Pulpwood Production, Prices, and Markets in North Carolina
by
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Abstract

In this paper, we first analyze trends in pulpwood production (1980-1997) and prices (1977-1998) in North Carolina. We then attempt to investigate spatial integration of the delivered and stumpage pulpwood markets for both mixed hardwood and pine in two regions of North Carolina (western; central and east combined). Results indicate that North Carolina's total roundwood removal volumes have grown at the rate of 3.3% per year, hardwoods at 3.7% per year, and softwoods at 3.1% per year with varying rates of growth among different FIA survey units. The two coastal FIA survey units dominate in softwood production, accounting for 74% of average total production over the period 1980 to 1997. The clearest trend is in the piedmont, where hardwood roundwood removals have shown substantial sustained increases over the last ten years. Mixed hardwood pulpwood prices have risen, suggesting a greater demand and increasing economic scarcity, particularly in the central and east region. The delivered pine pulpwood prices declined, suggesting relative abundance of pine pulpwood stumpage and/or logging efficiencies. With the exception of the delivered pine pulpwood market, the mixed hardwood pulpwood markets and stumpage pine market are cointegrated indicating that the two regions behave as one market for these products. Enhanced timber markets across the state, including wood chipmills, are increasing integrated product markets.

INTRODUCTION

North Carolina has roughly 18.7 million acres of timberland as of 1990. Of this, 48% is located in the coastal plain (9 million acres), 31% in the piedmont (5.7 million acres), and 21% in the mountains (4 million acres) (Brown, 1998, 1998b). There are 5 main pulpmills, with 4 located in the Coastal Plain and one in the Mountains. There are 18 major chipmills that take roundwood, chip it, and ship the chips to other locations. Of these 4 are in the Mountains, 9 in the Piedmont, and 5 in the Coastal Plain. Timber products are well recognized as an important component of the North Carolina State economy. Overall the timber product sector has shown significant growth in recent decades. Among the different sectors, the pulp and paper sector has particularly shown significant growth, with output volumes increasing 200% over the 1955 to 1995 period according to currently ongoing research.

These timber products are sold in markets, that are spatially linked and interdependent. Regional prices of these products can be used to study the linkages in the market. Trends in pulpwood removal volumes and prices over time can capture any changes in the resource base and market conditions. We can view the two North Carolina regions - western (NC1) and central and eastern combined (NC2) as one market if the prices in each market move together and do not diverge by more than the transportation and transaction costs in the long run. We are interested in examining whether the two regions (NC1 and NC2) are spatially integrated as one complete market for pulpwood or if they behave as separate markets. Cointegration tests have been used in recent years to examine this issue. Cointegration tests for the existence of a long-run equilibrium relationship among spatially separated markets. A state of equilibrium where price changes in one market result in equilibrating changes in the other such that local prices in alternative markets differ by no more than transportation and transaction costs is called the law of one price. According to Engle and Granger (1987), the law of one price should hold if markets are cointegrated.

Several researchers have examined the issue of market cointegration and law of one price. Buongiorno and Uusivuori (1992) studied the U.S. pulp and paper export market; Jung and Doroodian (1994) looked at the U.S. lumber market. Murray and Wear (1998) analyzed Pacific Northwest and Southern lumber market. Limited work has been done on the southern pulpwood market. Nagubadi and Munn investigated pulpwood stumpage markets in the South Central U.S. In this paper, we focus our attention on the pulpwood market in North Carolina, studying pulpwood production, price trends, and market cointegration to understand the nature of the pulpwood market. Finally we consider the effect of

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chipmills on the pulpwood market. The specific objectives of this research were to:

- Analyze trends in pulpwood production and prices
- Conduct cointegration analysis of price series for pulpwood
- Examine the pulpwood market and the chipmill linkages

DATA AND METHODOLOGY

Timber product output and pulpwood surveys conducted by the USDA Forest Service were used to analyze pulpwood production. We examined trends in roundwood pulpwood production (softwoods and hardwoods) for the period 1980 to 1997 for the four USDA Forest Service Forest Inventory and Analysis (FIA) survey units in North Carolina (Mountains, Piedmont, Northern Coastal Plain and Southern Coastal Plain). Time series analysis of the data contained in the Southern Pulpwood Production (SPP) reports allows a description of annual roundwood pulpwood production trends within North Carolina at the FIA survey unit level. We also used aggregate Timber Product Output (TPO) data to measure broad regional production trends in the state.

