the beginning of Timber Mart-South's reports in 1976. We report conversion factors for every state's regions, verify the statistical nature of all time series created using them, and report tests of seamlessness. We find that our technique enables the creation of new, seamless series for pine sawtimber stumpage and delivered sawlogs, and pine and hardwood pulpwood stumpage and delivered logs, In only a few cases were we able to identify remaining regime shifts in the time-series of quarterly prices that corresponded with the 1992 boundary reconfigurations. However, these statistically significant shifts may not be related to the boundary reconfigurations.

INTRODUCTION

For over twenty years, Timber Mart-South (Norris Foundation, 1977-1998) has been reporting to subscribers prices of various wood products from Southern forests. These long-term price series have been critical resources for research into optimal harvest behavior (e.g., Brazee and Mendelsohn (1988), Washburn and Binkley (1990, 1993), Haight and Holmes (1991), Thomson (1992), Hultkrantz (1993)), demand and supply equation estimates (e.g., Newman (1987)) and general analyses of price and supply trends in the southern United States. Many of these analyses have relied on consistent temporal and spatial reporting units. The mentioned research has relied on the consistency of Timber Mart-South (TMS) data at least through 1987. Unfortunately, since 1987, these units have not been consistent. From 1976 (December) until 1988 (March), prices were reported monthly. Also in 1988, the reporting frequency changed to quarterly, beginning from the first quarter. A quarterly time-series can be derived from a monthly time-series by either averaging the three months or by taking consistent (e.g., middle-month) samples from the monthly data. Indeed, many authors have already used such techniques to carry out their research with these data (Haight and Holmes 1991, Thomson 1992, Hultkrantz 1993, Washburn and Binkley 1993).

A more significant statistical challenge is Timber Mart-South's change in 1992 from (typically) three reporting regions per state to two. The goal of this paper is to describe and statistically test the searnlessness of a conversion technique we developed to address this change in reporting areas. The resulting series permit. longitudinal analyses of the current two regions per state, extending back to the beginning of Timber Mart-South's reports in 1976. This conversion is accomplished by weighting prices in the old regions by average annual removals from each county, yielding proxy prices that correspond to the new regions.

To evaluate the validity of this approach, we test these time series by (i) sampling the middle month of each region's pre-1988 proxy prices and taking the quarterly price for the 1988-1991 proxy series and appending them to the corresponding 1992-1998 actual quarterly series, creating quarterly series that run from 1977-1998; (ii) conducting unit root tests of each 1977-1998 quarterly series to verify the need for differencing of the data, as a preliminary step in (iii) estimating intervention models of each of

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the differenced series, using a dummy variable corresponding to the 1992 regime shift. We analyzed the seamlessness of six product series for twenty-one TMS regions, including those that had reconfigured boundaries and those that did not. For brevity we'll refer to the TMS reporting regions as Areas.

METHODS

We begin our methods by explaining how region weights were calculated and applied, then explain the structure of the intervention models used to evaluate TMS Area weighting schemes. Middle-month sampling was used to generate the quarterly observations for the pre-1988 series.

Area Weighting

Early TMS reporting techniques were described in Gunter and Cubbage (1987). These authors explained that TMS prices have been reported as simple average sale prices per unit volume within an Area. Average prices are reported by contracted consultants to Timber Mart-South, Inc. For stumpage, reported prices are the observed average price of timber sales organized by the consultant. For delivered products, simple averages over all reporting mills are calculated. The published TMS "average" price for the Area for the period is the simple average of the reports within product categories for that period. Product categories analyzed here are southern pine pulpwood stumpage and delivered logs, southern pine sawtimber stumpage and delivered logs, and mixed hardwood pulpwood stumpage and delivered logs.

TMS published maps of old and new TMS Areas and these were used to identify Area boundaries. Old and new Area borders within each state, while described by TMS (Norris Foundation 1992) as "diffuse and gradual," typically follow state and county boundaries. We surmised, then, that county-level data on forest resources would provide a reasonable method for converting the old Area prices to new Area prices for 1986-1991.

Forest resources within each county were defined by product. Pine sawtimber and delivered sawlog prices were assumed to be most closely related to sawtimber resources, while pulpwood prices were assumed to be best related to poletimber resources. Similar reasoning led to resource definitions for hardwood products.

