IMPACT OF TIMBER SALE CHARACTERISTICS ON PINE SAWTIMBER PRICES IN NON-INDUSTRIAL PRIVATE FORESTS OF SOUTHERN UNITED STATES: IMPLICATIONS OF FOREST FRAGMENTATION

by

POORNIMA BHAHUROTHU

(Under the Direction of Jacek P. Siry)

ABSTRACT

This study analyzes how timber sale characteristics influence pine sawtimber prices in non-industrial private forests. Data were collected from Timber Mart-South for a 10 year period for all 11 southern states. Data were analyzed using hedonic pricing method and a quadratic transformation was used for variables SALE SIZE and LENGTH CONTR to fit in the regression equation. Results showed that pine sawtimber prices were low for small acreages and then increased until they reached maximum at 427.2 acres. Pine sawtimber prices were higher for contract periods that were short and where sealed bid auctions were conducted. Sales conducted during the months of April-June generated greater revenue than the other three quarters. Increased competition, high quality timber, excellent market and logging conditions were all positively correlated to pine sawtimber prices.

INDEX WORDS: Sale characteristics, Pine sawtimber, Forest fragmentation, NIPFs.

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POORNIMA BHAHUROTHU

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POORNIMA BHAHUROTHU

Major Professor: Jacek P. Siry
Committee: Thomas G. Harris Jr
Bob Izlar
Lawrence A. Morris
Neelam C. Poudyal

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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CHAPTER 1

INTRODUCTION

The United States is unique among countries with large forest acreage because of the dominant role of private forests. Private forest landowners own 56% (423 million acres) of the nation's forest land area while 44% of forest land is owned by public (federal, state and local) agencies. An estimated 58% of total volume of growing stock is on private forest land (Smith et al., 2009). Nearly two-thirds (285 million acres) of the private forest land is owned by non-industrial private forest landowners (NIPFs). Non-industrial private forest landowners include families, individuals, corporations and other private groups that own private forest land but do not own and operate a primary wood-processing facility. NIPF are categorized into family forest owners and other non-industrial private owners. Family forest owners include individuals, families, trusts, estates, family partnerships and other unincorporated groups of individuals. Family forest owners own 35% and other private groups of non-industrial forest landowners own 21% of nation's forest land (Butler, 2008). Basic relationships of forest landowners are summarized in Figure 1.

The United States forests are divided into four major regions (North, South, Pacific Coast and Rocky Mountains) based on their broad climatic similarity and latitude. Private ownership predominates in the South (with more than 75% of southern forest land) followed by the North region (with 75% of northern forest land). The majority of forests in Rocky Mountain (70% of forest land) and Pacific Coast regions (51% of forest land) are federally owned. Family forest owners own 58%, other private owners own 28% and public agencies own 13% of southern forest land.

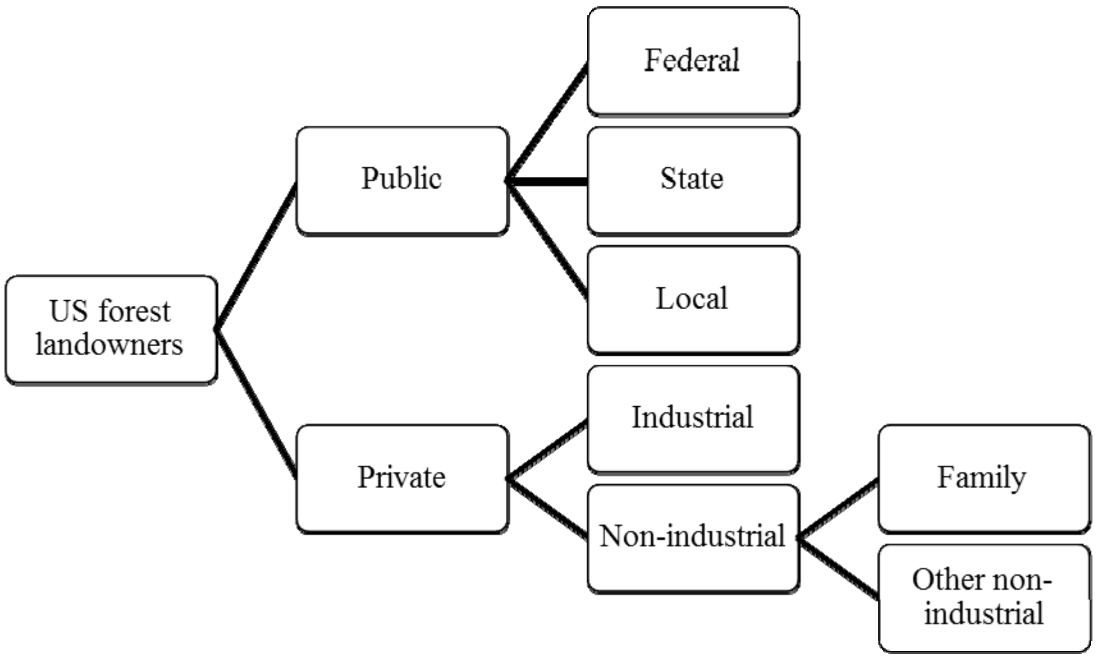

Figure 1: Categorization of US forest landowners

Changes in forest policies, divestiture of forest industry lands and selling of family forest lands have brought major changes in the size of forest land holdings. Most of the NIPFs own small forest land holdings. Nearly 61% of family forest owners own less than 10 acres of forest land. Average size of forest holding of a family forest owner is 25 acres (Butler, 2008). Accelerated forest fragmentation and parcelization is decreasing the average size of the forest holding of NIPFs. Forest fragmentation is defined as the process of dissecting large and contiguous forests into smaller units separated by different vegetation types and/or areas of intensive human activity. Parcelization is defined as the process by which large tracts of single owner forest land are divided into many small parcels with multiple owners. Forest fragmentation and parcelization caused by various social and demographic forces are breaking larger conterminous forests into smaller pieces with increased number of owners. Hence there is a need to pay greater attention to the problems associated with small scale ownership.

High average costs are a primary obstacle to increasing forest productivity on these small tracts. Effects of tract size on average cost are more prominent in mechanized operations. Since forest regeneration, management and harvesting are heavily mechanized, these operations are characterized by high average costs on small tracts. Regeneration and timber stand improvement affect future wood supplies, while harvesting costs and revenues determine present wood availability. In this context, economics of forest tract size is becoming increasingly important.

Economies of Size

Economies of size are achieved when per unit costs decline as the size of the plant changes and diseconomies of size occur when unit costs increase as the size of the plant changes. Optimum size of the plant is defined as that size of the plant that has minimum costs of production while meeting its demand conditions, supply conditions of the factors of production, taxes, subsidies or any other factor which might affect the economic operation of the plant. Depending upon on the variation of economic environment, different firms in an industry have different optimum sizes. Economies of size can be studied by determining and interpreting long run average cost curve, which is in turn related to a number of short run average cost curves. In short run average cost relationships, it is assumed that one or more resources are fixed. Initially the average costs per unit of output decline rapidly with an increase in output, due to fuller utilization of resources and spread of associated fixed costs over more units. The average costs then level off and at some point, these average costs tend to increase. This is due to addition of increased proportion of variable resources to the fixed resources so as to achieve greater levels of output. The lowest point in this short run average cost curve thus represents the point at which all the production resources are efficiently used for that particular firm size (Figure 2). Thus the short run period permits changes to output that are technologically possible without changing the firm size. In long run, all resources are variable.

A long run average cost curve is obtained by estimating a series of short run average cost relationships for different firm sizes and drawing a curve tangent to all these short run average cost curves (Miller et al., 1981) (Figure 3). Thus the long run average cost curve represents the lowest average cost per unit of output for different firm sizes for a given price and technological relationships (Madden and Partenheimer, 1972). The average costs can be decreased largely through improved technical relationships. As size of the firm increases, economies of size can result from division and specialization of labor, increased use of advanced technology and more efficient machines, and lower administrative costs per unit of output. If the firm size increases too much, diseconomies of size occurs (average unit costs increase) due to management problems in controlling and combining inputs in the production process (Granskog, 1978).

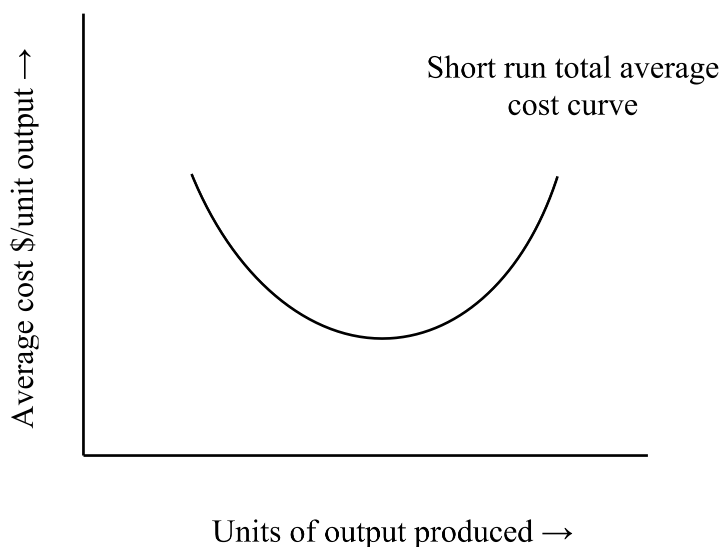

Figure 2: Short-run average cost curve for a single plant size.

In forestry, the long run average cost curve is L-shaped, indicating economies of size up to a point (unit costs of production decline as the size of the plant increases) but beyond that output level, average costs neither rise nor fall when size is increased. The point at which average costs cease to fall is known as the point of minimum optimum scale (Bain, 1969). In 1972, Madden and Partenheimer suggested three economic principles that are important in analyzing a firm's production decisions, using short-run and long run average cost curves. In the short run, a firm will be in production only if its average revenue (per unit price) exceeds average variable costs. In the long-run, a firm will continue to produce only if its total revenue exceeds total costs (both fixed and variable costs). Under conditions of perfect competition with many small firms, prices will sink toward a level such that all profits will tend to be erased.