We examined trends in pulpwood prices between 1977 and 1998 for two North Carolina regions, the western (NC1) and the central and eastern (NC2) region. We used University of Georgia's "Timber Mart South" data for pulpwood price analysis (TMS 1977-1998). Timber Mart South reported prices monthly from 1977 until the end of 1988 and since 1988 to the present, it reports quarterly. There were three regions in North Carolina and Virginia in the Timber Mart South price reports until 1991. However, the reporting area coverage changed to two regions in 1992. The three region price series that existed until 1991 was converted into a two region price series by a weighting procedure developed by the Southern Research Station and North Carolina State University, so that the different time frames are comparable (Prestemon 1997). As a result, consistent price data for the two regions were available from 1977-1997 for the state of North Carolina. There are two different prices considered for the analysis: (1) the delivered log price which is the price at the mill and (2) the stumpage price of standing trees in the woods. Quarterly average delivered and stumpage prices of mixed hardwood and pine pulpwood product categories, were used in the analysis. All reported prices were adjusted for inflation using the all commodity producer price index (1982=100), and regression techniques were used to estimate trends in real prices. The regression used to analyze prices and pulpwood volume removal trends follows.

\[ Y = b_0 + b_1X + \mu \]

Where \( Y \) = natural logarithm of prices or volume of pulpwood removed; \( X \) = year; \( \mu \) = Residual error.

For the regression with prices, the annual rate of change " \( r \) " in prices is calculated using the expression \( r = (\text{antilog } b_1)-1 \).

According to Engle and Granger (1987), testing for cointegration involves two steps. Cointegration between the western and eastern market for pulpwood first requires a test of non-stationarity of the individual price series of interest, which is a necessary condition. The price series is considered non-stationary if the mean or variance of that price series varies over time or else it is considered stationary. An augmented Dickey - Fuller (ADF) test is used to test for the stationarity of individual price series, which is given by the following expression.

\[
p \Delta P_t = \alpha + \phi P_{t-1} + \sum \theta_i \Delta P_{t-i} + \mu_t \]

\( \Delta P_t \) = lagged values of the first difference in prices \( P_t \) - \( P_{t-1} \) where \( P_t \) = logarithmic price series (delivered and stumpage) for NC1 and NC2 for mixed hardwood & pine pulpwood product categories; \( \theta_i \) = coefficients; \( i \) = number of lags; \( t \) = time; \( \mu_t \) = error term.

The purpose of including lagged values is to ensure that the errors are uncorrelated. We used the Akaike Information Criteria (AIC) to select the appropriate number of lags to be used. One lag was sufficient to eliminate any autocorrelated disturbances from the price series in most cases. As a sufficient condition for non-stationarity, the second step is to test, whether the unit root process can characterize price series. ADF tests for unit root under the following null and alternate hypotheses. If the null hypothesis of \( \phi = 1 \) is accepted then the price series is considered non-stationary. Thus if:

- \( \text{H}_0 : \phi = 1 \) (price series follow the unit root process)
- \( \text{H}_a : \phi < 1 \) (price series follow the stationary process)

In order to test this we first posit a relationship between prices in western North Carolina market and eastern North Carolina market such that price changes in the western market are reflected by equilibrating changes in prices in the eastern market and such an equilibrium relationship
can be represented by the following cointegration regression:

\[ P_t^W = \alpha + \beta P_t^E + \mu_t \]

Where \( P_t^W \) and \( P_t^E \) represent logarithmic prices in period \( t \) in western and eastern North Carolina and the residual error term \( \mu_t \) represents proportional deviations from price parity. The estimated parameters from the above equation are then used to calculate estimates of the residual errors expressed in the equation below.

\[ \Lambda \Lambda \Lambda \mu \Lambda \]
\[ P_t^W - \alpha - \beta P_t^E = \mu_t \]

We then use the ADF test to test for a unit root in the residuals using the expression given below.

\[ \Lambda \Lambda \mu \Lambda \Delta \nu_t = -\phi \nu_{t-1} + \sum \theta_i \Delta \nu_{t-i} + \mu_t \]

where \( \nu_t \) = residuals in period \( t \); \( \Delta \) = first difference; \( i \) = number of lags; \( t \) = time

If the individual price series are non-stationary but their combination in the cointegration regression produces a stationary series for residuals in period \( t \), then the price series are cointegrated.