The United States Forest Service's Forest Inventory and Monitoring (formerly, Forest Inventory and Analysis) records standing timber inventory, growth, and removals as part of its periodic surveys of forest resources. We chose county-level removals by species as the best weighting approach, since it is removals that are priced by TMS, not inventory. This choice is similar to techniques outlined by Granskog and Crowther (1991) in creating weighted state- and southwide-average pulpwood price series.

Each TMS Area contains several counties and portions of counties. The following expresses the proportion, π, of the old TMS Area ($i=1,..I$) contained in the new Area ($j=1,2$), as a function of the proportion p, of the removal volume q, found in the county k, for wood product r:

$$\pi_{ijr} = \sum_{k=1}^{K} p_{ijk} q_{kr} \tag{1}$$

In our analysis, weights were calculated with equation (1) for all Southern states for which a consistent series of data could be identified. Data on hardwood and softwood sawtimber and poletimber removals were obtained from the Forest Service's Forest Inventory and Analysis database (Forest Service 1997). Tables 1-4 report the weights.

Price series for product r were then generated from the old reporting regions with the following equation:

$$P_{jr,t} = \sum_{i=1}^{I} \pi_{ijr} P_{ir,t} \tag{2}$$

where $P_{jr,t}$ is the price of product r in TMS new Area j in period t and $P_{ir,t}$ is the price of product r in TMS old Area i in period t, and π_{ijr} is the weight used in converting old Area series to new Area series.

TMS Areas changed only slightly in some states while others underwent more substantial revision. One way to measure the degree of change is measuring its relative diversity. For example, a new Area that is composed of equal parts of old Areas 1, 2, and 3 has experienced the most change in definition while one that is composed of 95% old Area 1 and 5% old Area 2 has changed little. A diversity index such as Shannon's diversity index can quantify the change. Area j's diversity index of reconfiguration for product r is therefore:

$$D_{jr} = -\sum_{i=1}^{I} \pi_{ijr} \log(\pi_{ijr}) \qquad (3)$$

This diversity index is bounded by 0 and 0.477 for base-10 logarithms, where 0 indicates no reconfiguration and 0.477 indicates creating one new Area from equal parts of three old Areas.

Intervention Modeling

Weights were generated-and are available from the authors--from removals data. Weights constructed using inventories of pine and hardwood sawtimber and poletimber were also examined (not shown), but we found few notable differences between removals-based and inventory-based estimates in any equation estimates regarding magnitudes of coefficients or ARMA structures of differenced series.

For pulpwood prices, weights used in equation (2) were those derived from poletimber removals (Table 1 for pine, Table 3 for mixed hardwood). For pine sawtimber prices, weights used in equation (2) were those for pine sawtimber removals (Table 2). No hardwood sawtimber price series were examined because TMS has not had a consistent series of sufficient duration to make a useful evaluation.

The resulting data series covered the first quarter of 1977 to the last quarter of 1998. Prices were expressed in natural logarithms and were nominal (undeflated), in order to avoid problems encountered by filtering the data through a deflating mechanism (Schnute 1987). All quarterly price series were evaluated with augmented Dickey-Fuller (ADF) tests (Dickey and Fuller 1979) to determine whether series were integrated. ADF tests were performed for the entire series, a maximum of eighty-eight observations per region per product (some regions had missing observations), and involved no dummies indicating either region shifts or frequency of price reporting.

ADF tests included an intercept and sufficient lagged-difference terms to ensure white-noise errors, and all showed that nonstationarity could not be rejected for any series. After first-differencing, then, all series were stationary using ADF tests, indicating that they could be effectively modeled as ARMA(p,q) series.

Intervention models included a dummy variable with a value of 1 corresponding to the first quarter of 1992, zero otherwise. The structure of this equation, suppressing region and product subscripts, was:

$$d(P_t) = a + \beta R_t + A(L)d(P_{t-1}) + B(L)\varepsilon_t \qquad (4)$$

where a is a constant; R_t is a dummy with a value of one for the first quarter of 1992 and zero otherwise; β measures the degree of price change for the first quarter of 1992, independent of other changes; $d(P_t)$ is the current innovation; A(L) and B(L) are polynomials in the lag operator L. The term βR_t is what is referred to as the noise in the model, deviations from the ARMA model which remain after all correlations with past changes in price and random errors are accounted for.

