Regular Article
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 31, No. 1, pp. 38-46, February, 2015
http://dx.doi.org/10.7747/JFES.2015.31.1.38

JFES
Journal of Forest and Environmental Science

The Analysis of Pine Stumpage Prices Based on Timber Sale Characteristics of the Southern United States

Hojung Kim[1,*] and Chris Cieszewski[2]
[1]*The Forest Center of Climate Change, Korea Forest Research Institute, Seoul 130-712, Republic of Korea*
[2]*Warnell School of Forestry and Natural Resources, The University of Georgia, Athens, 30605, United States*

Abstract

The stumpage price changes were calculated and analyzed from the data collected by Timber Mart-South from 1998 to 2007. We analyzed the relationship between pine sawtimber stumpage prices and timber sale characteristics using hedonic pricing method. Quadratic transformation was employed for sale size and contract length. Stumpage prices increased with sale size, contract length, bid sales, and the number of bidders. The presence of above average or excellent grade, market conditions, and logging conditions also are positively related to stumpage prices.

Key Words: stumpage prices, hedonic pricing method, timber-marth-south, timber sale characteristics

Introduction

Forest landowners often need access to current timber market information because they need to know what they have and how to sell it. Since timber markets basically depend on the supply and demand, timber buyers and sellers need up-to-date timber market information such as market trends and trade news. However, it is not an easy task to predict timber price (Mei et al. 2010). Timber market is a function of the relationship between timber and a variety of factors, such as wood consumption, wood supply, production technology, finished product demand, and stumpage prices, and also the change in timberland ownership may have had a significant influence on timber markets (TMS 2009). Delivered prices include harvesting, transportation, and other markups above the stumpage price, and fuel costs and distances to mills will have effect on transportation costs, where wood quality and tract size are the main factors concerning harvest costs (TMS 2009).

The hedonic price method is an approach which most commonly uses regression analysis to estimate the implicit values of characteristics from a value of commodity price (Rosen 1974). In the process of manufacturing, some production inputs could be diverse and have significantly different characteristics. In such cases, a hedonic pricing approach is suitably employed for estimating the implicit prices of the various characteristics of an input and the demand for the input subsequently (Ladd and Martini 1976). Thus, a hedonic model can be used to explain production factors or the prices of differentiated products. This hedonic price approach has been adapted to timber markets with heterogeneous inputs such as species composition, tree size, volume, and quality based on the assumption that such characteristics affect the lumber production (Puttock et al.

Received: February 26, 2014. Revised: September 25, 2014. Accepted: September 29, 2014.

Corresponding author: Hojung Kim

The Forest Center of Climate Change, Korea Forest Research Institute, Seoul 130-712, Republic of Korea
Tel: 82-2-961-2888, Fax: 82-2-961-2879, E-mail: hojung.kim.17@gmail.com

1990). We can efficiently analyze the implicit values of independent variables for stumpage price and can bring results about the derived demand of heterogeneous inputs for timber markets using hedonic price functions.

Timber Mart-South (TMS) publishes quarterly southern price reports. They started to report timber prices in 1976, and market news in 1996. In this paper, based on the TMS data (TMS, various years) and a variety of reports about timber markets in southeast United States, we have analyzed the stumpage detail characteristics and their influence on pine stumpage prices using a hedonic price function with the objective of providing better insight into the change of stumpage prices with related timber sale characteristics and anticipated demand for each input.