**RESULTS AND DISCUSSION**

**Trends in North Carolina Pulpwood Output**

North Carolina's annual pulpwood production grew from 4850 thousand cords in 1980, to 7215 thousand cords in 1997 (+49%). North Carolina's growth in annual pulpwood production outpaced the growth rate of the South as a whole (+39%) in the period since 1980. Pulpwood production increases in North Carolina over the period 1990-1997 have shown a 28% increase from the 1990 level of 5657 thousand cords (Johnson 1996, SRS-3 p.13; Johnson & Steppleton 1999). North Carolina reported the greatest increase in pulpwood production (29%) of all the southern states for the period 1996-1997 (Johnson & Steppleton 1999).

The regressions indicate, the average annual volume of pulpwood produced increased by 2.8% per year between 1980 and 1997. Softwood pulpwood had an average increase of 2.3% over the period since 1980, but overall volumes have been essentially constant since 1991. Hardwoods have shown more substantial rates of increase, growing at an average rate of 3.6% annually since 1980.

**Trends in Roundwood Removal Volumes**

From 1980 to 1997, North Carolina's annual roundwood pulpwood harvests increased 47.5%. Hardwood harvests showed the greatest increase (67.4%), growing from 1.2 million cords in 1980 to 2 million cords in 1997. Softwoods increased from 2 million cords in 1980 to 2.7 million cords in 1997, a 35.5% increase (Figure 1, 2, 3). Expressed in terms of average annual growth rates obtained from OLS regression over the period 1980-1997, total roundwood harvest volumes have grown at the rate of 3.3% per year; hardwood roundwood have grown at a rate of 3.7% per year and softwood roundwood at 3.1% per year.
roundwood pulpwood. Despite some annual volatility, this region has shown sustained increases throughout the 1980s and 1990s, overtaking the Northern Coastal Plain as North Carolina’s dominant pulpwood producing region in the mid 1990s and reaching a record volume of 1.7 million cords in 1997. The Piedmont recorded declines in overall pulpwood volumes throughout most of the 1980s, but has rebounded and increased throughout the 1990s such that volumes are once again approaching those of the coastal plain regions. The Mountains provide substantially less roundwood pulp compared to other regions. After recording significant percentage increases in the late 1980s and early 1990s, the Mountains have shown declining pulpwood volumes in recent years. Within each of the four survey units, volume trends over time appear similar for hardwoods and softwoods. With the exception of the Northern Coastal Plain, volume trends for hardwoods and softwoods appear to follow very similar trends within individual FIA survey unit, while trend differences among the various units are pronounced.

The two coastal regions dominate in softwood production, accounting for 74% of average total production over the period 1980 to 1997. The Piedmont and Mountains together produced only slightly more than a quarter of the average hardwood volumes. The combined annual softwood pulpwood output from the Piedmont and Mountain regions reached a peak of 768 thousand cords in 1981. The Coastal Plains are also the largest producers of hardwood roundwood, however the gap between production volumes is smaller, and decreasing. On average, the two coastal regions provided 69% of the total annual hardwood pulpwood volume over the period 1980 to 1997. However, substantial increases in from the Piedmont are changing this pattern, so that the Coastal Plain supplied only 59% of the state’s domestic hardwood pulp harvest in 1997, compared with 70% in 1990. The Northern Coastal Plain and the Mountains have provided declining hardwood volumes since the mid-1990s. The clearest trend is in the Piedmont, where hardwood roundwood volumes have shown substantial sustained increases over the last ten years.

Overall, a comparison of harvest levels between the two years 1980 and 1997 for domestically utilized roundwood pulpwood reveals that 1997 harvest volumes are 73% higher in the Southern Coastal Plain, 29% higher in the Northern Coastal Plain, 42% higher in the Piedmont and 44% higher in the Mountains. Volume comparisons for softwoods show that 1997 harvest levels were 64% higher in the Southern Coastal Plain, 42% higher in the Northern Coastal Plain, 97% higher in the Piedmont and 9% higher in the Mountains. In 1997, domestically utilized hardwood pulp harvests were 69% higher in the Mountains, 130% in the Piedmont, and 95% higher in the Southern Coastal Plain, and 13% higher in the Northern Coastal Plain when compared to the base year of 1980.

