Real Price Trends and Seasonal Behavior of Louisiana Quarterly Pine Sawtimber Stumpage Prices: Implications for Maximizing Return on Forestry Investment

by

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Abstract

This study identifies and analyzes historical real price trends and the seasonal variability of softwood sawtimber stumpage prices in Louisiana over the period 1956-98. Statewide quarterly pine stumpage price time series data were taken from various issues of Quarterly Report of Forest Products compiled and distributed by the Louisiana Department of Agriculture and Forestry. The time series was adjusted for inflation using the Bureau of Labor Statistics Producer Price Index (PPI)-Commodities, Series ID: WPUSOP3000, not seasonally adjusted.

Visual examination of the inflation adjusted series suggested testing a four period (trend) model with consideration of quarterly variability. A single regression equation combining the additive and multiplicative forms was used to test for differential slope coefficients on the basis of real price trends and to test for differential intercept coefficients on the basis of seasonality. Historical real price trends (differential slope coefficients) were found to be separated into four statistically significant periods: 1) 1956 to 1964 (base period), 2) 1965 to 1979 \( [p = 0.000] \), 3) 1980 to 1985 \( [p = 0.000] \), and 1986 to 1998 \( [p = 0.000] \). Analyses of the individual trend periods revealed that real stumpage prices decreased in period one, increased in period two, decreased in period three then, increased in period four. Over the full 43 years, 1956 -1998, softwood sawtimber stumpage prices increased from $141.19/MBF to $384.61/MBF (constant 1998 dollars) for an average compound increase of 2.36% annually.

Examination of seasonality over the four individual time periods revealed that quarterly volatility in softwood sawtimber stumpage prices has increased over time. The most recent period, 1986-1998, was the only period in which seasonal variations in the trend were found to be statistically significant. Using winter quarter stumpage price as the base quarter, summer and fall quarter stumpage prices were found to be significantly lower at the 95 percent probability level. Spring quarter stumpage prices were found to be significantly lower than winter quarter prices at the 80 percent probability level. The differential intercept coefficients for summer, fall, and spring quarters for the period 1986-98 were -$26.10/MBF \( [95\%CI = -$50.46 to -1.74] \), -$26.05/MBF \( [95\%CI = -$50.44 to -$1.66, and -$15.88/MBF \( [95\%CI = -$40.22 to $8.46] \) respectively. The obvious implication for return on forestry investment is a predicted stumpage price differential of up to $50.00/MBF Doyle Log Scale in constant 1998 dollars depending on the time of year (quarter) in which the stumpage is sold.

INTRODUCTION

The rate of return on any forestry investment is greatly influenced by the stumpage price received by the landowner at the time of sale. When selling timber, it is important to understand local stumpage market structure and to have an estimate of plausible near future market conditions. Many factors, such as timber quality for intended use, type of harvest (e.g. thinning or final), sale size, tract accessibility (e.g. all-weather or limited access), distance from mill, time of year, degree of competition for stumpage, industry capacity cycles, and general economic conditions affect the stumpage price paid for a particular tract of timber. While most of the above listed factors are not directly controllable by a landowner, the time of year that stumpage is sold is controllable. Hence, an informed short-term decision must be made.

Yin (1999) used both non-seasonal and seasonal ARIMA models to generate one-lead quarterly stumpage price forecasts for southern pine sawtimber and pulpwood in six southern states. Nominal dollar values were used to generate the forecasts. Hence, the stumpage price forecasts included an implied forecast of inflation. Lutz (1998) provided comprehensive analyses of many stumpage price time series including Louisiana southern pine sawtimber. Lutz used average annual stumpage prices that, by design, do not contain a seasonal component. Hence, there is a lack of empirical evidence as to the effects of stumpage market seasonality on real (constant dollar) forest investment returns.

Nonindustrial private landowners (NIPFs) own 61.2% or 8.607 million acres of a total 13.855 million acres of timberland in Louisiana with the remaining timberland being divided between forest industry (28.4% or 3.937 million acres) and government (9.5% or 1.311 million acres) (USDA Forest Service 1993). Virtually all of the industrial landowners and many of the NIPFs manage their timberslands, at least in part, for profit.

The goal of this study was to provide insight into southern pine sawtimber markets accessible to landowners in Louisiana. The objectives of this study were to: 1) test for historic structural changes in Louisiana southern pine sawtimber stumpage markets, 2) determine to what extent the short-run timing (seasonality) of pine sawtimber stumpage sales historically affected the rate of return on forest
investments in Louisiana, and 3) develop a short-run stumpage price forecast using the Box-Jenkins method.