Literature Review

Newman (1987) presented an econometric analysis of the southern softwood stumpage market from 1950 to 1980. He used three stage least square regression techniques on both supply and demand system of pulpwood and solidwood (combined lumber and plywood) markets. The three stage least square regression techniques provided simultaneous parameter estimation of market systems. Haight and Holmes (1991) analyzed monthly and quarterly series of stumpage prices in terms of stationarity with a test to determine whether a time series variable is non-stationary using an autoregressive model for loblolly pine in the southeastern United States. The statistical results showed that a non-stationary random walk model can be more suitable for the quarterly series of average prices. Otherwise, they showed that stationary autoregressive models can be efficiently employed for monthly series and for the quarterly series of opening monthly prices which is made by sampling the monthly series in quarterly intervals. Wagner et al. (1994) used applied welfare analysis and current stumpage market conditions to compute the estimate of economic effects of environmental regulations on southern softwood stumpage markets. Sun and Kinnucan (2001) presented an applied welfare analysis method which fixed a flawed procedure designed by Wagner et al. (1994) and is easy to apply. Hensyl (2005) examined influences of land and ownership characteristics on the price of stumpage in Virginia's nonindustrial forests. Based on data of timber procurement personnel and sawmills from central Virginia a price equation base model and bid equation base model were developed. The effect of the decrease in both tract size and the amount of harvest and the behavior of landowners on marginal values of sale characteristics was analyzed. They also assessed how the fragmented forest affects the competitiveness regarding timber sale. Mei et al. (2010) modeled and forecasted the stumpage price of pine sawtimber with various time series models in the U.S. South. In 12 southern timber regions, they developed a univariate autoregressive integrated moving average model as a benchmark and applied other multivariate time series methods in comparison with a discrete-time framework. Under the continuous-time framework, they fitted both the geometric Brownaian motion and the Ornstein-Uhlenbeck process to the underlying data. They found that the vector autoregressive model produced more accurate results in the 1-year period by the mean absolute percentage error criterion. They also found that seven among 12 southern timber regions played crucial roles in the long-run equilibrium and market risks are well captured by conditional variances and covariances from the bivariate generalized autoregressive conditional heteroscedasticity model.

The hedonic pricing method has been used to estimate economic values for environmental services that directly have influence on market prices. The hedonic pricing method is based on the premise that the price of a marketed good is related to its characteristics, or the services it provides. Buongiorno and Young (1984) predicted the market value of sales in Chequamegon National Forest. They developed a multiple regression made with 14 independent variables and adapted stepwise regression with the independent variables which are relevant to the high bid on a competition of timber sale. They found that a simple linear model explained 93% of the variance in high bid for competitive sales using data from 1976 to 1980. Puttock et al. (1990) estimated stumpage prices in southwestern Ontario using a hedonic function approach. They expected that the stumpage price was influenced by various characteristics of timber used in the production of lumber. They estimated hedonic price functions for timber using pooled time-series cross-section data which are driven by a large sample of timber sales.

Munn and Palmquist (1997) estimated hedonic price equations using stochastic frontier estimation procedures for stumpage prices. They asserted that because the distributions of consultant and nonconsultant sales are not normal enough, ordinary least squares (OLS) is not adequate for estimating hedonic price equations for a timber stumpage market. Their new model and estimator are regarded as more suitable for timber markets than the traditional hedonic model and ordinary least squares (OLS) procedures with applied statistical techniques developed for stochastic frontier analysis to hedonic price functions. Their model will be more credible of such timber markets when there is uncertainty of price on both sides of buyers and sellers, and empirical results supported this model. Vasievich (1980) quantified the effect of timber sale factors on the costs of conducting timber sales and prices paid for the sales using a linear regression model. He used data from timber sale reports by Indiana State Forests and analyzed 11 site and sale conditions statistically. Leefers and Potter-Witter (2006) estimated hedonic price model to gain insights into timber sale characteristics and competition for public lands stumpage. They studied Lake States national forests and land managed by the Michigan Department of Natural Resources (MiDNR) to give useful information about the stumpage price impacts of sale and institutional sale characteristics. Based on empirical results, they found that the models within the same geographic region cannot be transferred easily to other regions. Sydor and Mendell (2008) analyzed timber bid transactions using hedonic regression techniques in central Georgia. They estimated a regression model of softwood stumpage prices from pay-as-cut transactions against timber sale and stand characteristics.

Data

We used quarterly stumpage prices reported from 1998 to 2007 in southern 11 states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia) (TMS, various years). The data included area, county, sale date, sale type, sale size, total volume, total price, haul district, length contract, number of bids, high bids, low bids, type of cut, grade, market conditions, logging conditions, product type, and product amount (Table 1). The species and product group were classified into pine pulpwood, pine chip-n-saw, and pine sawtimber to be compared as references.