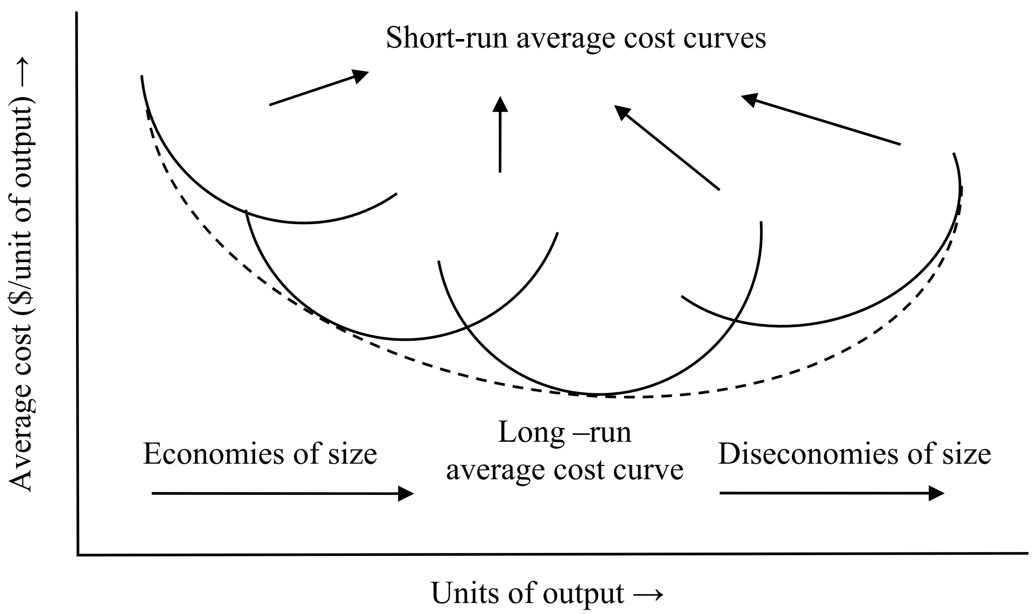

Figure 3: Long-run average cost curve.

However, of the three economic principles that are discussed by Madden and Partenheimer (1972) only the short-run interpretation is applicable for "firms" that are composed of owner's tracts of land. Owners will produce timber only if the total revenues (timber sales) exceed total variable costs (harvesting costs), so the short-run interpretation is valid. In timber production long run costs may exceed revenues, so the long-run interpretation is less applicable. Therefore forest lands are removed from timber production but still remain forested and their growing stock continues to increase. They may be owned for multiple objectives and at times the fixed costs (such as management costs and taxes) are met by other products. These lands are considered for timber production only at the time of potential harvest, so the short-run interpretation is often applicable to these firms. However, in forestry, the actual firms are the crew (contractors or loggers) who perform operations such as planting, thinning and harvesting. These are the manufacturing plants that outputs such as seedlings planted, trees thinned or cords harvested.

For the "firms" that are composed of contractors or loggers all the three economic principles apply. Contractors or loggers operate in short run, only if the price received per unit exceeds average variable costs, and in the long run, only if the total revenues exceed total costs. Finally, prices for logging or planting contractors have tended to eliminate pure profits. Therefore, economics of forest tract size refer to variations in the average costs of outputs (seedlings planted, trees thinned and cords harvested) for firms operating on different tract sizes (Cubbage, 1983b). In forestry, economies of size are achieved by spreading the initial fixed costs for capitalization and transport of machinery over a larger output. Diseconomies of size arise due to various reasons on smaller tracts (Row, 1978). The most important of all is the fixed-cost component involved in the mechanized operations of forest management, regeneration and harvesting. Diseconomies of size occur from moving and setting up machinery on smaller tracts and administering silvicultural operations. Revenues per unit volume of timber sold were less for small tracts or sales when compared to large tracts or sales.

An estimated 11 million private forest owners owning 423 million acres of private forest land have become crucial to future timber supplies in the United Sates. A continued downward trend in NIPF's parcel has become an active area of research. Many previous studies point to the costs involved in timber management, reforestation and harvesting operations on smaller tracts. They implied the need for cost control measures on changing tract sizes. There are many articles that have discussed the determinants of timber supply from private forests by relating stumpage prices with forest, owner and economic variables (Guttenberg, 1956; Buongiorno and Young, 1984; Puttock et al., 1990; Huebschmann et al., 2004; Dahal and Mehmood, 2005; Hensyl, 2005; Kilgore et al., 2010). Examination of NIPF's harvesting behavior over prices and non-timber amenities is a common approach in much of this literature. Major research is also conducted in developing timber valuation models based on stand, land, owner and sale characteristics for public forests in various regions and states. Developing such models is useful for determining fair market values of timber, estimating the bid prices prior to sale and improving decisions on forest management investments. Few authors used these timber appraisal methods for comparing federal and state stumpage sales, which involved both public and private forests (Sendak, 1992; Munn and Rucker, 1995; Leefers and Potter-Witter, 2006). Determining stumpage prices of non-industrial private forests based on characteristics, such as decreasing tract sizes, decreasing volumes, presence of landowner and harvesting preferences of landowners, which are associated with changing forests, is conducted to show the effect of forest fragmentation on stumpage prices and competitiveness of timber markets.

In the above timber appraisal methods stumpages prices were not determined for NIPF of larger geographical areas. Studies pertaining to smaller areas such as a group of counties or a particular state or province may have limited application, due to region-specific factors.

Moreover, factors or sale characteristics that are assumed to influence stumpage prices were not significant in much of these studies.

Objective

The objective of this research is to analyze how various sale factors and characteristics influence stumpage prices in private forests in the southern United States. Data analyzed in this study were taken from Timber-Mart South, a repository of timber transaction prices collected from various private companies, landowners and consultants in southern United States. Various sale characteristics such as sale size, sale type, number of bids, contract length, season of sale, year of harvest, timber quality, market conditions, logging conditions that are assumed to influence stumpage prices are used in the analysis to test their effect.

CHAPTER 2

LITERATURE REVIEW

Effects of tract size in forest management

Effects of tract size on forest management attracted the attention of researchers as early as the 1950s. Sundberg (1966) examined the cost of forestry operations for the manual methods that were present in Sweden in the 1960s. He found out that in southern Sweden, which is well populated and has well developed road network, 5-10 acres of forest land were required to perform economical clearcut operations and 25-50 acres of forest land to perform thinning operations. While in northern Sweden (remote forests with road network not well developed), 37-50 acres of forest land were required to perform economical clearcuts and about 148 acres to perform thinning operations. He also estimated that an individual owner required 74-148 acres of forest land in southern Sweden and 741-988 acres of forest land in northern Sweden to allow wood harvest every 5 years. He also pointed out that with increased mechanization, the required size of forest parcel to carry economical operations also increased. Hall and LeVeen (1978) stated that modest-sized agricultural farms (100-320 acres) have most of the technological advantages over small and large farms. Average costs are 50% higher for 10-20 acre tract sizes and 25% higher for 30-40 acre tract sizes. Average costs increase rapidly for tracts below 50 acres and for tracts from 10-20 acres they are prohibitive (Cubbage, 1983b). In 1984, Straka et al. performed correlation analysis of Mississippi forest management data and found out that size of the forest holding is positively related to timber production on NIPF. A forest survey conducted by Sheffield et al. (1985) identified significant declines in annual growth of pine timber on non-industrial private ownerships. The authors notes that many NIPF owners left their stands to naturally regenerate after harvesting as one of the reason for the decline in the annual growth of pine timber. They observed that less than 20% of NIPF land with pine and oak-pine stands was artificially regenerated to pine after harvested.

Royer (1987) found that reforestation costs were a significant determinant of reforestation behavior among southern landowners. Gardner (1981) found that reforestation costs were lower for 50 acre tracts and these costs increase for smaller tracts (2-20 acres). Small forest landowners have less capital and some owners find that returns on additional capital invested in agricultural production on farm are higher when compared with wood-lot investments. Small forest landowners find it difficult to employ labor to work on their lands for non-harvest operations, since non-harvest operations on small tracts provide limited employment opportunity for them to work. It will be costly to supervise this labor and more time is lost in getting them to and from the land (Clawson, 1957).

Row (1974) studied the effect of tract size on equivalent annual income for three different management regimes. He found that economies of size can be obtained in 80 acre tract sizes for all management regimes. For tracts less than 80 acres, there were acceptable rates of return for only few management regimes. Tracts of 20 acre size yielded positive returns only when natural stands were intensely managed. For tracts of 10 acre size no management regime yielded positive returns. Smaller tracts were also profitable on more productive sites (site indices 80-100 feet). He concluded that management of natural stands on cutover sites was advantageous over plantations for small owners, because fixed costs associated with site preparation, planting and spraying operations could be avoided. Row (1978) mentioned that the probabilities of loss from fire, storm and pests were higher on small tracts since they were exposed to open spaces. He also concluded that studies tended to overestimate opportunities for increased management when they did not consider the small tract disadvantages for highly intensive management.

Wikstrom and Alley (1967) performed statistical cost research on cost control for national forests in the northern region of the United States. They identified tract size as the most critical variable affecting costs of forest management practices such as slashing, burning, piling, terracing, pruning and thinning operations. They concluded that for tracts less than 40-50 acres per acre costs increased rapidly as tract size decreased. They also identified accessibility as another important factor affecting timber growing costs. They found that, on average, the equipment mileage costs for driving to the site were $6 per acre for small tracts and $1.25 per acre for average size tracts. They sketched the average cost curves for prescribed burning, terracing and planting by tract size and determined the “minimum” cost level could be achieved at 25 acres for planting, 50 acres for terracing and at least 100 acres for prescribed burning.

Vasievich (1980) found out that per acre burning cost was strongly influenced by the size of the burn in southern national forests. He observed that the cost of burning was $4.82 per acre for 50-acre burns in 12-year rough (years since last burn), and only $0.35 per acre for 2,400-acre burns in 4-year rough. Cost of mechanical site preparation was high ($170/ac) for small landowners (1-4 acres), while for landholdings over 100 acres it was only $50 per acre. Costs of prescribed burning and cost–share payments were also higher on small tracts. This is due to higher costs associated with fire lane construction and moving equipment to these small sites.

Olson et al. (1978) developed equations for estimating stand establishment, release and thinning costs in the Lake States. While determining the minimum cost per acre, they found out that average manual planting costs leveled off at about 20 acres, machine site preparation costs at 40 acres, aerial spraying costs at 60 acres, prescribed burning costs at 64 acres and manual release costs at 50 acres. Cost of planting hardwood seedlings was high on small sites when compared to large holdings (Londo and Donald, 2004). In 1984, Guldin observed that as the planting contract acreage increased costs also increased and peaked for tracts ranging from 140-250 acres. For contractors with large permanent crews these tract sizes were economically small and for small contractors these tract sizes were too big to perform planting operations. Small average size of national forest parcels required four moves between planting sites to cover the same acreage as in industrial contracts. Therefore shifting to plant smaller parcels required more time and was expensive. Workers demanded more money for planting to compensate their loss due to traveling time to and from the work sites.