METHODS

Data
Statewide quarterly pine stumpage price time series data were taken from various issues of Quarterly Report of Forest Products compiled and distributed by the Louisiana Department of Agriculture and Forestry. The time series was adjusted for inflation using the Bureau of Labor Statistics Producer Price Index (PPI)-Commodities, Series ID: WPUSOP3000, not seasonally adjusted. Visual examination of the inflation-adjusted series (Figure 1) suggested testing a four period (trend) model with consideration of seasonal variability.

Model Development
A single regression equation combining the multiplicative and additive forms was used to test the full time series 1956, 1st quarter to 1998, 4th quarter (n = 172), for differential slope coefficients on the basis of real price trends (structural change) and to test for differential intercept coefficients on the basis of seasonality. The base time series subset used for the differential slope test model was 1956, 1st quarter to 1964, 4th quarter. Dummy variables were included to represent three other time series subsets: 1965, 1st quarter to 1979, 4th quarter; 1980, 1st quarter to 1985, 4th quarter; and 1986, 1st quarter to 1998, 4th quarter. Winter quarter was the base quarter used for the differential intercept test. Dummy variables were included to represent spring, summer, and fall quarters. Model development was as follows:

\[ Y_{ti} = \beta_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_1 t_1 + \gamma_2 (D_2 t_2) + \gamma_3 (D_3 t_3) + \gamma_4 (D_4 t_4) + \epsilon_t \]

where:
\[ Y_{ti} = \text{pine stumpage price in constant 1998 dollars at time } t_i (i=1-4) \]
\[ \beta_1 = \text{intercept (winter quarter base quarter)} \]
\[ \beta_2 = \text{differential intercept for spring quarter} \]
\[ \beta_3 = \text{differential intercept coefficient for summer quarter} \]
\[ \beta_4 = \text{differential intercept coefficient for fall quarter} \]
\[ \gamma_2 = \text{slope coefficient for subset 1965, 1st quarter to 1979, 4th quarter} \]
\[ \gamma_3 = \text{slope coefficient for subset 1980, 1st quarter to 1985, 4th quarter} \]
\[ \gamma_4 = \text{slope coefficient for subset 1986, 1st quarter to 1998, 4th quarter} \]
\[ \epsilon_t = \text{error term} \]

An equation with a single trend coefficient was used to test the most recent trend for seasonality. Again, dummy variables were included to represent the differential intercepts for spring, summer, and fall quarters. The most recent trend model was developed as follows:

\[ Y_{t} = \beta_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_1 t + \epsilon_t \]

where:
\[ Y_{t} = \text{pine stumpage price in constant 1998 dollars at time } t \]
\[ \beta_1 = \text{intercept (winter quarter base quarter)} \]
\[ \beta_2 = \text{differential intercept for spring quarter} \]
\[ \beta_3 = \text{differential intercept coefficient for summer quarter} \]
\[ \beta_4 = \text{differential intercept coefficient for fall quarter} \]
\[ \beta_1 = \text{slope coefficient for subset 1986, 1st quarter to 1998, 4th quarter} \]
\[ t = \text{trend subset 1986, 1st quarter to 1998, 4th quarter} \]
\[ \epsilon_t = \text{error term} \]
RESULTS

Structural Change and Seasonality in the Full Time Series

The structural change regression analysis coefficients, t values, and significance levels are presented in Table 1. The constant (intercept) represents the first quarter (winter quarter) stumpage value in 1956, expressed in constant 1998 dollars. The slope coefficient for the base time series subset (1956, 1st quarter to 1964, 4th quarter) is the unstandardized Beta for $t_1$, expressed in constant 1998 dollars.

