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Price Dynamics and Spatial Market Structure for Three U.S. Southern Pine Timber Products

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PRICE DYNAMICS AND SPATIAL MARKET STRUCTURE FOR THREE U.S. SOUTHERN PINE TIMBER PRODUCTS

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ABSTRACT

Evidence of price correlations or cointegrations in timber markets is often interpreted as indicative of the competitiveness and efficiency of these markets. This conclusion is based on the assumptions that firms price F.O.B. and F.O.B. pricing in spatial markets is expected to yield results analogous to the usual competitive results in spaceless markets (i.e., firms set price equal marginal cost plus transportation costs). Competitive arbitrage is the error correction mechanism assumed through which spatial markets are linked. This conclusion could be misleading. In the presence of significant intra-regional transportation costs between spatially dispersed markets, firms have an incentive to exploit their spatial market power. Price correlations therefore may be consistent with other, non-competitive pricing schemes such as collusive basing point pricing. In this dissertation, we model the economic impacts of oligopsony in the procurement of timber in the presence of significant intra-regional transportation costs and test it on three forest products (Pine Saw Timber (PST), Pine Chip and Saw (CNS) and Pine Pulpwood (PPW)) for seven U.S. south-eastern and south-central states using quarterly data from 1976 to 2009. We find that the south-east south central market region is not a single market. However, there is evidence of market integration between 6 to 33 percent of the markets depending on the product, with the most integration occurring in higher valued product markets (PST) as predicted by our theory. Price discrimination was found in 19 to 24 percent of the markets while collusive basing point pricing exists in 13 to 18 percent of the markets. There is also evidence to support the hypothesis that interpreting price cointegrations in timber markets as market integration could be misleading

given evidence that 55 to 65 percent of basing point price regions also are cointegrated.

DEDICATION

To my sister Angelina Domakyaareh Mornah, who paved the way for me and made sure I was never wanting throughout my education even if that meant sacrificing her own comfort to make me comfortable.

To my brother Bernard Mornah who offered endless support and encouragement throughout this journey.

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LIST OF ABBREVIATIONS

PST	Pine Saw Timber
PPW	Pine Pulpwood
PCNS	Pine Chip and Saw
F.O.B.	Free On Board
WTO	World Trade Organization
GATT	General Agreement on Tariffs and Trade
NAFTA	North American Free Trade Agreement
TPO	Timber Product Output
BPP	Basing Point Pricing
MFC	Marginal Factor Cost
TMS	Timber Mart South

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CHAPTER I

INTRODUCTION AND BACKROUND

1.1 Introduction

Evidence of price correlations or cointegrations in timber markets is often interpreted as indicative of the competitiveness and efficiency of these markets. This conclusion is based on the assumptions that firms price F.O.B.[1] and F.O.B. pricing in spatial markets is expected to yield results analogous to the usual competitive results in spaceless competitive markets. This means that competitive arbitrage is assumed to be the mechanism through which spatial markets are linked. This conclusion could be misleading because we may observe price co-movements that are not consistent with competitive arbitrage yet wrongly interpreted as such by the methods we use.

In this dissertation, we model the economic impacts of oligopsony[2] in the procurement of timber products in the presence of significant intra-regional transportation costs. We test our model on three forest products (Pine Saw Timber (PST), Pine Chip and Saw (CNS) and Pine Pulpwood (PPW)) for seven U.S. south-eastern and south-central states (two regions per state) using quarterly data from 1976 to 2009. These three products, because of the significant

[1] F.O.B. stands for Free on Board or Freight on Board, which is the price charged when a product is loaded onto a transportation vehicle, after which stage the buyer is responsible for paying the cost of shipping.

[2] Oligopsony is a form of imperfect market competition characterized by a small number of buyers (but powerful) and a large number of sellers. Usually, oligopsony power exists in markets for primary products or intermediate inputs. The key characteristic of oligopsony is that the buyers recognize that their output and pricing decisions are interdependent.

differences in their prices, especially between PST and PPW, also allow us to verify other predictions of our model such as, higher valued products are expected to have more F.O.B. price relations than lesser valued products.

Specifically, we ask:

- Are timber markets for three timber products (PST, PPW and CNS) integrated for 7 southeastern and southcentral states in the U.S?
- What is the market structure and the pricing behavior that characterize the trajectory of observed prices in these products' markets?
- Can price cointegrations or correlations be interpreted as indicative of the degree of competitive market integration for these three products?

In our empirical analysis, we find, consistent with our theory, that in the presence of significant intra-regional transportation costs between spatially dispersed markets, firms have an incentive to exploit their spatial market power. Competition between spatial markets decreases as distance between the markets increases. At the same time, non-competitive pricing behaviors such as price discrimination increase with increasing distance between markets. There is also evidence of some form of collusive basing point pricing for all three products, with about 13 to 18 percent of markets for which the claim could not be rejected. We also find that between 55 to 65 percent of markets that support some form of basing point pricing also are cointegrated. In addition, in line with our theoretical model, we find that higher valued products have more competitively integrated markets than lower valued products. This is because higher valued products offer more opportunities for arbitrage profits than lower valued products.