Effects of tract size on timber harvesting

The spreading of initial fixed costs for moving and setting up a harvest system is the main cause for economies of size (Thienpont, 1976). These moving and setting up costs are higher for smaller tracts. If these costs exceed revenues, timber on these tracts will not be harvested. This in turn affects the present and future wood supply (Cubbage, 1982). Cubbage (1983a) studied the effect of tract size on timber harvesting costs in southern pine stands. He observed that highly mechanized systems were more sensitive to tract size changes due to large moving expenses, while costs of pre-hauler systems were not sensitive to tract size changes. He also found that manual tree length systems and highly mechanized full-tree system incurred excessive harvest costs on tracts less than 60 acres. Stump-to-stump bobtail systems and short wood pre-hauler systems were cost competitive but their use was limited due to lack of available manual labor. Holmes (1986) studied factors that affect timber supply from non-industrial private forests in Connecticut. He observed that forest tract size, forestry assistance and stumpage prices had a positive influence on the propensity to harvest timber. Cubbage and Harris (1986) reviewed published literature to examine whether tract size was a limiting factor in planting, management, harvesting and marketing aspects of timber management. They observed that average costs followed an L-shaped curve, indicating high average costs on small tracts which leveled off on larger tracts. They observed that most cost reductions occurred at tract sizes ranging from 40-50 acres. They also suggested that tract size economies are important to large landowners with multiple stands and management units since the cost of supervision, management and data collection increases with increase in number of small firms. They also observed that tract size was not a significant in studies determining timber prices.

Greene et al. (1997) estimated the impact of changes in timber sale sizes on the economics of timber harvesting operations. Timber sales data collected from buyers of standing timber in Georgia and other adjacent states included year of purchase, state and county, type of landowner, total harvest acres, total preharvest cruised tons, type of sale and type of cut (clear or partial cut). Three logging systems were evaluated and a spreadsheet in Auburn Harvesting Analyzer format was created. For each system a median set of economic conditions were configured. Delivered costs per ton were recorded for each logging system and analyzed with linear regression. Baker et al. (2008) noted that in Georgia the annual production of timber per $1,000 invested in machinery decreased from 1987 to 2002 due to increase in the number of small logging firms. From 2002 to 2007 annual production increased with increase in the number of large logging firms. They also found out that the majority of logging contractors had shifted from clearcuts to thinning as predominant harvest type. This clearly shows that less timber is being harvested per tract and higher logging costs on per ton basis are incurred. Baker et al. (2010) studied the impact of timber sale characteristics on harvesting costs and observed that per ton logging costs were higher for small tracts and low harvest volumes (both in quadratic mean diameter and tons per acre). These costs decreased when the values of these sale characteristics increased. When the production reached maximum at a given set of conditions, these costs decreased gradually.

Methodological approaches in timber appraisal research

Buongiorno and Young (1984) applied a statistical procedure to predict the market value of sales in Chequamegon National Forest. The main sources of data were comparative timber sales of the same area (transaction evidence procedure). They developed a multiple regression equation by including all possible variables and then used stepwise regression to estimate the equation with 14 variables. Puttock et al. (1990) used hedonic pricing approach and time series cross section data pooled from a large sample of timber sale notices in southwestern Ontario. Timber sale notices provided information about the number of trees marked, an estimate of average quality of marked trees and volume of each species. Information on the area of sale, its location and its accessibility were also provided. Vasievich et al. (1997) used linear regression model (sometimes called as statistical transaction appraisal) to quantify the effect of timber sale factors on the costs of conducting timber sales and prices paid for the sales. They statistically analyzed 11 site and sale conditions to determine the effect of sale costs, bid prices and number of bids using data from 445 timber sale reports from Indiana State Forests.

Hensyl (2005) tested several hypotheses to determine the relationship between stumpage prices and various sale characteristics. Data were collected from timber procurement personnel and sawmills that purchased timber from central Virginia (central Virginia includes areas which are often the source of factors associated with forest fragmentation such as areas prone to increased population pressures). Price equation base model and bid equation base model were used to determine the effect of forest fragmentation on marginal values of sale characteristics and competitiveness of timber sale bidding. Leffler et al. (2003) determined factors that influence the choice between auctions and negotiated sales procedures on private timber sales. Data were collected by mailing questionnaires to timber buyers and timber consultants. In another study, an ordinary least square regression was used to develop a bid price model for sawtimber and pulpwood using data from industrial, non-industrial private and public timber sales in Arkansas, (Dahal and Mehmood, 2005). Data were collected from timber sale notices, contracts and bid abstracts from two national forests, the Arkansas Forestry Commission and several private forestry consultants. Huebschmann et al. (2004) used a logarithmic form of regression model to estimate sale bid prices from the sale's characteristics. The logarithmic form was used to correct much of the heteroskedasticity in the original data.

Theoretical framework

Hedonic pricing is a method which uses multiple regression analysis to estimate the implicit values of attributes from the value of a priced commodity (Rosen, 1974). Initially hedonic price function was developed by A.T. Court in 1939 in context of consumer choice theory (like consumers purchasing cars) where the price of the marketed good is related to its characteristics or services it provides (as cited in Herath and Gunther, 2010). Later this approach was applied for making decisions in the production of some consumer goods that used heterogeneous inputs. It was noted that various characteristics of these heterogeneous inputs contributed to the output production. This approach was applied to a timber stand (a heterogeneous input with several characteristics such as species composition, quality, tree size and volume) used in the production of lumber, assuming that its characteristics would attribute to the lumber production function (Buongiorno and Young, 1984; Puttock et al., 1990). Hedonic price function was applied to a heterogeneous input such as timber, for the production of lumber by considering derived demand for timber by the saw mills. Derived demand curves for timber are graphically presented in Figure 4.

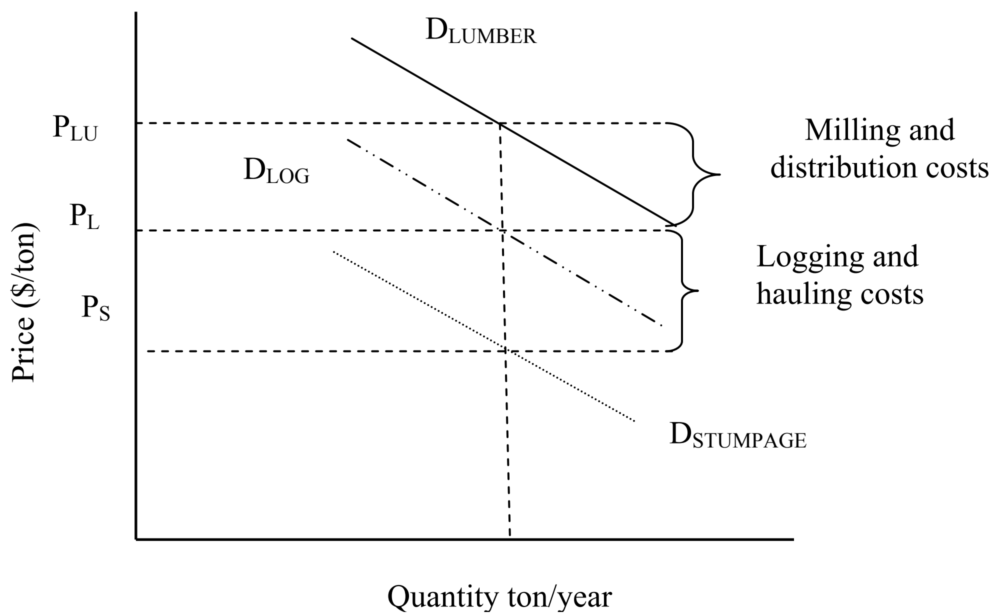

Figure 4: Derived demand curves for timber
(Source: www.agriculture.purdue.edu/.../TimberDemandandSupply_001.ppt)

In the case of heterogeneous inputs, the total production of output depends on the amounts of various input characteristics. Therefore, production function for a profit maximizing competitive firm, for single output say, is stated as:

$$Q_z = F(V_1, V_2 \ldots\ldots V_m) \qquad (1)$$

Where Q_z = quantity of product Z

V_j = quantity of input characteristic (j = 1, 2….. m)

For the production of output Z, single input X with m-dimensional vector characteristics is used. Then the firm's profit function is stated as:

$$\Pi = P_z \,.\, F(V_1 \ldots\ldots V_m) - P_x X; \qquad (j = 1\ldots\ldots m) \qquad (2)$$

Where P_z and P_x = prices of output Z and input X respectively

X = number of units of each characteristic of the input.

First order conditions for profit maximization are:

$$\partial \Pi / \partial X = P_z \sum_j (\partial F / \partial V_j) (\partial V_j / \partial X) - P_x = 0 \qquad (3)$$

Solving for P_x gives:

$$P_x = P_z \sum_j (\partial F / \partial V_j) (\partial V_j / \partial X) \qquad (4)$$

Where $(\partial V_j / \partial X)$ = marginal contribution of input X to the j^{th} characteristic used in production

$(\partial F / \partial V_j)$ = marginal product from one unit of characteristic j

$P_z (\partial F / \partial V_j)$ = value of the marginal product of the j^{th} characteristic of input X in producing output Z.

Assuming $(\partial F / \partial V_j)$ is constant and equal to β_j

$$P_x = P_z \sum_j \beta_j (\partial V_j / \partial X) \qquad (5)$$

Assuming the quantity of characteristic j is proportional to the number of units of X ($V_j = \theta_j X$)

$$(\partial V_j / \partial X) = \theta_j = V / X$$

Therefore Equation (5) can be written as:

$$P_x = P_z \sum_j \beta_j (V_j) / X \qquad (6)$$

Multiplying the above equation by X:

$$P_x X = P_z \sum_j \beta_j V_j \qquad (7)$$

The above equation represents the stumpage price of a timber stand which is equal to the sum of the marginal value products, $P_j\beta_j$, of each characteristic multiplied by the total quantity of each characteristic, V_j, in that particular timber stand. From Equation (7), the empirical model is expressed as follows:

$$PSTprice = \beta_0 + \beta_1 V_1 + \beta_2 V_2 + \beta_3 V_3 \ldots\ldots\ldots + \beta_j V_j \qquad (8)$$

Where PSTprice = pine sawtimber price ($)

β_0 = constant or the intercept

$\beta_1, \beta_2 \ldots\ldots \beta_j$ = marginal value of each sale characteristic

$V_1, V_2 \ldots\ldots V_j$ = quantity of each sale characteristic

Importance of the southern timber market

Of the four major forest regions (North, South, Pacific Coast, Rocky Mountains) private ownership of forest land predominates in the South (Smith et al., 2009). Large areas of federally owned land in the western forests (comprising Pacific coast and Rocky Mountains) were removed from harvest in the early 1990s, making the South the largest lumber producing region in the United States (Howard, 2007). Growing stock removals were highest in the South region in 2006, accounting for 62% of the nation's total growing-stock removals (Smith et al., 2009). Increasing levels of production from private forests and presence of major mill capacity makes the South the world's largest single industrial wood producer with its influence felt on international timber markets.