Table 1. Test Results for Structural Change in the Full Time Series.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized</th>
<th>t value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 172</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>142.468</td>
<td>17.950</td>
<td>.000***</td>
</tr>
<tr>
<td>Spring Qtr.</td>
<td>-4.815</td>
<td>-0.557</td>
<td>.578</td>
</tr>
<tr>
<td>Summer Qtr.</td>
<td>-9.649</td>
<td>-1.115</td>
<td>.266</td>
</tr>
<tr>
<td>Fall Qtr.</td>
<td>-11.682</td>
<td>-1.347</td>
<td>.180^</td>
</tr>
<tr>
<td>$t_1$ (Base)</td>
<td>-0.973</td>
<td>-2.396</td>
<td>.018**</td>
</tr>
<tr>
<td>$t_2$ (1965-79)</td>
<td>3.364</td>
<td>9.287</td>
<td>.000***</td>
</tr>
<tr>
<td>$t_3$ (1980-85)</td>
<td>4.304</td>
<td>6.470</td>
<td>.000***</td>
</tr>
<tr>
<td>$t_4$ (1986-98)</td>
<td>6.287</td>
<td>16.895</td>
<td>.000***</td>
</tr>
</tbody>
</table>

***Significant beyond the 99% probability level
**Significant beyond the 95% probability level
^Significant beyond the 80% probability level

Model R Square = 0.793

Based on the t-test results, the differential slope coefficients (trend coefficients) for each of the time series subsets are significantly different from the base series subset beyond the 99 percent probability level. Hence, the null hypotheses: $h_1 = h_2$, $h_1 = h_3$, $h_1 = h_4$, were rejected. Each series subset is considered to have a statistically different trend representing key structural changes in stumpage market dynamics.

The differential intercept coefficients (seasonality coefficients) were tested for the entire 172-quarter series. Based on the t-test results, three of the differential intercept coefficients are significant for the most recent trend period with one being marginally significant. Using winter quarter stumpage price as the base, summer and fall quarter stumpage prices were found to be significantly lower beyond the 95 percent probability level. Spring quarter stumpage prices were found to be significantly lower than winter quarter prices at the 80 percent probability level. Hence, the null hypothesis: $h_1 = h_2$ was not rejected while the null hypotheses: $h_1 = h_3$ and $h_1 = h_4$, were rejected. The differential intercept coefficients for summer and fall quarters for the subset 1986-98 are: -26.10 /MBF [95%CI = -50.46 to -1.74] and -26.05/MBF [95%CI = -50.44 to -1.66] respectively.

Seasonality in the Most Recent Trend

The most recent trend regression coefficients, t values, and significance levels are presented in Table 2. The constant (intercept) represents the first quarter (winter quarter) stumpage value in 1986, expressed in constant 1998 dollars. The slope coefficient is the unstandardized Beta for $t_4$, expressed in constant 1998 dollars.

The differential intercept coefficients (seasonality coefficients) were tested for the most recent 52-quarter series. Based on the t-test results, three of the differential intercept coefficients are significant for the most recent trend period with one being marginally significant. Using winter quarter stumpage price as the base, summer and fall quarter stumpage prices were found to be significantly lower beyond the 95 percent probability level. Spring quarter stumpage prices were found to be significantly lower than winter quarter prices at the 80 percent probability level. Hence, the null hypothesis: $h_1 = h_2$ was not rejected while the null hypotheses: $h_1 = h_3$ and $h_1 = h_4$, were rejected. The differential intercept coefficients for summer and fall quarters for the subset 1986-98 are: -26.10 /MBF [95%CI = -50.46 to -1.74] and -26.05/MBF [95%CI = -50.44 to -1.66] respectively.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Beta</th>
<th>t value</th>
<th>Sig.</th>
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<tr>
<td>n=52</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>134.063</td>
<td>12.031</td>
<td>.000***</td>
</tr>
<tr>
<td>Spring Qtr.</td>
<td>-15.878</td>
<td>-1.312</td>
<td>.196^</td>
</tr>
<tr>
<td>Summer Qtr.</td>
<td>-26.102</td>
<td>-2.156</td>
<td>.036**</td>
</tr>
<tr>
<td>Fall Qtr.</td>
<td>-26.051</td>
<td>-2.148</td>
<td>.038**</td>
</tr>
<tr>
<td>t4</td>
<td>5.859</td>
<td>20.507</td>
<td>.000***</td>
</tr>
</tbody>
</table>

***Significant beyond the 99% probability level.
**Significant beyond the 95% probability level.
^ Significant beyond the 80% probability level.

Model R Square = 0.900

Short-Term Price Forecasting Using a Seasonal ARIMA Model

A desirable outcome of studying historical stumpage prices is a price forecast. The preceding analyses identify the most recent trend period (1986, 1st quarter to 1998, 4th quarter) and establish seasonality as being statistically significant over the course of the most recent trend period.