Preliminary analysis on pine stumpage data

Stumpage prices (TMS, various years) were preliminarily analyzed to process raw data initially. The average of 10 years (1^{st} quarter 1998 to 4^{th} quarter 2007) of pine stumpage prices were compared to their average prices 4^{th} quarter 2007 in Table 2.

Materials and Methods

Hedonic price model using multiple regression model for estimating stumpage prices

We used the hedonic pricing method to estimate the

Table 1. Pine stumpage sales data

Name	Value	Unit
Quarter	1～4	
Year	1998～2007	
States	AL, AR, FL, GA, LA, MS, NC, SC, TN, TX, VA	
Area	1～2	
County	Counties of each states	
Sale size	1 to 3,000	Acres
Length contract	1～48	Months
Number of bids	1～22	
Type of cut	Thinning, clearcut	
Grade	Below average, average, above average, excellent	
Market conditions	Poor, fair, good, excellent	
Logging conditions	Poor, fair, good, excellent	
Stumpage/delivered	Stumpage prices	$/tons
Product price	1～70	$/tons

Table 2. Average of 10 year and average of 4th quarter 2007 of pine stumpage price

	Pine pulpwood ($/tons)	Pine chip-n-saw ($/tons)	Pine sawtimber ($/tons)
Average of 10 year	27.19	27.19	43.29
Average of 4th quarter 2007	8.70	19.16	39.58

stumpage price of pine sawtimber for economic values that affect the stumpage price. The hedonic pricing method is regarded as a preference method of estimating demand or value in economics. The fact that good prices in a market are influenced by their characteristics becomes a basis for hedonic price method. For hedonic price analysis, it is necessary to estimate how the dependent variable (stumpage price) is influenced by the independent variable (all various characteristics for stumpage price) and the hedonic price (implicit price), which is the change in stumpage price by the change in one of those characteristics, is estimated using the function of linear or non-linear (Boardman et al. 2011).

Based on the data analysis, a non-linear regression model was developed to estimate stumpage prices because the fitted line versus residuals was non-linear. Thus, we used a quadratic transformation. Pine sawtimber stumpage prices was estimated as:

$$y_s=\beta_0+\beta_1 x_1+\beta_2 xS+\ldots \beta_i x_i+\varepsilon \text{ for } i = 1,2, \ldots n \quad \text{Equation 1}$$

where y_s=*stumpage price*, x_1=*quarter2*, x_2=*quarter3*, x_3=*quarter4*, x_4=*year*, x_5=*sale type*, x_6=*sale size*, x_7=*sale size squared*, x_8=*length contract*, x_9=*length contract squared*, x_{10}=*number of bid*, x_{11}=*harvest type*, x_{12}=*grade*, x_{13}=*market condition*, x_{14}=*logging condition*.

The regression variables used in multiple regression are described with unit of measurement in Table 3.

Quadratic forms were used for the variable *sale size* and *contract length* in our regression model. Quadratic forms are used to estimate parameters of threshold models, which have inflection point or threshold point. As the dependent variable changes in threshold model, quadratic terms help determine maximum and minimum values and help infer information related to economies of size. The inflection point is calculated as

Table 3. The description of dependent and independent variables

Variable name	Unit of measurement and variable description
stumpage price	Pine stumpage price ($/ton)
quarter 2	Dummy variable, 1 if second quarter of the year, 0 otherwise
quarter 3	Dummy variable, 1 if third quarter of the year, 0 otherwise
quarter 4	Dummy variable, 1 if fourth quarter of the year, 0 otherwise
year	The year when the timber is harvested
sale type	Dummy variable, 1 if sealed bid, 0 negotiated
sale size	Total area harvested (ac)
sale size squared	Square of variable sale size
length contract	Contract period (month)
length contract squared	Square of variable length contract
number of bids	The number of bid during timber sale auction
harvest type	Dummy variable, 1 if clearcut, 0 otherwise
grade	Dummy variable, 1 if above average or excellent, 0 otherwise
market conditions	Dummy variable, 1 if above average or excellent, 0 otherwise
logging conditions	Dummy variable, 1 if above average or excellent, 0 otherwise