Variables used in previous timber appraisal methods

Softwood products account for majority of commercial use in the southern region. Smith et al. (2009) stated that in 2006 softwoods accounted for 63% of growing-stock removals while hardwoods accounted for 37% of growing-stock removals. Pulpwood prices may be affected by the oligopsony power identified in the pulpwood market (Mei and Sun, 2008). Murray (1995) examined oligopsony power in both pulpwood and sawlog markets and stated that U.S. pulpwood market has more oligopsonistic power than the sawlog market.

Buongiorno and Young (1984) showed that the acreage of timber sold is positively correlated to bid prices. Hensyl (2005) showed that for tracts less than 50 acres, acreage size has a negative impact on price paid per ton. The access variable is not significant for tracts greater than 50 acres, indicating that smaller tracts require good access more than larger tracts. Greene et al. (1997) considered timber sale size, rather than tract size, as most reliable measure of acreage involved in timber harvesting operations. Landowners might offer a portion of their timber stand for harvest during a timber sale to meet their financial needs. Hence they used timber sale size rather than tract size as reliable measure of sale size. They estimated the impact of changes in timber sale sizes on the economics of timber harvesting operations. Huebschmann et al. (2004) observed that the value of per unit volume of sawtimber tends to be greater for larger sales than for small sales. This is due to the fact that the economies of scale allow buyers to pay more per unit on large sales.

Previous studies of stumpage prices show that longer contracts between sellers and buyers generated higher stumpage prices (Munn and Rucker, 1995; Dunn and Dubois, 2000; Leefers and Potter –Witter, 2006). Kilgore et al. (2010) suggested that longer contracts increased stumpage prices in Minnesota State Forests. They also observed that an additional year on a timber sale contract increased stumpage prices by 4%, but the marginal impact of this additional year was constant from 2001 to 2006. Leffler et al. (2003) stated that auctions are more likely to occur on timber tracts with a greater percentage of pine sawtimber than tracts with less pine sawtimber. Similarly auctions are more likely to occur on tracts which offered large volume of timber for sale than tracts with a small volume of timber. They also stated that auctions are more likely to occur in more populated regions, where potential buyers are expected to respond to an auction, than in remote mountainous regions. They also found out that the likelihood of auction being chosen is lower for thinning sales and salvage sales than clearcuts.

Buongiorno and Young (1984) recognized that estimating timber price by ordinary least square regression would not be an adequate method for sales that received no bids. Various authors observed a positive correlation between the number of bids received during the sale and the winning bid value (Johnson, 1979; Brannman et al., 1987; Dunn and Dubois, 2000; Leefers and Potter-Witter, 2006). Sendak (1991) observed that greater sales revenue was generated on timber sales when there were fewer no-bid auctions. Dahal and Mehmood (2005) found out that bid price per acre was higher in the autumn season in Arkansas, since fall months in Arkansas are comparatively dry and therefore increase the harvesting intensity. Leefers and Potter-Witter (2006) and Kilgore et al. (2010) also found out that different seasons have different levels of competition and can significantly influence stumpage prices. Vasievich et al. (1997) observed that direct costs were lower where clearcutting was indicated as harvesting method when compared to selection thinning and seed tree cuts. Leffler et al. (2003) stated that the likelihood of auction being chosen was lower for thinning sales and salvage sales than clearcuts. Dahal and Mehmood (2005) and Hensyl (2005) stated that select cut harvests offered lower prices per ton when compared to clearcuts. Select cut harvests are time intensive and require great attention from the harvesting crews. Hence the loggers tend to pay reduced prices to the landowner for their timber.

Puttock et al. (1990) suggested that with improved quality of timber, stumpage prices also increase. Sendak (1992) observed that Vermont National forests sales drew fewer bidders when compared to state forests due to poor quality of timber stands. Howard (2007) stated that about 60% of lumber consumed in 2005 was used for housing in the United States. Hubbard and Abt (1989) noticed that logging conditions had a positive significant effect on stumpage prices in Florida. They used logging conditions as a dummy variable and assigned a value of 1, if the soil of the harvesting site was dry and 0, if the soil was wet.

CHAPTER 3

DATA AND ANALYTICAL MODEL

Data used in this research project were collected from Timber Mart-South (TMS is operated by Frank W. Norris Foundation, which has contracted with Daniel B. Warnell School of Forest Resources at the University of Georgia for its compilation, publication and distribution), a major timber price reporting service for 11 states in the southern United States. Timber Mart-South collects and publishes most detailed data of both stumpage and delivered wood markets, which are further sub-classified by species group (hardwood and softwood) and product category (sawtimber, chip-n-saw and pulpwood). The essence of this study was to analyze stumpage prices, based on various sale characteristics, in private forests in the southern United States. This study used data collected from 2000 to 2009. During this period pine sawtimber prices decreased due to decreased demand for pine sawtimber. This study used Timber Mart-South data collected from various private companies, landowners and consultants in the southern United States.

Quarterly data were available in numeric spreadsheets for each year for 11 southern states (i.e., Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Virginia, Tennessee and Texas). These numeric spreadsheets were then imported into Excel and all the sheets were merged to form one dataset in Excel. This Excel spreadsheet had data from the year 2000 to 2009, for all four quarters and for all the 11 southern states. The dataset had several columns, values of each column and their units are represented in Table 1.

The data were first filtered for stumpage prices to delivered wood prices. Stumpage prices are the prices paid to the landowner for standing timber. Prices of various timber products that were available in the dataset were represented in $/ton. Volumes of each timber product available in the dataset were represented in tons. Column ‘quarter’ was filtered for values 1 to 4 and column ‘year’ was filtered for values 2000 to 2009, excluding all other values. Column ‘state’ had abbreviated forms of the 11 southern states. Columns ‘area’ and ‘county’ gave information on location of a sale. Column ‘sale size’ represented the acreage that was harvested for sale in acres. Observations that had sale size values greater than 1,000 acres, 73 in total, were deleted assuming that they contain errors.

Column ‘numbers of bids’ represented the number of bids received during the sale. There were 45 observations that had zero value (0 bids). All these observations were assigned a value of 1 since it was assumed that there should be at least one bid for a sale to occur. Column ‘length contract’ represented the period of contract between buyer and seller in months. Column ‘sale type’ stated the type of sale occurred. Sales occurred were either represented as sealed bid auctions or negotiated sales. Column ‘harvest type’ represented the type of timber harvest. Harvesting operations conducted on sold tracts were either clearcuts or thinning operations. Column ‘grade’ represented the quality of timber offered during the sale. Grade values were represented as below average, average, above average and excellent timber qualities. Column ‘market conditions’ represented the demand and supply of pine sawtimber and their prices in the timber market. Values of market conditions were represented as poor, fair, good and excellent conditions. Column ‘logging conditions’ represented the topography of the tract that was harvested. Values of logging conditions were represented as poor, fair, good and excellent conditions.

Table 1: Source data spreadsheet coding.

Column name	Values	Units	Conversion factors
Stumpage/ delivered prices	stumpage prices	$/ton	
Product	cns, pst, ppw, hst, hpw, ost		
Product price	1 to 65	$/ton	
Product volume	1 to 2,859,656	ton, scribner board feet, doyle board feet, international board feet, cords	scribner board feet to tons: pst/7.5, cns/7.5 ppw/8.75 doyle board feet to tons: pst/8, cns/9.975 international board feet: pst/6.225, cns/6.285 cords to tons: cns/2.68, ppw/2.68
Year	2000 to 2009		
Quarter	1 to 4		
State	AL, AK, FL,GA, LA, MS, NC, SC, VA, TN, TX		
Area	1, 2		
County	various counties of all 11 states		
Sale type	negotiated, sealed bid		
Sale size	1 to 10,000	acres	
Total volume of all products	1 to 500,000	ton	
Total dollars earned in sale	6 to 3,166,338	$	
Hauling distance	2 to 175	miles	

Length contract	1 to 48	months	
Harvest type	thinning, clearcuts		
Grade	below average, average, above average, excellent		
Market conditions	poor, fair, good, excellent		
Logging conditions	poor, fair, good, excellent		
Number of bids	0 to 22		
Highest bid value	6 to 14,621,310	$	
Lowest bid value	5 to 3,777,749	$	

Preliminary analysis of data

The sorted data were first analyzed to examine pine stumpage price variation over time. Average annual prices for the period from 1st quarter 2000 through 1st quarter 2009 were calculated for pine sawtimber (PST), pine chip-n-saw (CNS) and pine pulpwood (PPW) and plotted over time. Average pine sales (sales including PST, CNS and PPW) and prices categorized by each sale characteristic were plotted to show the effect of sale characteristics on pine stumpage prices.

It was observed that prices of pine sawtimber and chip-n-saw were higher in 2000 and then started declining thereafter. An increase was observed in 2006 in pine sawtimber prices. Pine pulpwood prices were highest in the year 2000, decreased since then and are now approaching the 2000 levels (Figure 5). Average price of pine sawtimber recorded in the first quarter of 2009 was much lower than its 10 year average price. Average price of pine chip-n-saw recorded in the first quarter of 2009 was also lower than its 10 year average price. Average price of pine pulpwood recorded in the first quarter of the year 2009 was slightly higher than its 10 year average price. Among, these three products pine sawtimber prices show most variability (Table 2).

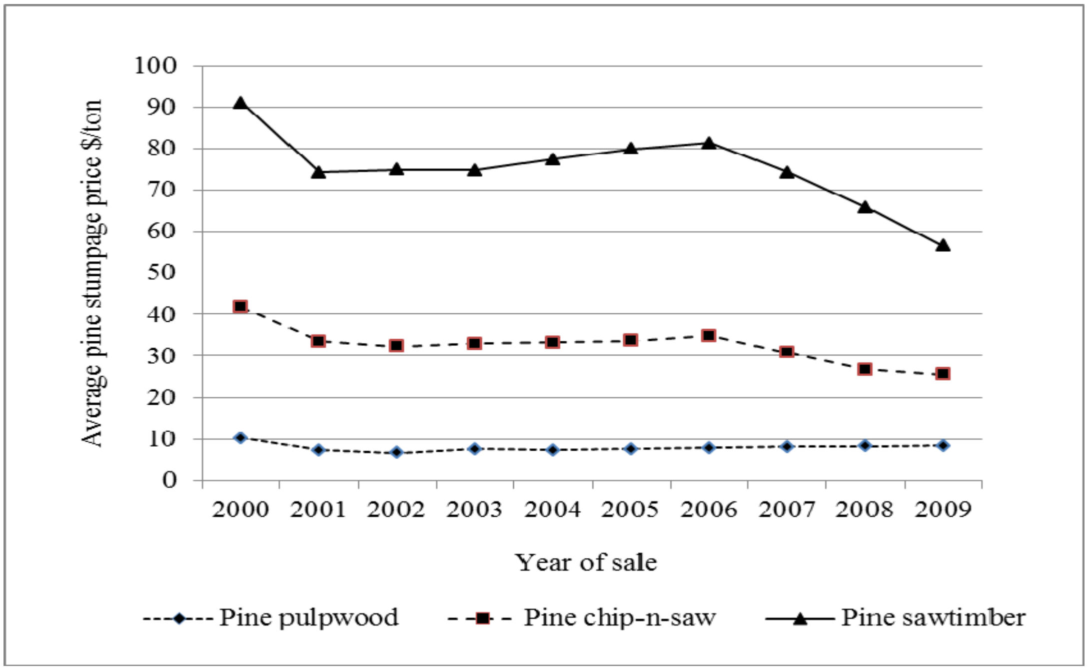

Figure 5: Southern average annual pine stumpage prices.