In this section, the prior findings are used to aid in identification of an appropriate Autoregressive Integrated Moving Average (ARIMA) model. A detailed explanation of the ARIMA modeling process is presented in Enders (1995). The Box-Jenkins (1976) approach of model identification, estimation, and diagnostic checking is used in conjunction with the ARIMA analytic routine in the SPSS™ version 8 software package.

Multiplicative seasonal ARIMA models are written as ARIMA (p,d,q) (P,D,Q)s, where:

p = number of nonseasonal autoregressive coefficients
d = degree of nonseasonal differencing
q = number of nonseasonal moving average coefficients
P = number of multiplicative autoregressive coefficients
D = degree of seasonal differencing
Q = number of multiplicative moving average coefficients
s = seasonal period

An examination of the correlogram of the first differenced most recent trend series subset (Figure 3) supports the validity of the significance of seasonality in the data. An ARIMA (0,1,0)(0,1,1)4 model was chosen using the Akakie Information Criterion (AIC).

Figure 3. Correlogram of the First Differenced Most Recent Trend.

Table 3 presents a comparison of the outputs of the estimated ARIMA (0,1,0)(0,1,1)4 model with outputs from a plausible non-seasonal ARIMA (2,1,0) model. The ARIMA (2,1,0) has been fitted to southern pine sawtimber stumpage price series in previous literature (e.g. Yin 1999).

Model 1 is a first differenced and seasonally differenced multiplicative seasonal moving average model. The model has no autoregressive coefficients. The seasonal moving average coefficient, ($,$s = 0.702), is significant beyond the 99 percent probability level. Model 1 AIC = 418.216 which is somewhat lower than the AIC of Model 2 (AIC = 461.578). The Ljung-Box Q-statistics for the periodic lags do not indicate any significant autocorrelations in the residuals.

Model 2 is a non-seasonal first differenced second order autoregressive model with no moving average coefficients. The constant term and second order autoregressive coefficient are significant beyond the 95 percent and 99 percent probability levels respectively. The Ljung-Box Q-statistics for the periodic lags indicate marginally significant autocorrelations in the residuals at lags 8, 12, and 16. Hence, Model 2 is not capturing all the information available in the data.
Table 3. Comparative Summary of Plausible ARIMA Models (Most Recent Trend)

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 51a</td>
<td>ARIMA</td>
<td>ARIMA</td>
</tr>
<tr>
<td></td>
<td>(0,1,0)(0,1,1)4</td>
<td>(2,1,0)</td>
</tr>
</tbody>
</table>

Coefficients:

<table>
<thead>
<tr>
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<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>---</td>
<td>5.541 (.015)b</td>
</tr>
<tr>
<td>&quot;1&quot;</td>
<td>---</td>
<td>-0.128 (.351)</td>
</tr>
<tr>
<td>&quot;2&quot;</td>
<td>---</td>
<td>-0.421 (.005)</td>
</tr>
<tr>
<td>$s_1$</td>
<td>0.702 (.000)</td>
<td>---</td>
</tr>
</tbody>
</table>

Diagnostics:

<table>
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<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
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</thead>
<tbody>
<tr>
<td>RSS</td>
<td>22,885.066</td>
<td>26,483.764</td>
</tr>
<tr>
<td>AIC</td>
<td>418.216</td>
<td>461.578</td>
</tr>
<tr>
<td>Ljung-Box Q(L4)c</td>
<td>0.640 (.958)</td>
<td>1.808 (.771)</td>
</tr>
<tr>
<td>Ljung-Box Q(L8)</td>
<td>3.863 (.869)</td>
<td>13.635 (.092)</td>
</tr>
<tr>
<td>Ljung-Box Q(L12)</td>
<td>5.498 (.939)</td>
<td>17.295 (.139)</td>
</tr>
<tr>
<td>Ljung-Box Q(L16)</td>
<td>7.417 (.964)</td>
<td>23.848 (.093)</td>
</tr>
</tbody>
</table>

Forecast:

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998, 4th Qtr.</td>
<td>Pred./Actuald 402.46/374.84</td>
<td>398.21/374.84</td>
</tr>
</tbody>
</table>

aLast observation was reserved for model validation.
bSignificance levels are shown in parentheses.
c(Li) = at periodic lag number i
dConstant 1998 Dollars/MBF Doyle Log Scale

"i = autoregressive coefficients
$s_i$ = seasonal moving average coefficient
RSS = Residual Sum of Squares
AIC = Akakie Information Criterion

Figure 4 presents the actual stumpage price series in constant 1998 dollars and the ARIMA (0,1,0)(0,1,1) predicted values. Figure 5 presents the first differenced, seasonally differenced stumpage values in constant 1998 dollars. A graphical comparison of actual stumpage prices to predicted stumpage prices (Figure 4) and first differenced, seasonally differenced predicted stumpage prices (Figure 5) indicates the ARIMA (0,1,0)(0,1,1) model provides a reliable representation of the most recent trend series subset.