RESULTS

Intervention models, equation (4), were estimated for every product and region, and results of the significance of the dummy variable, R_t, are reported in Table 1. Column 1 of each table shows the TMS Area identifier-the two-letter postal abbreviation plus the Area number (1 or 2). Column 2 in these tables contains indices of diversity of reconfiguration of new TMS Areas for sawtimber and sawlog delivered mill prices. Columns 3 and 4 show whether the coefficient on the dummy variable was significantly different from zero at 10 (*), 5 (**), or 1% (***). Column 5 shows the diversity of change index for pulpwood, while columns 6 and 7 show the significance of the dummy coefficients for pulpwood stumpage and delivered mill prices. Finally, column 8 shows the reconfiguration change diversity for hardwood pulpwood and columns 9 and 10 indicate the statistical significance of the dummy variable.

Several TMS Areas appeared to have no changes in region definitions: FL1 (most cases), LA1, LA2, MS2, SC1, TX1, TX2, and VA1. By this measure, the states with the most radical changes in configuration were AL1, AL2, FL2, GA2, MS2, NC2, VA2, and TN2.

Seventeen of sixty-three stumpage price series and thirteen of sixty-three delivered log price series registered region reconfiguration dummy coefficients significantly different from zero at 10% significance. The frequency of statistical significance of that dummy coefficient was over twice the rate expected (thirteen) given the 10% threshold.

For a subset of products and TMS Areas, prices in the first quarter of 1992 increased significantly. This was true irrespective of the amount of region reconfiguration, and it was geographically centered on the Southern Appalachians. Of the seventeen stumpage price series with significant region dummies, seven had no TMS Area reconfiguration. The regions significantly affected for pine pulpwood stumpage were GA1 (northern Georgia), both Mississippi series, both South Carolina series, and VA1 (western Virginia). For pine sawtimber, the pattern was similar-both Georgia series, SC1 (western South Carolina), and VA1 (western Virginia).

Hardwood pulpwood stumpage did not follow the same pattern-price shifts were statistically different from zero in scattered locations and indicated both positive changes and negative changes in price corresponding to the time of area change.

Similar results are identifiable in delivered prices, with pine pulpwood and sawlog prices jumping upward in TMS Areas in and surrounding the Southern Appalachians. Uniformly, the amount of change was smaller than that exhibited by stumpage prices.

Why prices jumped a similar amount in the Southern Appalachian TMS Areas in the first quarter of 1992 might have been due to chance, a common force in the wider economy, or to simultaneous changes in sampling frequencies or intensities in these Areas at the same time as shifts. To examine the second possibility, we examined price data for southern pine lumber, housing starts, and gross domestic product. Incorporation of these data into the intervention equation estimates (not shown but available from the authors) resulted in a sometimes substantial reduction in standard errors of equation estimates and some partial, but not complete, explanation of the price jumps for the first quarter of 1992. Indeed, GDP in the U.S. increased by eight percent (at an annual rate) from the fourth quarter of 1991 to the first quarter of 1992 (United States Department of Commerce 1999a), housing starts in the U.S. South increased by 14 percent over the previous quarter (United States Department of Commerce 1999b), and southern pine lumber prices increased by 8 percent between those two quarters (United States Department of Commerce 1999c).

Unfortunately, the Department of Commerce figures are applicable only at the regional or national level, while the observed price shifts happened at much finer geographical resolutions. Indeed, if the entire region were spatially integrated, then prices would move together region-wide and would be affected by the same market-level demand factors, but our results do not support this contention. If the jump in price is not a phenomenon of TMS sampling changes that began with the first quarter of 1992, then we must look to other factors.

Another way to uncover the effects of the region change for those with significant dummy coefficients would be to compare the corresponding TMS series with comparable non-TMS series or with price trends outside the region. Stumpage price data compiled by Haynes (1998, p. 30-68) show that large price increases in the first quarter of 1992 corresponded with similar price changes in the Pacific Northwest, probably resulting from a severe curtailment of timber harvests on National Forests of that region. From the fourth quarter of 1991 to the first quarter of 1992, Douglas-fir stumpage prices increased by 34% on Eastside National Forests of Oregon and Washington and 72% on Westside National Forests. Softwood timber harvests from those National Forests dropped 4.4 billion board-feet in 1990, 0.8 billion-board-feet in 1991, and 0.7 billion-board-feet in 1992. The delay in price rise until 1992 may have been due to low demand in 1991, only rising in 1992 when the national economy strengthened.