In order to assess patterns of change in pulpwood harvest, it is important to consider harvest quantities as well as rates of harvest change. While harvests in the Mountains have shown significant growth over the period 1980 to 1997, harvests are increasing from a relatively lower base. Changes in harvest rates in the other three regions reflect substantially larger changes in absolute volumes. As an example, the 69% increase in hardwood volume in the Mountains represents a change from 87,775 cords in 1980 to 148,586 cords in 1997, an annual harvest increment of 60,811 cords. In comparison, the Piedmont region combines a very large rate of growth with a substantial baseline, so that the 130% growth corresponds to an annual harvest level of 669,102 cords, an incremental increase of 377,618 cords, when compared to a 1980 baseline of 291,484 cords.

**Price trends**

Like all markets, the interaction of pulpwood demand and supply determines the price. Prices serve as a signaling mechanism in response to changing demand and supply conditions and so act as an indicator of scarcity. Price is influenced by pressure from both sides of the market - from sellers supplying the pulpwood, who will reduce the harvest if the price falls, and from buyers, who reduce the amount purchased as prices rise. A change in behavior on either side will lead to a different quantity of the product being exchanged in the market at a different price.

The real prices of both delivered and stumpage mixed hardwood pulpwood (Figure 4, 5)
increased in North Carolina. The percent increase varied as indicated in Table 1.

**Table 1. Average annual rate of change in prices from pulpwood regressions**

<table>
<thead>
<tr>
<th>Regression Type</th>
<th>Rate of change per year (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Del Hwd W</td>
<td>0.39*</td>
</tr>
<tr>
<td>Del Hwd E</td>
<td>0.68*</td>
</tr>
<tr>
<td>Del Pine W</td>
<td>-0.28*</td>
</tr>
<tr>
<td>Del Pine E</td>
<td>-0.26*</td>
</tr>
<tr>
<td>St Hwd W</td>
<td>0.41*</td>
</tr>
<tr>
<td>St Hwd E</td>
<td>0.23*</td>
</tr>
<tr>
<td>St Pine W</td>
<td>0.34*</td>
</tr>
<tr>
<td>St Pine E</td>
<td>0.17*</td>
</tr>
</tbody>
</table>

* denotes 1% level of significance. Hwd=hardwood
Del and St indicate delivered and stumpage prices.
W = NC1 and E = NC2

Rising prices would suggest a greater demand for mixed hardwood pulpwood and increasing economic scarcity in this region. Increased pulpwood production reported in this and other studies suggests that there is an increase in demand for hardwood pulpwood both in the domestic and export market. The quantity of hardwood as a percentage of total North Carolina domestic pulp production has increased from 34% in 1980 to 38% in 1990 and 43% in 1997. Over the same period, softwood roundwood share has declined by 4% of total pulpwood, from 41% in 1980 to 37% in 1997. The balance of roundwood consumed was in other product classes. The annual volume of domestically utilized roundwood hardwood pulp harvest in North Carolina has increased 67% during the period 1980-1997, from 91 million cu. ft. in 1980 to reach 152 million cu. ft. in 1997 (Johnson and Steppleton 1999). Additionally, international hardwood exports from North Carolina have increased from none in 1980 to about 26 million cu. ft. in 1997 (Brown 1999). Roughly 80% of these chip export volumes originate as North Carolina hardwood stumpage. Inclusion of these export volumes would increase estimates of hardwood as a percentage of overall harvest, and increase the estimated rate of growth in roundwood hardwood pulp harvest from 67% to 90% over the period 1980-1997.