Table 2: Southern pine stumapage prices ($/ton) comparison: 10 year average vs 1st quarter 2009 average.

	Pine pulpwood	Pine chip-n-saw	Pine sawtimber
10 year average	7.93	24.68	42.46
1st quarter 2009 average	8.37	17.22	30.92

Most pine sales occurred on tracts ranging from 51-100 acres, followed by tracts ranging from 0-50 acres. The least number of sales occurred on tracts ranging from 151-200 acres (Figure 6). Higher prices for pine sawtimber and pine pulpwood were received for sale sizes ranging from 151-200 acres and for pine chip-n-saw higher prices were received on sale sizes ranging from 101-150 acres. Prices received on sale sizes ranging from 0-50 acres were lower for all three pine products (Figure 7, Table 3).

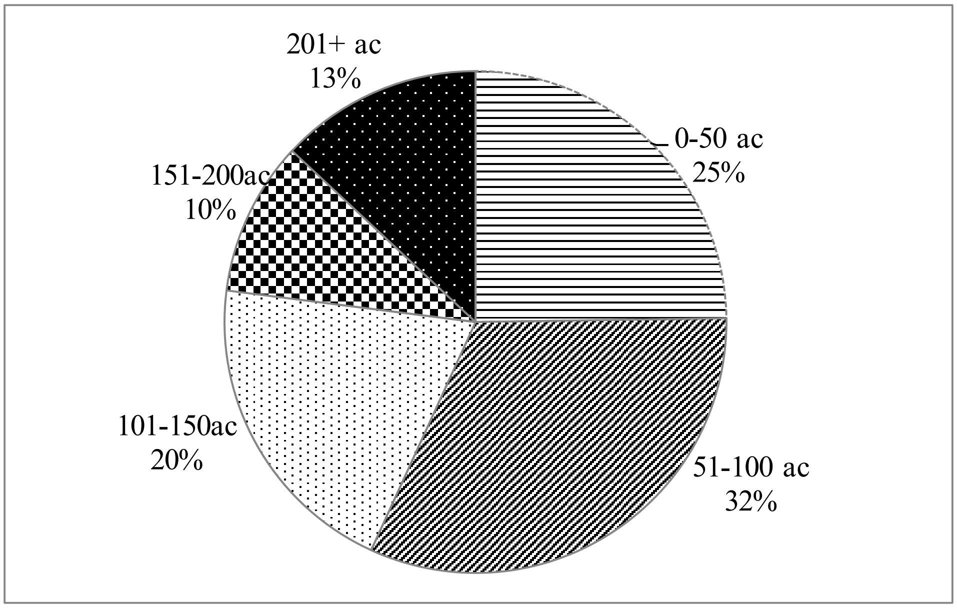

Figure 6: Southern average pine stumpage sales by sale size (acres).

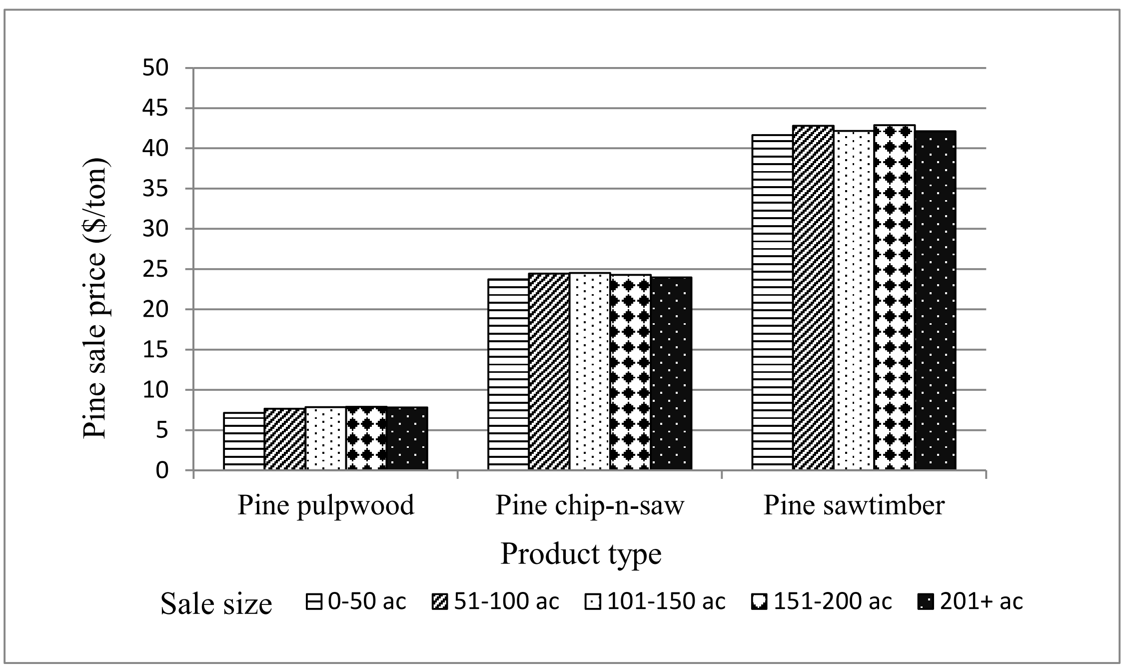

Figure 7: Southern average pine stumpage sales price ($/ton) for different sale sizes (acres) by product type.

Table 3: Southern average pine stumpage sales price ($/ton) by sale size (acres).

Sale size (acres)	Pine pulpwood	Number of sales	Pine chip-n-saw	Number of sales	Pine sawtimber	Number of sales
0-50 ac	7.16	2,228	23.73	1,290	41.67	1,758
51-100 ac	7.69	2,330	24.44	1,576	42.83	1,765
101-150 ac	7.86	1,380	24.54	998	42.19	1,031
151-200 ac	7.92	733	24.31	536	42.89	502
201+ ac	7.83	1,162	23.99	826	42.16	673

Majority of the pine sales were clearcuts (approximately 58%) . Thinning harvests constituted 42% and were most common in sales involving pine chip-n-saw (Figures 8 and 9). Pine stumpage prices received for clearcut harvests were higher when compared to thinning harvets (Table 4).

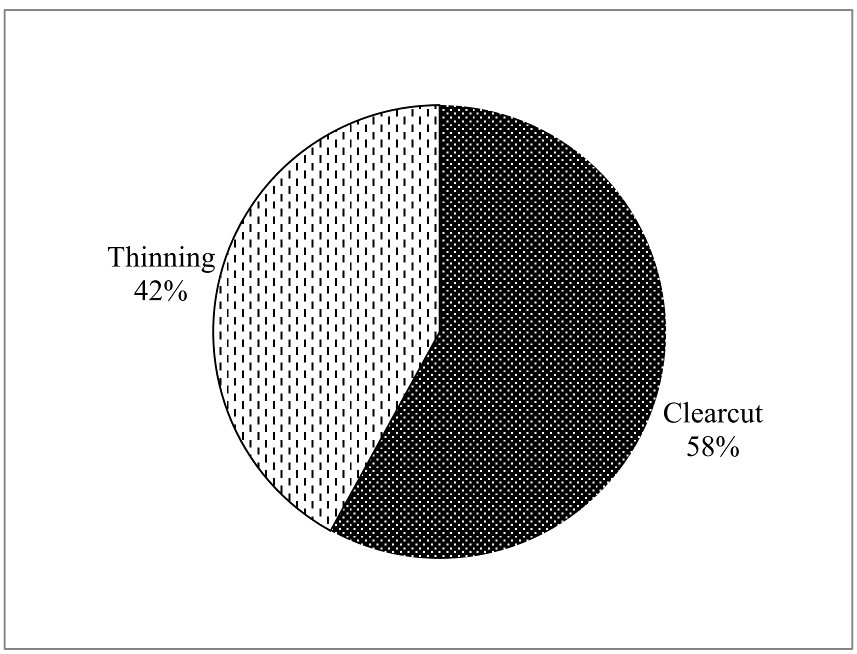

Figure 8: Southern average pine stumpage sales by harvest type.

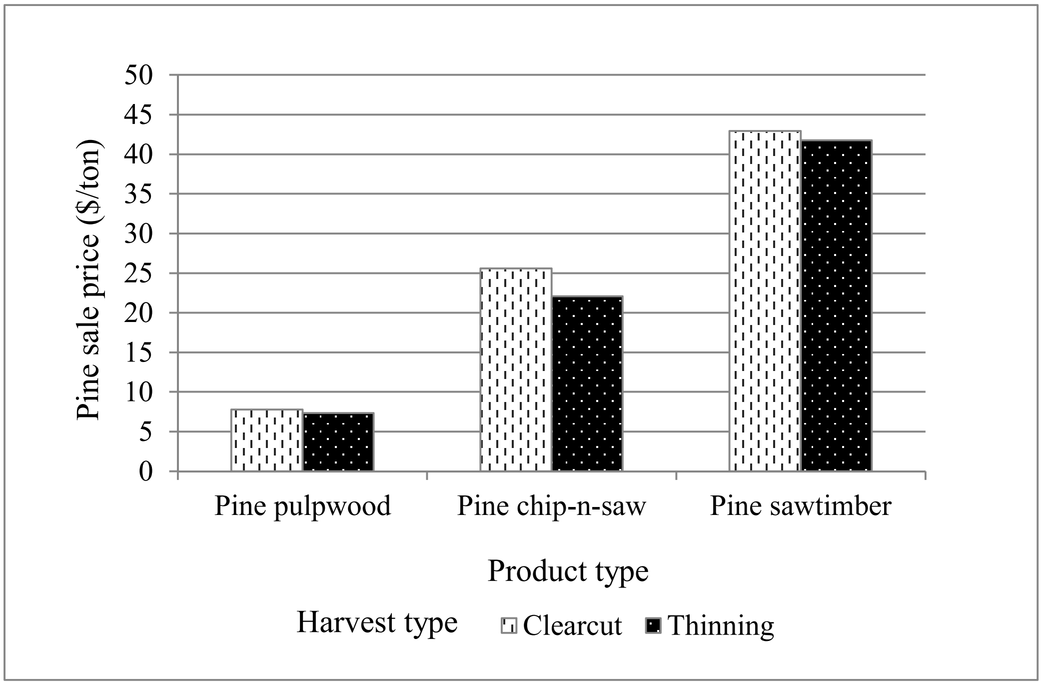

Figure 9: Southern average pine stumpage sales price ($/ton) for different harvest types by product type.