Table 4. Descriptive Statistics of variables

	Mean	Standard deviation	Minimum	Maximum	Sum
stumpage price	44	12	0	70	109,980
sale size	104	122	2	3,000	258,463
sale size squared	25,658	193,470	4	9,000,000	63,606,273
contract length	17	7	1	48	42,702
contract length squared	341	232	1	2,304	846,441
number of bids	5	3	0	22	12,901

Inflection point=β_1/ -2β_2 Equation 2

Where:

β_1=linear term coefficient

β_2=quadratic term coefficient

For the regression analysis, we found missing data in 497 samples of sales. Thus the final sample size was 2,465 sales. We developed basic descriptive statistics for dependent and independent variables. We reported mean, standard deviation, minimum, maximum, and sum for variables (Table 4) and also reported the percentage of type 1 in each dummy variable (Table 5).

Multiple regression analysis was conducted in R statistical software.

Table 5. The percentage of type 1 in dummy variables

Variable name	% of type 1
sale type	94.96
harvest type	56.03
grade	38.44
market conditions	17.06
logging conditions	21.94

Results and Discussion

The regression results are presented in Table 6. The model R-squared equals 0.1807 and adjusted R-squared 0.1767, which indicates that the goodness of fit of the model is relatively low. However, the model is globally significant based on the F-statistic. The likely reason for relatively low R-squared can in part be explained by the fact that we removed 497 observations of sales from the analysis. In addition, during the research period one notable thing is that southeast average pine sawtimber stumpage prices peaked in 1998 and have substantially dropped since then, which means there were some factors that influence on pine stumpage price severely that were not accounted for in this analysis. Particularly, based on the reports regarding stumpage prices (TMS, various years), the fuel prices increased from 1998 to 2007 and they seem to affect stumpage price. Puttock et al. (1990) found that the hauling distance greatly affects the timber price. It is suggested that such variables regarding the fuel prices and hauling distances need to be incorporated to acquire better fitted regression results. Although the pine stumpage price showed mainly a decreasing tendency, there were some main fluctuations in stumpage price change during the research period. It is likely that such a situation have also contributed to relatively

Table 6. Parameter estimates for pine sawtimber stumpage price regression model

Variable	Parameter estimate	Standard error	t-value	Pr (>|t|)
Intercept	39.73	1.495	26.582	0.000***
quarter2	0.7902	0.559	1.414	0.158
quarter3	-1.919	0.6085	-3.153	0.002**
quarter4	-1.352	0.6088	-2.221	0.026*
year	-0.6266	0.07954	-7.878	0.000***
sale type	2.091	1.02	2.051	0.040*
sale size	0.008978	0.002664	3.37	0.001***
sale size squared	-0.00000367	0.000001626	-2.257	0.024*
contract length	0.4019	0.1287	3.123	0.002**
contract length squared	-0.02003	0.003692	-5.425	0.000***
number of bids	0.8403	0.08424	9.975	0.000***
harvest type	-3.306	0.4587	-7.207	0.000***
grade	2.606	0.4483	5.813	0.000***
market conditions	3.934	0.6167	6.38	0.000***
logging conditions	2.133	0.5488	3.886	0.000***

Note, Signif; codes, 0; '***'0.001; '**'0.01; '*'0.05; '.'0.1; ' '1.

low R-squared values, compared to other similar research using hedonic price function (Buongiorno and Young 1984; Puttock et al. 1990; Leefers and Potter-Witter 2006; Sydor and Mendell 2008). Variables describing *year*, *contract length*, *number of bids*, *harvest type*, *grade*, *market conditions*, and *logging conditions* are statistically significant based on corresponding probabilities. Variables such as *quarter 4*, *sale type*, and *sale size squared* are significant at $\alpha=0.01$. Further, *quarter 3* and *contract length* are significant at $\alpha=0.0001$. Other independent variables except *quarter 2* are significant at $\alpha<0.0001$. Only variable *quarter 2* is not significant even at $\alpha=0.1$.