However, the delivered pine pulpwood prices declined between 1977 and 1998 suggesting that this material is more abundant (Table 1 and Fig...
6) or that harvesting costs have decreased. This could also indicate technical substitution with hardwoods, without regard to absolute softwood volume abundance. But pine stumpage prices increased (Fig 7). The increasing trend observed for pine stumpage prices may be the result of volatile price movements observed in the stumpage market after 1987 causing a few quarters of significantly higher prices in relation to the rest. Increased stumpage pine prices may reflect increased ability to use smaller stock for dimension lumber implying increased competition for smaller dbh softwood. The lower delivered price increases tend to reflect harvesting efficiency and better utilization, not more available wood since scarcity is exhibited in stumpage markets. Stumpage prices are about one-third the delivered price. Hence, the remaining two-thirds reflect the harvesting and transportation cost. The delivered pine prices declined at an annual rate of 0.28% in western part of the state and 0.26% in the central and eastern part of the state. This decline in prices could be because North Carolina experienced the greatest growth in softwood pulpwood production between 1983 to 1992, and demand increases have moderated since. We observed increasing trends of roundwood pulpwood production in the Southern Coastal Plain and Piedmont which explains the decline in delivered pine prices in the central and eastern part of the state. This increased growth in roundwood pulpwood from the Southern Coastal Plain and Piedmont goes mostly to the mills in South Carolina and Virginia. Wear reported increased pulpwood harvesting between 1986 and 1992 and much of this harvest increase was in southwestern North Carolina, where pulpwood production expanded by 53 percent. Pulping capacity in that region is relatively small, suggesting that the mills to the south and west - in Georgia and Tennessee - are drawing increasing amounts of material from this region. The implication is that hauling distances and zones of procurement for pulpwood are expanding, foreshadowing increasing demand for pulpwood timber (Wear 1996). This explains the decline in delivered pine prices in western part of the state.

On average the prices in the two regions of North Carolina parallel one another. From 1978 until 1981, the prices declined in the two regions. An increasing trend was observed up until the middle of 1985 for delivered pine and hardwood pulpwood. After 1985 no real trend was observed in prices except for the normal fluctuations in the market cycle for pine pulpwood but an increasing trend was observed for hardwood pulpwood. The central and eastern part of the state (NC2) experienced the largest average annual increase in price of 0.68% per year for delivered mixed hardwood, indicating a greater competition among the four pulpmills in the region. On average, the delivered and stumpage prices of mixed hardwood pulpwood were higher in the western part of the state (NC1) compared to central and east region (NC2). However, delivered and stumpage prices of pine pulpwood were higher in NC2 compared to NC1 indicating a greater competition for the resource in the east.

Pulpwood Market and the Role of Chipmills

The pine stumpage and mixed hardwood pulpwood markets for stumpage and delivered wood were essentially cointegrated as indicated by the cointegration tests. This implies that the law of one price holds for both product categories in the two North Carolina regions (NC1 and NC2) studied. No cointegration was found between the western and eastern market for delivered pine. It is interesting to note that stumpage pine pulpwood market is cointegrated but the delivered pine market is not. Tests for non stationarity revealed that delivered pine prices were stationary while prices for the other product categories studied were not. This indicates that the delivered pine markets in the two regions are independent of one another. The possible reasons could be the lower volumes of pines produced in the west, relatively higher harvesting and transportation cost resulting in lowering the profit margin and returns to investment. The west is also more susceptible to market shocks like the gypsy moths and other environmental disasters. The west also has a low softwood component of the total pulpwood produced. Given the presence of 4 pulpmills in the Coastal Plains and only one in the Mountains, there is relatively lesser demand for pine pulpwood in the western part of the state.

The results of the unit root test for nonstationarity of the individual price series are given in Table 2. The results of the cointegration tests from the cointegration regression for delivered mixed hardwood pulpwood, stumpage mixed hardwood pulpwood, and stumpage pine pulpwood are given in Table 3, Table 4, and Table 5 respectively. These results show individual price series are nonstationary for delivered and stumpage mixed hardwood pulpwood and stumpage pine pulpwood. However,
Table 2. Unit root test for nonstationarity of price series