Table 1. Degree of region reconfiguration, as measured with Shannon's diversity index, and statistical significance of region shift dummies in intervention equation estimates of Timber Mart-South constructed series, 1977-1998.

TMS Area	Pine Sawtimber & Sawlog Diversity of Change	Pine Sawtimber Stumpage	Pine Sawlog FOB Mill	Pine Pulpwood Diversity of Change	Pine Pulpwood Stumpage	Pine Pulpwood FOB Mill	Mixed Hardwood Pulpwood Diversity of Change	Mixed Hardwood Pulpwood Stumpage	Mixed hardwood Pulpwood FOB Mill
AL1	0.30			0.30			0.30		
AL2	0.33	*		0.33			0.32		
AR1	0.19			0.25			0.20		
FL1	0.00			0.00			0.00		*
FL2	0.15			0.26			0.28		
GA1	0.24	***	***	0.24	***	*	0.20		
GA2	0.30	*		0.30			0.27	**	
LA1	0.04			0.00			0.19		**
LA2	0.00			0.00			0.00	**	
MS1	0.30			0.27	***		0.37		***
MS2	0.00			0.00	*		0.00		
NC1	0.26			0.30		**	0.20		***
NC2	0.30		**	0.26			0.30		
SC1	0.00	***	***	0.00	***	**	0.00		*
SC2	0.30			0.28	***		0.29	**	
TN1	0.14			0.11		**	0.25		
TN2	0.28			0.30			0.23	**	
TX1	0.00			0.00			0.00	**	
TX2	0.00			0.00			0.00		
VA1	0.00	*		0.00	*		0.00	***	***
VA2	0.28			0.25			0.29		

Note: Asterisks indicate that the estimate of the coefficient on the dummy variable corresponding to the quarter of the region reconfiguration, 1992(I), was statistically different from zero at 10 % (*), 5 % (**) or 1% (***) significance. Diversity of change is Shannon's index of diversity of the mix of old TMS Areas.

Data on Mississippi pine pulpwood prices, collected by the Mississippi State University Extension Service (Daniels 1991, 1992), show that Mississippi pine pulpwood stumpage price changes were large, just as the TMS series showed. The Extension Service's statewide average pine pulpwood stumpage price jumped in 1992 by 32% over the 1991 level, while the price jump for a removals-weighted average of TMS Areas for that state was 27% over the same period. This argues that the significant dummy coefficients for these two series (MS1 and MS2 pine pulpwood stumpage) was not an artifact of our weighting scheme for that state.

CONCLUSIONS

Timber Mart-South data are an important statistical resource for economists and others interested in tracking timber prices over time. To make the whole length of series most useful these series must be statistically consistent. We presented here a method to make the series statistically seamless. Our intervention model was able to detect for some of the reconstructed TMS Areas a degree of measurable and statistically significant residual price shock corresponding with the timing of the TMS region reconfiguration. However, after investigating secondary data sources and evaluating the potential effects of changes in the larger economy, we cannot conclude that the reconfiguration was the source of the statistically significant price change for these regions. Indeed, Mississippi Extension Service's price data showed a nearly identical price increase from 1991 to 1992 as that exhibited by the comparable Timber Mart-South series. Without comparison series from other states where a product price changed by a statistically significant margin our results remain somewhat inconclusive.

Nonetheless, for 96 of the 126 series analyzed, we have confidence that the weighting scheme presented here produces seamless series, at least at the degree of statistical significance chosen (10%). Because the removal levels in Areas with significant dummies were small relative to those without significant dummies, these 96 seamless series account for prices representing the vast majority of the volume of southern timber. For the remaining 17 stumpage price series and 13 delivered log price series, we have somewhat less confidence that they are seamless. Had we chosen a more stringent 5% statistical significance threshold, eight more of the 126 series would be deemed seamless.

Economists and others who are concerned about the integrity of data might avoid the questionable TMS series and confine inferential tests about market behavior to those series that were found to be seamless. Such a strategy would still permit testing on prices representing the vast majority of the timber and logs produced in the United States South.

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