To investigate seasonal effects, quarters when sales occurred were represented by dummy variables with the *quarter 1* as the reference. Pine sawtimber prices in *quarter 3* decreased by $1.92/ton and in *quarter 4* decreased by $1.21/ton based on the *quarter 1* as the reference variable holding all independent variables constant. Although *quarter 2* is not statistically significant, it has a high coefficient value, indicating positive influence on timber prices. *Quarter 3* has the largest negative coefficient value among all quarters. Fiery (2012) illustrated the annual change of pine sawtimber with more detail information of monthly stumpage price trends in South-wide states. Based on the results of stumpage price changes in two different time scales, we can see that while mainly the yearly stumpage price maintained a decreasing tendency from 2010, the monthly changes of stumpage price relatively showed little bit more increasing tendency in quarter 1 and 2 than quarter 3 and 4. From their illustration, it looks like that although the quarter factors as dummy variables cannot change the main stream of stumpage price severely, it induces the minor and temporary changes in timber price. Such a similar tendency seems to be shown in our results for stumpage price change during our research period. The continuous variable *year* represents the *year* in which timber was harvested. This variable has a negative impact on stumpage prices which declined during the period 1998 to 2007. Pine sawtimber stumpage prices declined by $0.627/ton per year. Most of all, the increase of fuel price is considered a major reason for the decreasing tendency of stumpage price as we shown in literature review during the research period.

Basically as the *sale size* increases by one acre, pine sawtimber stumpage price increases by $0.009/ton initially. This result is in agreement with other research regarding sale size (Buongiorno and Young 1984). Based on an interpretation of inflection point of sale size, as the *sale size* increases after reaching the maximum, the stumpage price starts to decline by $0.000004/ton with all other independent variables held constant, which means it is not whole lot. If logging and hauling costs tend to decrease as tract size increases, stumpage price seems to increase. The reason for such increase of stumpage price is inferred from the fact that delivered price equals stumpage price adds logging and hauling costs and based on assumption the delivered price should be maintained under other conditions are same, we saved the money in logging and hauling costs and can get higher price for stumpage. However, it seems that logging and hauling costs start to increase after reaching some point due to diseconomy of size.

Based on equation 2, we determined stumpage prices were maximized when sale sizes reach about 1,223 acres. This does not agree with our preliminary data analysis, which indicated that timber prices were maximized when sale sizes ranged from 151 to 200 ac, although the calculated inflection point (1,223) is within the range of input data. Basically the sale size results of preliminary data analysis are calculated based on all other independent variable are not constant. However, the results of inflection point for the sale size are calculated based on the assumption that all the other independent variables are constant. We guess that such difference seems to make a gap between preliminary results and a calculated inflection point. We infer that in real world there were some beneficial factors that influence high stumpage price in the sale size range from 151 to 200 ac, but theoretically diseconomy of size seems to work at larger sale size than that based on our data. In addition, although the preliminary results show the different maximum ranges to our calculated maximum point, the stumpage prices of all ranges in preliminary results are very close to each other As same phenomenon, the coefficients for *sale size* and *sale size squared* reach almost zero, which means the slopes for *sale size* and *sale size squared* were extremely small and stumpage prices are very similar within all ranges of stumpage price, given our data sets of TMS during our research period (TMS, various years). We also infer that although during the research period the stumpage price had been decreased globally, it was almost maintained at a relatively high level, which means demands for stumpage consistent and enough not to work diseconomy of size. We need to further investigate whether a quadratic model is suitable for estimating a reasonable inflection point in timber markets, and which ranges of inflection values are calculated with data of different regions or time periods.

The *contract length* has similar impacts on prices as the *sale size* variable. As contract length measured in months increased so did pine stumpage prices by $0.402/ton. This positive relationship between contract length and pine stumpage price is also supported by other research (Dunn and Dubois 1999; Kilgore et al. 2010). After reaching the maximum point, pine stumpage price decreased by $0.023/ton. The optimum contract length was calculated as 10 months based on equation 2 to get the highest stumpage price. Basically, it seems that as contract length increases loggers will have a more flexible time to harvest based on the market conditions, making positive impact on timber price, while as contract lengths last too long loggers cannot respond to properly the possible dynamic changes of stumpage market. However, the optimum of stumpage prices at 10 months can be a spurious interpolation due to insufficient data, because timber stumpage contracts typically run for 6 month periods and have options to extend and timber growth would be an important appraisal issue for longer term contracts. We have not captured that information in other models.