<table>
<thead>
<tr>
<th>Price Series</th>
<th>T stat for H0</th>
<th>F</th>
<th>Prob&lt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Del Hwd W</td>
<td>-2.23</td>
<td>2.51</td>
<td>0.44</td>
</tr>
<tr>
<td>Del Hwd E</td>
<td>-1.27</td>
<td>0.87</td>
<td>0.85</td>
</tr>
<tr>
<td>Del Pine W</td>
<td>-3.11</td>
<td>5.08</td>
<td>0.03</td>
</tr>
<tr>
<td>Del Pine E</td>
<td>-3.09</td>
<td>4.83</td>
<td>0.04</td>
</tr>
<tr>
<td>St Hwd W</td>
<td>-1.02</td>
<td>0.86</td>
<td>0.85</td>
</tr>
<tr>
<td>St Hwd E</td>
<td>-2.71</td>
<td>3.72</td>
<td>0.14</td>
</tr>
<tr>
<td>St Pine W</td>
<td>-1.34</td>
<td>0.97</td>
<td>0.83</td>
</tr>
<tr>
<td>St Pine E</td>
<td>-2.27</td>
<td>2.62</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Del and St indicate delivered and stumpage prices. W=NC1 and E=NC2 and Hwd=hardwood

Table 3. Cointegration test results

Stage 1.

Dependent variable: Del Hwd W

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>T for H0</th>
<th>Prob&gt;t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.33</td>
<td>7.12</td>
<td>0.0001</td>
</tr>
<tr>
<td>Del Hwd E</td>
<td>0.64</td>
<td>12.38</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

R² = 0.64

Stage 2. Unit root test on residuals

T statistic for H0 = -4.03
Prob > t = .001

Del=delivered price, Hwd=hardwood, W=NC1 and E=NC2

Table 4. Cointegration test results

Stage 1.

Dependent variable: St Hwd W

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>T for H0</th>
<th>Prob&gt;t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.49</td>
<td>4.90</td>
<td>0.0001</td>
</tr>
<tr>
<td>St Hwd E</td>
<td>0.84</td>
<td>13.83</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

R² = 0.69

Stage 2. Unit root test on residuals

T statistic for H0 = -4.1477
Prob > t = 0.0001

St = stumpage price, Hwd=hardwood, W=NC1 and E=NC2

Table 5. Cointegration test results

Stage 1.

Dependent variable: St Pine W

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>T for H0</th>
<th>Prob&gt;t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.73</td>
<td>-3.08</td>
<td>0.002</td>
</tr>
<tr>
<td>St Pine E</td>
<td>1.25</td>
<td>12.66</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

R² = 0.65

Stage 2. Unit root test on residuals

T statistic for H0 = -3.47
Prob > t = .0007

St = stumpage price, W = NC1 and E = NC2

In order to understand the role of chipmills in these markets, the trends in timber product output and prices suggest that for a given stand being close to multiple chipmills improves harvesting opportunity. The presence of these chipmills that have replaced the concentration yards that existed before might be improving transportation efficiency that in turn might be facilitating cointegration between markets. In this respect, wood chipmills have improved processing efficiency and markets for wood, thus helping increase demand and price.

Conclusions

North Carolina's total roundwood removal volumes have grown considerably, with varying rates of growth among different FIA survey units. The Coastal Plain forest survey units are the predominant producers of roundwood pulpwood in North Carolina, with the Piedmont experiencing increasing trends in hardwood roundwood pulpwood volumes in recent years. About 59% of the total hardwood roundwood pulpwood and 74% of the total softwood roundwood pulpwood produced was from the Coastal Plains. On average, real prices of mixed hardwood pulpwood were higher in western North Carolina compared to the central and eastern regions. However, real prices of pine pulpwood were higher in the central and east. The largest average annual rate of increase in prices was observed for delivered mixed hardwood pulpwood suggesting a greater demand for mixed hardwood pulpwood and increasing economic scarcity, particularly in the Alabama, Arkansas, Louisiana, Mississippi, and Tennessee were cointegrated and thus considered a single market, with the opposite for pine pulpwood market.
central and east region. Delivered pine pulpwood prices have declined, suggesting relative abundance of pine pulpwood stumpage and/or logging efficiencies. With the exception of the delivered pine pulpwood market, the mixed hardwood pulpwood markets and stumpage pine market in the two regions are cointegrated and therefore act as one complete market. This implies that, if integrated market shocks are felt in one region, drawing from the other region can compensate them. In the long run the prices in the western, central and eastern regional markets will move toward equilibrium. The presence of wood chipmills probably is facilitating cointegration between markets. Our study does not address the possibility of substitution of hardwood pulpwood for pine in pulp production, as we did not examine the cointegration between the pine pulpwood and hardwood pulpwood market, which may be an area to pursue research in the future.

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