Table 4: Southern average pine stumpage sales price ($/ton) by harvest type.

Harvest type	Pine pulpwood	Number of sales	Pine chip-n-saw	Number of sales	Pine sawtimber	Number of sales
Clearcut	7.77	2,510	25.57	3,679	42.91	3,144
Thinning	7.32	1,944	22.06	3,043	41.74	1,767

Approximately two-thirds of the pine sales during this 10 year period were sealed bid auctions, while one-third sales were negotiated sales (Figure 10). A major difference in the average prices of pine sawtimber and pine chip-n-saw was observed when there were sealed bid auctions when compared to negotiated sales. Prices received through sealed bid auctions were higher. Average pine pulpwood prices did not vary much with each sale type (Figure 11, Table 5).

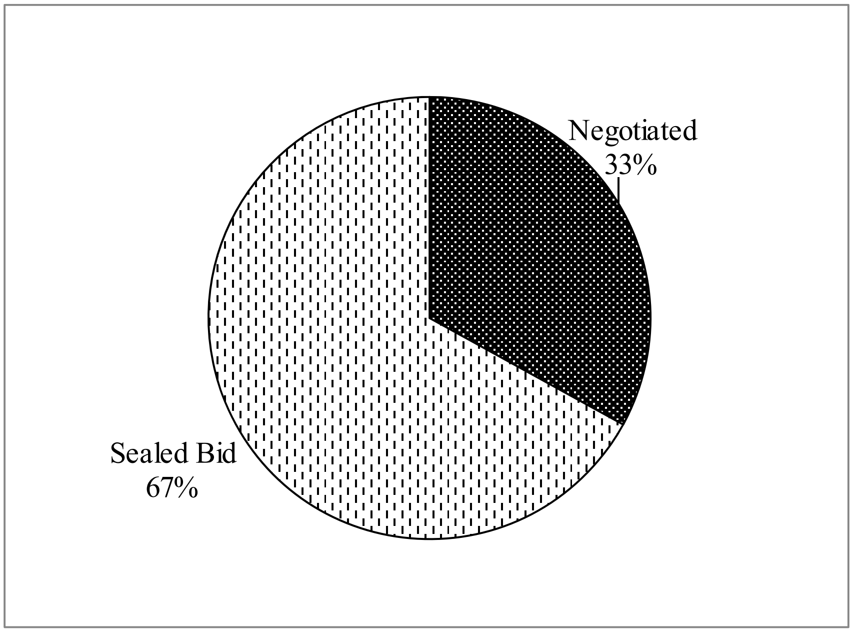

Figure 10: Southern average pine stumpage sales by sale type.

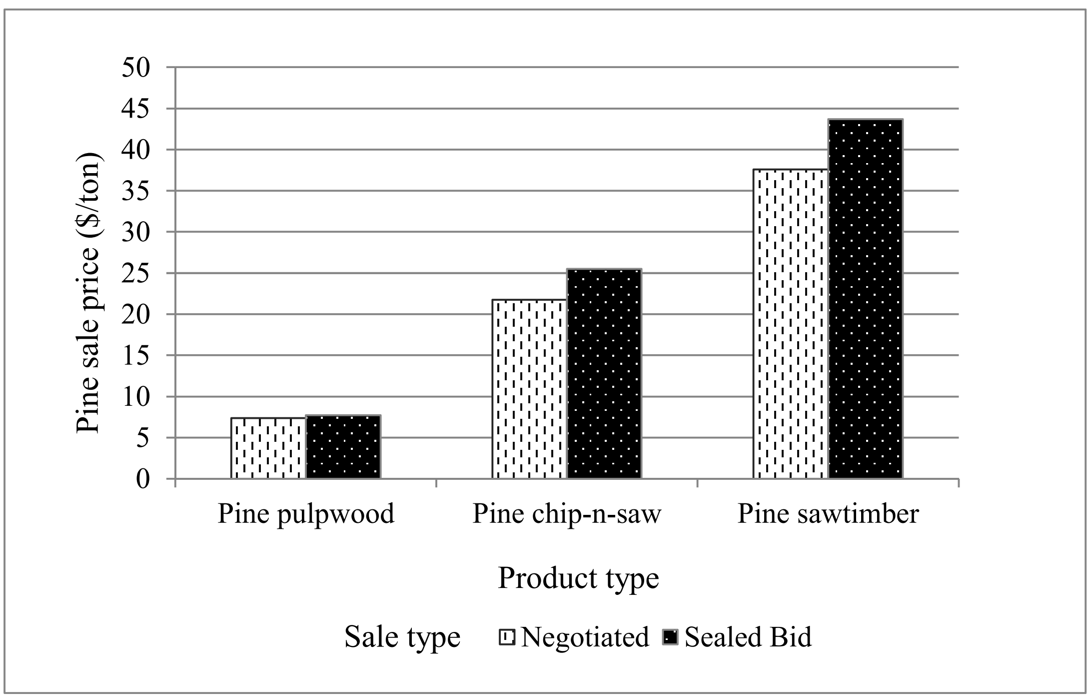

Figure 11: Southern average pine stumpage sales price ($/ton) for different sale types by product type.

Table 5: Southern average pine stumpage sales price ($/ton) by sale type.

Sale type	Pine pulpwood	Number of sales	Pine chip-n-saw	Number of sales	Pine sawtimber	Number of sales
Negotiated	7.37	2,422	21.73	1,625	37.56	1,181
Sealed bid	7.72	4,179	25.48	2,699	43.68	3,808

Pine sales that received 1-3 bids were more common (about 63%) in the data sample (Figure 12). More competition was observed in sales where pine pulpwood and pine sawtimber were offered together. Pine sawtimber prices increased gradually with increase in the number of bids when compared to pine pulpwood and pine chip-n-saw prices (Figure 13, Table 6).

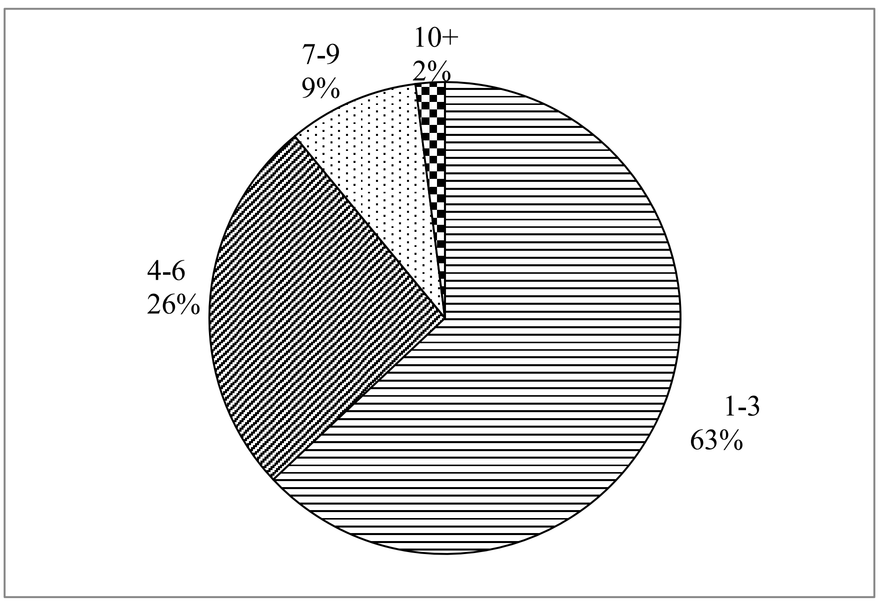

Figure 12: Southern average pine stumpage sales by number of bids.

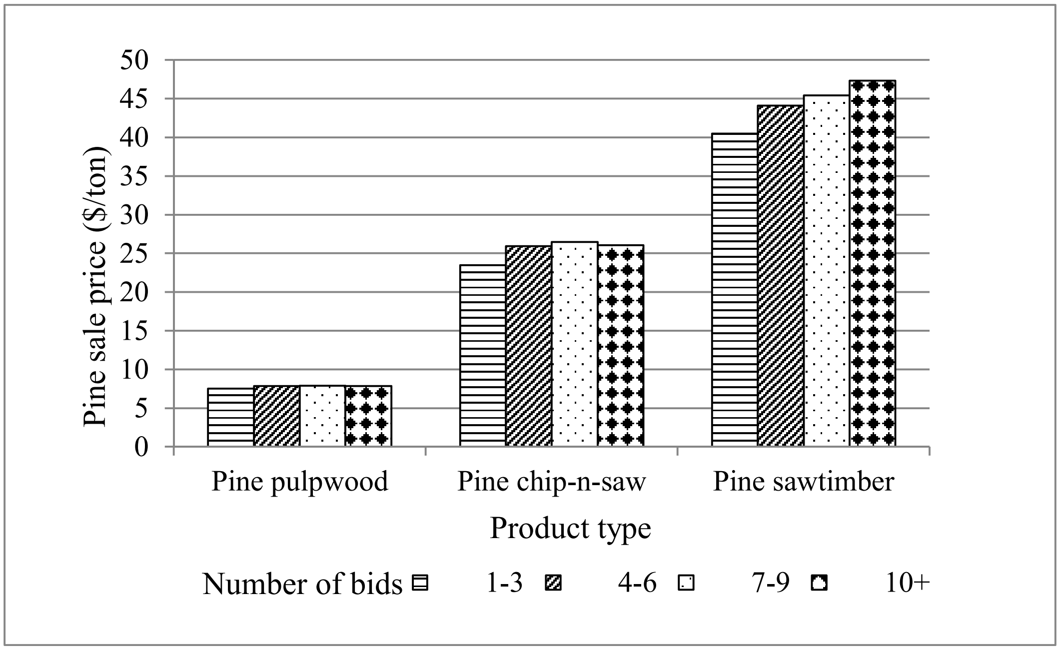

Figure 13: Southern average pine stumpage sales price ($/ton) for different number of bids by product type.

Table 6: Southern average pine stumpage sales price ($/ton) by number of bids.