Sale type can be classified as a sealed bid sale or a negotiated sale. In our results, sealed bid prices tended to exceed negotiated sale prices by $2.09 per ton. It seems that sealed bid sales were associated with higher prices because it can provide opportunities to take more bids, thus enhance possibility to obtain higher prices. *Number of bids* also influenced pine sawtimber stumpage prices. As the number of bids increased the pine sawtimber prices increased by $0.84/ton per each additional bid. It is inferred that more bids provide more chance to get higher price. We conclude that pine sawtimber stumpage prices get higher in the case of sealed bid auctions and larger number of bidders. Clearcut as a *harvest type* had a negative impact on pine sawtimber price which is decreased by $3.31/ton than thinning, and the results is in agreement with the preliminary analysis. In general, we can expect that stumpage prices will be lower on thinning because the logging costs are higher. Logging costs for thinning tend to be higher since less volume per acre and per tract is being harvested and the trees removed are generally the smaller diameter stems in the stand. However, in our preliminary analysis the result is reverse in pine sawtimber stumpage price, and showed a positive coefficient on thinning. We infer the unexpected result came from the fact that usually the harvest on thinning is more focused on pine pulpwood and pine chip-n-saw than pine sawtimber because harvested timbers by thinning more tend to be more used for pulpwood and pine chip-n-saw. Thus, the stumpage price for pine sawtimber can be not a major issue for in the harvest by thinning, making the unexpected results happen specially during our research period. Another idea for the unexpected result can be that based on the assumption the demand for pine sawtimber is constant, the supply amount by thinning can be more limited than that by clear cut.

As expected, the presence of high quality timber (*grade* variable) had positive impact on stumpage prices. Above average or excellent grade had a positive coefficient 2.61, which indicates that above average or excellent quality increased prices by $2.61/ton. The *grade* variable was statistically significant and the impact was relatively large. This result is in agreement with other approach about stumpage price for timber using hedonic function (Puttock et al. 1990). In a similar manner, the *market conditions* variable was statistically significant and positively related to stumpage prices with the highest coefficient value 3.934. This means that the presence of above average or excellent market conditions have larger impacts than the other sale characteristics on pine sawtimber timber prices. The better market conditions imply that the demand for timber is bigger by consumption more (Bhahurothu 2011). Such increased demand for timber seems to make stumpage prices higher. The variable *logging conditions* is statistically significant and has a large value. When above average or excellent logging condition are present, the prices increased by $2.13/ton. This result corresponds with the analysis by Hubbard and Abt (1989). Although grade, market conditions and logging conditions as dummy variable showed big impacts on stumpage price, it is not easy to define a clear line between excellent or above average and average because the standards can be different according to real market, ground conditions, and one's perspectives. Thus, it is suggested that the coefficients are interpreted as values which are not absolute but implicit.

Conclusion

We developed a hedonic model for pine sawtimber based on various sale characteristics in non-industrial forest lands of 11 southern states in U.S from 1998 to 2007. A sample size of 2,465 was used and the model was globally significant. In this study it is evident that as sale size increases the price of sawtimber basically increases as well. When sale sizes are small buyers tend to pay less for timber because of higher harvesting costs. It was found that when sale size reaches 1223.4 acres the stumpage price was maximized through quadratic transformation. As contract length increased the pine sawtimber price basically increased, and when the contract length between the buyer and seller reaches 10 months, stumpage prices were maximized using quadratic transformation also. In quarter 2 of the year, sellers received higher prices than the other quarters. Sealed bid sales were characterized by higher stumpage prices as were the number of bids. Selective cuts showed a positive impact on timber price. The presence of excellent or above average level in grade, market conditions, and logging conditions made significant positive impacts on the price of pine sawtimber stumpage. This study will be useful mainly for owners of private forests to promote timber sales and to make more suitable plans for timber management in southern United States.