In Figures 4 and 5, the last input value used is 1998, 3rd quarter. The vertical dashed lines separate the input data from the forecast period. Model validation is done by comparing the predicted 1998, 4th quarter value to the actual 1998, 4th quarter value (refer to Table 3). The forecasts are presented through 4th quarter 1999 for comparison to historic values.

DISCUSSION

Price Tends (Structural Change)

Historical real price trends (differential slope coefficients) were found to be separated into four statistically significant periods representing key structural changes in Louisiana southern pine sawtimber stumpage markets:

1) 1956-1964, moderately decreasing real price levels
2) 1965-1979, rapidly increasing real price levels
3) 1980-1985, rapidly decreasing real price levels
4) 1986-1998, rapidly increasing real price levels

Overall, real prices increased at an annual compound rate of 2.36 percent for the 172-quarter series. However, real prices were at approximately
the same level at the beginning of the most recent trend (1986) as in 1956. Since 1986, the annual compound rate of increase has been 10.38 percent in real terms. It does not seem possible for this rate of increase to continue much longer. In fact, weak lumber demand in Asia during 1998 had the effect of lowering domestic softwood lumber prices as the year progressed which, in turn, put excess downward pressure on southern pine sawtimber stumpage prices throughout spring, summer, and fall quarters.

Seasonality in the Most Recent Trend

The full time series (n = 172 quarters) was tested for seasonality. The most recent trend, 1986-1998 was the only subset in which seasonal price variations were statistically significant. Averaged winter/spring period stumpage prices were the highest, with a mean premium of $26.05/MBF (Doyle Log Scale) over the averaged summer/fall period.

An external factor potentially affecting seasonality is an increasing tendency for southern pine lumber producers to carry higher log inventories into the wet season (winter). The driving force behind this move away from just-in-time (JIT) log inventory management, which rose in popularity during the 1980s, is the Sustainable Forestry Initiative (SFI). SFI does not allow for excessive rutting by logging equipment that often occurs during the wet season. Reduced dependence on winter quarter logging may effect the future significance of seasonality in Louisiana southern pine sawtimber stumpage prices.

Short-Term Forecasting

Both the seasonal and non-seasonal ARIMA models produce similar forecasts for 1998, 4th quarter. The ARIMA (0,1,0)(0,1,1)4 forecast is $402.46/MBF Doyle Log Scale while the ARIMA (2,1,0) forecast is $398.21/MBF Doyle Log Scale. Both forecasts compare somewhat favorably to the actual historic price of $374.84/MBF Doyle Log Scale. However, based on evaluation of the diagnostics, the ARIMA (0,1,0)(0,1,1)4 model is superior to the ARIMA (2,1,0) model from the standpoint of overall fit to the data. This is to be expected since the original series exhibits a relatively strong seasonal component which is best captured using a forecasting model containing a seasonal component.

While neither model provides the accuracy truly desired in a managerial decision making situation, the spreads between forecast price and actual price are within established 95 percent confidence intervals. The inherent volatility of the underlying stochastic price making process limits the ability of the forecasting model to provide precise and accurate outputs when considering Louisiana data. One possible explanation for both ARIMA forecasts being higher than the actual 1998 4th quarter value was weak lumber demand in Asia during 1998.

Summary

The results of this research project provide empirical evidence that short-term adjustments in stumpage sale timing should be considered in order to capitalize on favorable market conditions in Louisiana. If a tract is all-weather accessible, selling stumpage during the winter/spring period may increase the return on forest investment as much as $50.00/MBF Doyle Log Scale as compared to selling during the summer/fall period.

This study is based on historic quarterly southern pine sawtimber stumpage time series data for Louisiana only. Additional work is needed to determine to what extent, if any, seasonal variability in regionally integrated sawtimber stumpage and lumber markets plays a role in rate of return on forestry investment.

LITERATURE CITED