Number of bids	Pine pulpwood	Number of sales	Pine chip-n-saw	Number of sales	Pine sawtimber	Number of sales
1-3	7.5	5,261	23.45	3,707	40.48	3,285
4-6	7.84	1,683	25.92	1,082	44.09	1,599
7-9	7.87	656	26.46	340	45.4	624
10+	7.84	234	26.03	97	47.31	221

Variable selection

The following dependent and explanatory variables were used in the study analysis:

Pine sawtimber price

The data that were used for the analysis had prices of both softwood and hardwood products like pine chip-n-saw, pine sawtimber, pine pulpwood, hardwood sawtimber, hardwood pulpwood and oak sawtimber. This study analyzed prices of pine sawtimber (softwood product) since softwoods account for majority of commercial use in the southern region. Of the three softwood products only pine sawtimber prices were modeled. Higher correlation exists between pine sawtimber and pine chip-n-saw prices and pine sawtimber prices have the most variability (Tables 7 and 8). Pine sawtimber prices are used in their nominal values and are represented in $/ton.

Table 7: Spearman correlation coefficients of pine pulpwood, pine chip-n-saw and pine sawtimber prices.

	Pine pulpwood price	Pine chip-n-saw price	Pine sawtimber price
Pine pulpwood price	1.000	0.248 <0.0001	0.216 <0.0001
Pine chip-n-saw price	0.248 <0.0001	1.000	0.689 <0.0001
Pine sawtimber price	0.216 <0.0001	0.689 <0.0001	1.000

Table 8: Statistics of pine pulpwood, pine chip-n-saw and pine sawtimber prices.

Variable	Number of observations	Mean	Standard deviation	Minimum	Maximum
Pine pulpwood price ($/ton)	7,638	7.599	2.439	2.00	20.00
Pine chip-n-saw price ($/ton)	5,071	24.116	6.161	10.00	40.00
Pine sawtimber price ($/ton)	5,584	42.273	9.276	20.00	65.00

Sale size

The purpose of this study was to determine how increased forest fragmentation impacted pine sawtimber prices, by influencing various timber sale characteristics. Among various sale characteristics acreage was one of the most important explanatory variables that were considered to influence pine sawtimber prices. Forest fragmentation is decreasing the size of the timber tracts. Decreases in tract sizes influence other sale characteristics such as type of harvest, type of sale, number of bids received during sale (as discussed in literature review), which in turn might influence pine sawtimber prices.

From the literature review it was evident that logging and hauling costs were higher on smaller tracts (tracts less than 40-50 acres) and these costs decreased with increase in tract size. Therefore stumpage prices, which were obtained after deducting logging and hauling costs from delivered wood prices, were lower for smaller tracts increased with increase in tract size up to a certain point. At that point, maximum prices were paid per unit volume of timber. After that point, diseconomies of size occurred due to very large tracts and prices paid per unit volume decreased. In this study, both linear (SALE SIZE) and quadratic (SS) expressions of sale size (acres) were used as two different variables to account for both economies and diseconomies of size. Variables SALE SIZE and SS were expected to have a positive and negative coefficient respectively.

Contract length

Forest landowners sell timber to buyers after negotiating a contract for the exchange of a specified amount of timber for a certain price. The variable LENGTH CONTR represented the contract period between buyer and seller in months in this analysis. The coefficient of LENGTH CONTR was expected to have a positive effect on pine sawtimber price because increasing contract length increased loggers flexibility to harvest timber. In this study, a quadratic (LCLC) expression of variable LENGTH CONTR was used as a separate variable to account for very long timber sale contract between landowner and the same buyer. The coefficient of this quadratic expression was expected to have a negative effect on pine sawtimber price because landowner might miss a chance to receive higher stumpage prices from other buyers, when they stay with the same buyer for a very long time.

Type of sale

Timber sale can occur through negotiated sales or sealed bid auctions. In a negotiated sale, a price is established between a buyer and seller by face-to-face bargaining. A sealed bid auction involves taking bids from all the potential buyers and opening those bids at a specific time and place. The variable SALE TYPE was used as a dummy variable and it was assigned 1 if the sale type was a sealed bid auction, 0 if the sale type was a negotiated sale. The variable SALE TYPE was expected to have a positive correlation with pine sawtimber prices if the type of sale was a sealed bid auction.

Number of bids

The variable NO_OF_BIDS was used as a proxy for the level of competition during the sale. The higher the number of bidders participating in sale, higher the uncertainty level for each individual bidder, leading to a higher winning bid value. Hence, the coefficient of NO_OF_BIDS was expected to have a positive effect on pine sawtimber price. If the competition during the sale is so high then there is chance that bidders may also quote low prices. To account for such situations a quadratic (NBNB) expression of variable NO_OF_BIDS was used as a separate variable and its coefficient was expected to be negative. Variable NBNB was removed from the final model since it affected the overall significance of the model.

Year

The variable YEAR represents the year in which the timber was sold in a timber sale. In the preliminary analysis of data (Figure 5) it was observed that pine sawtimber prices declined from the year 2000 to 2009. This variable was included in the model to account for price changes over time. It was used as an continuous variable and was assigned a value of 1 through 10 for 2000 to 2009.

Season of sale (Quarter 1-4)

In this study, three dummy variables QUARTER1, QUARTER3 and QUARTER4 were created to account for seasonality changes in the quarters 1, 3 and 4 respectively by taking QUARTER2 as reference variable. Timber sales are usually high during the second quarter (summer season) due to dry weather conditions favoring increased harvesting operations. QUARTER1, QUARTER3 and QUARTER4 were expected to have a negative influence on pine sawtimber prices.

Type of harvest

Variable type of harvest can have a significant impact on stumpage prices. This variable was not included in the model because the data that were used in this analysis had clearcuts sales only.

Timber quality (Grade)

In this study, variable GRADE represented timber quality and was used as a dummy variable. It was assigned value 1, if the timber quality was above average or excellent, 0 otherwise. This variable was expected to be positively correlated to the dependent variable.

Market conditions

Timber value under conditions of market exchange is determined by demand and supply interactions. With housing starts growing there will be more demand for timber, leading to higher stumpage prices. In this study, variable MARKET CONDITIONS was used as a dummy variable and was assigned a value of 1, if the market conditions were excellent and 0, otherwise. This variable was expected to have a positive influence on pine stumpage prices.

Logging conditions

Logging conditions represented the type of terrain that timber occupied. Uneven ground with ridges and gullies, scattered rocks and stumps may attribute to breakage of felled trees. Topography of land plays an important role in determining the harvesting options that are desirable and feasible. Many harvesting systems are more productive on gentle terrain than on steeper slopes. In this study, variable LOGGING CONDITIONS was used as a dummy variable and was assigned a value 1, if the logging conditions were excellent and 0, otherwise. This variable was expected to have a positive correlation with the dependent variable.

Model Specification

The final model was specified as follows:

PSTprice = b_0 + b_1 SALE SIZE + b_2 SS+ b_3 LENGTH CONTR + b_4 LCLC + b_5 NO_OF_BIDS + b_6 YEAR+ b_7 QUARTER1 + b_8 QUARTER3 + b_9 QUARTER4 + b_{10} SALE TYPE + b_{11} GRADE + b_{12} MARKET CONDITIONS+ b_{13} LOGGING CONDITIONS

In this study, a non-linear relationship was determined between pine sawtimber price and sale characteristics to better approximate results. When selected sale characteristics were regressed against pine sawtimber prices, the graph of residuals vs predicted was a parabolic curve instead of a straight line. Hence, a quadratic transformation was used.

Table 9: Descriptive statistics of variables.

Variable name	Units of measurement/ Variable description	Mean	Std.dev	Minimum	Maximum	Expected sign
Dependent variable						
PSTprice	Nominal value of pine sawtimber price ($/ton)	42.709	9.532	20.00	65.00	
Independent variables						
SALE SIZE	Represents total acreage harvested for sale (acres)	93.256	83.244	1.00	950.00	+
SS	Square of variable sale size	15624.9	41971.9	1.00	902500	_
LENGTH CONTR	Contract period between buyer and seller for timber sale (months)	16.048	6.168	1	48	+
LCLC	Square of length contract variable	295.580	218.310	1	2304	_
NO_OF_BIDS	Represents the number of bids received during timber sale auction	5.021	2.868	1	22	+
YEAR	Represents the year in which the timber is harvested for sale (continuous variable)	5.249	2.87	1.00	10.00	?
QUARTER1	Dummy variable, 1 if it is first quarter of the year, 0 otherwise	0.354	0.478	0	1	_

QUARTER3	Dummy variable, 1 if it is third quarter of the year, 0 otherwise	0.151	0.359	0	1	_
QUARTER4	Dummy variable, 1 if it is fourth quarter of the year, 0 otherwise	0.240	0.427	0	1	_
SALE TYPE	Dummy variable, 1 if the type of sale is sealed bid auction, 0 otherwise	0.685	0.465	0	1	+
GRADE	Dummy variable, 1 if the timber quality is above average or excellent, 0 otherwise	0.295	0.456	0	1	+
MARKET CONDITIONS	Dummy variable, 1 if the market conditions are excellent,0 otherwise	0.094	0.292	0	1	+
LOGGING CONDITIONS	Logging conditions (dummy variable), 1 if logging conditions are excellent, 0 otherwise	0.207	0.406	0	1	+

CHAPTER 4

RESULTS AND DISCUSSION

The model used to analyze the pine sawtimber prices is found to be globally significant with an F-value of 31.08 and the corresponding probability of less than 0.0001. Regression results of the model are shown in Appendix A. The model used to estimate marginal values from the price analysis has an R^2 and adjusted R^2 of 0.21 and 0.20, respectively. Considering the structure of data (due to large number of missing observation the sample size used in the regression has decreased), these R^2 values are acceptable. In real timber markets, a large variation is observed in timber appraisal. Even tracts with similar timber stands are not appraised equally, i.e., the winning bid value differs from tract to tract. Table 10 shows the estimation results of the equation for pine sawtimber prices with robust standard errors. The original dataset contained 10,684 observations. Only 5,520 observations pertaining to clearcut sales were considered. This data subset is used in the regression analysis, but due to large number of missing values only 1,516 observations were used in the end. Coefficients of all variables, except that of QUARTER1 and QUARTER4, are significant at 5% level. Coefficients of these two variables are not significant even at 10% level.

Quadratic forms SS and LCLC were used for variables SALE SIZE and LENGTH CONTR, respectively. Quadratic models are most commonly used to estimate parameters of threshold models, in which the effect of independent variable on dependent variable changes from positive to negative, or negative to positive at some point of independent variable (called inflection point or threshold point). If the effect of an independent variable on the dependent variable changes from positive to negative, then the inflection point determines the level of independent variable at which the dependent variable is maximized. If the effect of an independent variable on the dependent variable changes from negative to positive, then then inflection point determines the level of independent variable at which the dependent variable reaches minimum.