Acknowledgements

This research was supported by Timber Mart-South, and Warnell School of Forestry and Natural Resources at the University of Georgia.

References

Bhahurothu P. 2011. Impact of timber sale characteristics on pine sawtimber prices in non-industrial private forests of southern United States: Implications of forest fragmentation. MS thesis. The University of Gerogia, Athens.

Boardman A, Greenberg DH, Vining AR, Weimer DL. 2011. Cost-benefit analysis: Concepts and practice. 4th ed. New Jersey, Prentice Hall.

Buongiorno J, Young T. 1984. Statistical appraisal of timber with an application to the Chequamegon National Forest. North J Appl For 1: 72-76.

Dunn MA, Dubois MR. 1999. Determining econometric relationships between timber sale notice provisions and high bids received on timber offerings from the Alabama department of conservation/state lands division, Timberlands investments: Improving the odds, Proceedings of the 1999 Southern Forest Economics Workshop. Mississippi State University, Biloxi, Mississippi, pp 83-90.

Fiery M. 2012. Pine Stumpage Price Trends in the US South, Forest2Market. Charlotte, North Carolina. http://www.forest2market.com/blog/Pine-Stumpage-Price-Trends-in-the-US-South.

Haight RG, Holmes TP. 1991. Stochastic price models and optimal tree cutting: results for loblolly pine. Nat Resour Model 5: 423-443.

Hensyl CH. 2005. Impacts of land and ownership characteristics on the stumpage prices for Virginia's nonindustrial forests. MS thesis. Department of Forestry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Hubbard WG, Abt RC. 1989. The effect of timber sale assistance on returns to landowners. Resource Management and Optimization 6: 225-234.

Kilgore M, Brown R, Blinn C, Coggins J, Pfender C. 2010. A national review of state timber sale programs and an analysis of factors influencing Minnesota state stumpage prices. A Report to the Minnesota Forest Resources Council, University of Minnesota, St. Paul, Minnesota.

Ladd GW, Martini MB. 1976. Prices and demand for input characteristics. Am J Agr Econ 58: 21-30.

Leefers LA, Potter-Witter K. 2006. Timber sale characteristics and competition for public lands stumpage: a case study from the Lake States. Forest Sci 52: 460-467.

Mei B, Clutter M, Harris T. 2010. Modeling and forecasting pine sawtimber stumpage prices in the US South by various time series models. Can J Forest Res 40: 1506-1516.

Munn IA, Palmquist RB. 1997. Estimating hedonic price equations for a timber stumpage market using stochastic frontier estimation procedures. Can J Forest Res 27: 1276-1280.

Newman DH. 1987. An econometric analysis of the southern softwood stumpage market: 1950-1980. Forest Sci 33: 932-945.

Puttock GD, Meilke KD, Prescott DM. 1990. Stumpage prices in southwestern Ontario: a hedonic function approach. Forest Sci 36: 1119-1132.

Rosen S. 1974. Hedonic prices and implicit markets: Product differentiation in pure competition. J Polit Econ 82: 34-55.

Sun C, Kinnucan HW. 2001. Economic Impact of environmental regulations on southern softwood stumpage markets: A reappraisal. South J Appl For 25: 108-115.

Sydor T, Mendell BC. 2008. Transaction evidence analysis:

Stumpage prices and risk in central Georgia. Can J Forest Res 38: 239-246.
Timber Mart-South (TMS). 2009. Stumpage detail report, 1st quarter 2009. Norris Foundation, University of Georgia, Athens, Georgia.
Timber Mart-South (TMS). Various years. Norris Foundation, University of Georgia, Athens, Georgia. http://www.timber-mart-south.com
U.S. Forest Service. 1982. An analysis of the timber situation in the United States, 1952-2030. USDA Forest Service, Washington Office, Washington, DC. Forest Research Report 22. pp 499.
Vasievich JM. 1980. Costs of hazard-reduction burning on southern national forests. South J Appl For 4: 12-15.
Wagner JE, Cubbage FW, Holmes TP. 1994. Estimated economic impacts of environmental regulations on southern softwood stumpage markets. South J Appl For 18: 156-162.