Among various sale characteristics variables, SALE SIZE and SS had a statistically significant positive and negative relationship with pine sawtimber prices, respectively. The result is consistent with the theory of economies and diseconomies of size. Logging and hauling costs tend to decrease with increases in tract size. Stumpage prices, which are obtained after deducting logging and hauling costs from delivered wood prices, tend to increase with increase in tract size up to a certain point. At the point of inflection, maximum prices paid per unit volume of timber. Beyond this point, diseconomies of size occur due to very large tracts; hence prices paid per unit volume of timber decrease. The regression analysis showed that with one unit increase in sale size, pine sawtimber prices increased by $0.025/ton initially and then decreased by $0.00003/ton beyond the point of inflection, holding all other independent variables constant. The point of inflection, where pine sawtimber prices maximize was determined using the formula

$$\text{Inflection point (maximum prices)} = \beta_1 / -2\beta_2 \qquad (9)$$

Where β_1= coefficient of linear term

β_2= coefficient of quadratic term

The coefficient values of variables SALE SIZE and SS were substituted for β_1 and β_2 respectively in the above equation and the sale size at which pine sawtimber prices maximized was obtained. The sale size value was calculated as 427.2 acres. This result differs from the results obtained from preliminary analysis of data where pine sawtimber prices maximized at 151-200 acres sale size. Pine sawtimber prices increased by $0.025/ton with each additional acre of sale size until the size of sale reached 427.2 acres, beyond 427.2 acres as sale size increased by one acre pine sawtimber prices decreased by \$0.00003/ton.

Table 10: Parameters estimates for the pine sawtimber prices.

Variable name	Parameter estimate	t-statistics	Standard error
INTERCEPT	40.53136***	22.92	1.769
SALE SIZE	0.02488***	4.12	0.006
SS	-0.00002912**	-2.32	0.000
LENGTH CONTR	0.42696***	2.59	0.165
LCLC	-0.02591***	-5.56	0.005
NO_OF_BIDS	0.56595***	6.00	0.094
YEAR	-0.80359***	-8.01	0.100
QUARTER1	-0.27222	-0.45	0.609
QUARTER3	-1.48757**	-1.97	0.754
QUARTER4	-0.71562	-1.09	0.657
SALE TYPE	1.90772**	2.16	0.884
GRADE	2.04323***	4.10	0.498
MARKET CONDITIONS	2.67056***	3.70	0.721
LOGGING CONDITIONS	2.22451***	3.86	0.576

Note: ** and *** denote significant at 5%, and 1% levels, respectively

Similarly variables LENGTH CONTR and LCLC were statistically significant with positive and negative coefficients indicating that pine sawtimber prices increased initially by \$0.4269/ton and then decreased by \$0.0259/ton. The period of contract at which pine sawtimber prices maximized was calculated as 8 months by substituting coefficient values of LENGTH CONTR and LCLC for β_1 and β_2 respectively in Equation (9). The result implies that prices for timber are higher if the period of contract between the buyer and seller is 8 months. If the contractual agreement between the buyer and landowner is more than 8 months, the landowner might miss an opportunity to receive higher prices from other buyers. The variable NO_OF_BIDS was significant with an expected positive coefficient. The result is consistent with previous studies and implies that with each additional bid received during the timber sale, pine sawtimber prices increased by $0.5659/ton. The variable NBNB was not statistically significant and therefore removed from the model. Type of sale represented by the variable SALE TYPE in the model was significant with a positive relationship with pine sawtimber prices. The result is tenable implying that sealed bid auctions fetch higher pine sawtimber prices than negotiated sales with more number of bidders participating in the sale. Pine sawtimber prices were higher by $1.9077/ton, if the type of sale was a sealed bid when compared to a negotiated sale. The significance and negative sign for the variable YEAR indicated that pine sawtimber prices were higher in the year 2000 and then decreased with each passing year, by $0.8036/ton. The result is consistent with the findings in the preliminary analysis of data.

Among the variables QUATER1, QUATER3 and QUATER4 which were used in the model to account for seasonality changes (with reference to 2^{nd} quarter of the year), only QUATER3 variable was statistically significant. The effect of this variable was negative indicating that pine sawtimber prices decreased by $1.4876/ton, if the timber sale was conducted during the third quarter of the year rather than the second quarter. Although the other two quarter variables, i.e. QUATER1 and QUATER4 were not statistically significant, the signs of the estimates were negative, as expected, indicating that timber sales conducted during QUATER1 and QUATER4 did not fetch higher prices than sales conducted during the second quarter. Both the variables had a negative sign suggesting that pine sawtimber prices decreased, if the timber sale occurred either during the first or fourth quarters of the year rather than the second quarter.

The variable GRADE which represented above average or excellent quality timber in the sale was significant and had a positive coefficient of 2.0432. Presence of above average or excellent quality timber significantly impacted the price of pine sawtimber and the positive coefficient implies that price of pine sawtimber increased when above average or excellent quality timber was offered for sale. The MARKET CONDITIONS variable was statistically significant and had the largest magnitude among all variables. It had a positive relationship with the pine sawtimber prices suggesting that presence of excellent market conditions increased pine sawtimber prices by $2.6706/ton. Higher the consumption of pine sawtimber greater will be its demand in the timber market. Hence, higher prices are offered for pine sawtimber in the sale. The LOGGING CONDITIONS variable was significant and had a positive influence on pine sawtimber prices. The result is consistent with the previous studies indicating that presence of excellent conditions for logging increased pine sawtimber prices by $2.2245/ton. Buyers pay stumpage prices after calculating the harvesting and logging costs. If the conditions for logging are favorable, they would incur low costs and tend to offer higher stumpage prices.

CHAPTER 5

CONCLUSIONS

Smaller harvest acreages are a distinct characteristic of accelerated forest fragmentation and parcelization on non-industrial private forests. The impact that smaller acreages have on the selling price of pine sawtimber is evident in this study. Holding everything else constant, pine sawtimber prices are lower for small sale sizes and increase with increase in sale size. Prices reached maximum at 427.2 acres. Buyers tend to pay low prices for small sale sizes due to higher harvestings costs. Pine sawtimber prices reached maximum when the period of contract between the buyer and the seller is 8 months. Prices decreased when the contractual agreement exceeded 8 months. Pine sawtimber prices increased by $1.0977/ton for sealed bid auctions when compared to negotiated sales. With each additional bid received during sale pine sawtimber prices increased by $0.5659/ton. Timber sales conducted during the second quarter of the year (April-June) received higher prices when compared to all other quarters. Pine sawtimber prices were lowest if the sale was conducted during third quarter of the year. Tracts offered for sale during first and second quarter also fetched lower prices but the results were not significant at 10% level. Pine sawtimber prices were higher when above average or excellent quality timber was offered for sale. Allowing excellent logging conditions like dry ground timber harvests and awaiting good market for pine sawtimber fetched good prices.

Several authors have appraised timber for non-industrial private forests using various variables but variables that are assumed to influence stumpage prices were not significant in most of these studies. Moreover, their studies were limited to small geographic areas. This study provided an appraisal method based on sale characteristics for pine sawtimber for the southern timber market. Analysis of factors influencing pine sawtimber prices revealed several opportunities to improve timber sale policies and practices for non-industrial private owners, whose average tract size is shrinking. Although several policies regarding non-industrial private forest landowners were made earlier, this study results identified common areas that may help to promote timber sales in the southern United States. These common areas include: (1) increasing more number of acres offered for sale; (2) decreasing contract length between buyer and seller; (3) promoting sealed bid auctions; (4) attracting more bidders; (5) offering sales in the months of April-June; (6) providing high quality timber; and (7) timing the market.

Southern non-industrial private forest landowners have diverse ownership use, management objectives and interests. For non-industrial private forest landowners who own land for timber production, this study is useful as it implies the sale characteristics that impact pine sawtimber prices. Apart from acreage, other sale characteristics that are positively correlated with stumpage prices should be seriously considered in making management decisions. Many non-industrial private forest landowners are unaware of forest management opportunities. Existing non-industrial private forest landowners who do not know how to manage their lands and new forest landowners should be well informed about timber management, timber marketing and selling practices and tax policies. Further research on this study in planning better management regimes for different tract sizes, conducting cost effective timber sale programs can be achieved.

Limitations of this study

Although this study used a large initial dataset for analysis, due to large number of missing observations the sample size finally used for the regression analysis was significantly smaller. The result stating that pine sawtimber prices reached maximum with contract lengths of 8 months can be a misinterpretation due to inaccurate parameter estimates of the variables LENGTH CONTR and LCLC. Several authors (Puttock et al., 1990; Vasievich et al., 1997; Leffler et al., 2003; Hensyl, 2005) discussed variables such as hauling distance and total volume of timber offered for sale as significant factors affecting stumpage prices. These variables were not accounted in this study due to their small number of observations. Values of variables MARKET CONDITIONS and LOGGING CONDITIONS were not defined properly in terms of their real market and ground conditions in the original data. Values such as 'excellent' for these variables do not clearly define practical conditions that are most favorable for logging and stumpage markets.

The model used in this study accounted for sales involving clearcuts, high quality timber, excellent market conditions and excellent logging conditions. Sales that had thinning harvests were not considered because their presence affected the overall significance of the model. The model for this study focuses on timber sales conducted in all 11 southern states. Applying the same to a particular region or state may not be effective due to changing local social, economic and market conditions.

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APPENDIX A

REGRESSION RESULTS

The SAS System 18:40 Saturday, April 2, 2011

The REG Procedure
Model: MODEL1
Dependent Variable: PSTprice

Number of Observations Read	5520
Number of Observations Used	1516
Number of Observations with Missing Values	4004

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	34175	2628.88417	31.08	<.0001
Error	1502	127058	84.59255		
Corrected Total	1515	161234			

Root MSE	9.19742	R-Square	0.2120
Dependent Mean	43.82582	Adj R-Sq	0.2051
Coeff Var	20.98631		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t value	Pr > | t |
Intercept	1	40.53136	1.76864	22.92	<.0001
Sale size	1	0.02488	0.00603	4.12	<.0001
ss	1	-0.00002912	0.00001258	-2.32	0.0207
Length contr	1	0.42696	0.16512	2.59	0.0098
lclc	1	-0.02591	0.00466	-5.56	<.0001
No_of_bids	1	0.56595	0.09428	6.00	<.0001
year_	1	-0.80359	0.10033	-8.01	<.0001
q1	1	-0.27222	0.60935	-0.45	0.6551
q3	1	-1.48757	0.75443	-1.97	0.0488
q4	1	-0.71562	0.65730	-1.09	0.2765
s1	1	1.90772	0.88412	2.16	0.0311
g1	1	2.04323	0.49839	4.10	<.0001
m	1	2.67056	0.72185	3.70	0.0002
l1	1	2.22451	0.57625	3.86	0.0001