There are several novel contributions in this dissertation which extend the spatial market literature in general and that on the timber industry in particular. It represents the first study to directly model and test the economic impacts of oligopsony in the procurement of forest products and for these geographic regions considered together. No study to our knowledge has focused on the south-east and south-central United States to ask the questions we intend to answer. This is especially so for CNS. These two regions represent by far the largest source of pine forest products in the United States. For instance, the states included in the study account for 75 percent of total southern timber output.[3]

We exploit, also, the richness of a multiproduct data set to draw more informed conclusions over and above that which would have pertained in a single product analysis. This allowed us to thresh out some possible inconsistencies or theoretical contradictions of conventional methods of determining spatial market integration in timber markets.

Finally, we use an updated data set covering periods when there were significant shocks to the market that could have affected its structure, conduct and performance over time. The last known study in this area used data ending in 1998. Since then, there have been many major market events in the sector. Examples of these shocks and changes include the U.S. – Canada Softwood Lumber Agreement of 2006, which started in 1982 as a dispute between the U.S. and Canada on subsidies for Canadian timber exports. Essentially, the dispute has manifested itself in limiting the amount of softwood lumber coming into the U.S. from Canada through a combination of trade restrictions in the form of trade quotas, tariffs and voluntary export restraints.[4] Softwood lumber imports from Canada have averaged over 90 percent of total softwood lumber imports since 1990. So a trade restriction is likely to have a significant effect on the market. Another shock covered by the data set used is that of the period of the worst natural disasters experienced in the industry in history - four hurricanes (Frances, Ivan, Katrina

[3] PST, PPW and CNS are all softwood products. The study states are AL, AR, FL, GA, LA, MS and SC.
[4] See Zhang (2007) and Reed (2001) for a detailed chronology of events regarding this dispute.

and Rita) all making landfall between 2004 and 2005 and destroying close to 6000 million cubic feet of timber of which 60 percent was softwood. The damage to softwood as a percentage of total timber damage is as high as 76 percent in some states. On average, 91 percent of the total timber damage from these four hurricanes occurred within the seven states being analyzed in this study. A number of structural changes have occurred within the industry vis-a-vis concentration and capacity utilization. Between 1976 and 2009, the number of saw mills in the south decreased by about 32 percent (from 122 to 83) while the total capacity increased by 22 percent (from 101,513 to 123,368 thousand cords) at the same time, thus indicating a higher degree of market concentration. This is even more pronounced in the study states, where the number of saw mills fell by 39 percent (98 to 60), while capacity increased by 28 percent (from 70,801 to 90,770 thousand cords).

This dissertation has important implications for public policy regarding the recent consolidations among the buyers of such (forest) products for the fates of the industry's suppliers and for the welfare of the consumers of final products. The recent wave of antitrust cases brought against buyers in the industry makes the study all the more important.

A few studies have examined the question of timber market integration in the United States and beyond. Nagubadi, Munn and Alireza (2001) examined the question of timber market integration for hardwood pulpwood, mixed hardwood sawtimber and oak sawtimber in six southern states for the period 1977 to 1997 using both bivariate and multivariate cointegration techniques. They find that the six states cannot be classified as a single market on the basis of their multivariate analysis. However, bivariate results provide support for market integration of pairs of markets for each of the three products. Using these results, the authors concluded that there was evidence to support the existence of three separate markets for hardwood pulpwood and two separate markets each for mixed hardwood and oak saw timber within the six-state region they examined. Using the same methodology, Niquidet and Manley (2008) assessed the extent of market integration of log prices for four regions in New Zealand using monthly price series from 1995 to 2006. They find evidence to support the hypothesis that export grades of logs displayed significant integration across regions and generally followed the law of one price. They, however, did not find evidence to support integration of domestic grades of logs that were supposed to be regionally segregated. Other studies using the same methodology to assess the extent of timber market integration include Daniels (2011), who used correlation analysis combined with cointegration analysis to examine the question of timber market integration for 62 western U.S. national forests using quarterly stumpage prices from 1984 to 2007. The author finds that prices from the Beaverhead-Deerlodge and Salmon-Challis Forests and the Kootenai and Idaho Panhandle Forests are linked and then concludes that "only these two sets of forests can be modeled as integrated stumpage markets". David (2000) tested the law of one price for five Canadian softwood lumber regional markets (Atlantic Canada, Quebec, Ontario, the Prairies and British Columbia) using quarterly data for the 1981 - 1997 period. They too did not find evidence of a single market for the five-region market but had evidence to support bivariate integration of market pairs.

While the law of one price or cointegration of prices may hold as a statistical concept, acceptance of it is not sufficient to conclude that markets are integrated since prices can be cointegrated for reasons other than competitive arbitrage. This limits the application of cointegration analysis alone to test for market integration, especially in spatial markets with significant intra-regional transportation costs.

Bingham et al. (2003) recognized this limitation and applied both bivariate cointegration analysis and multivariate regression analysis to re-examine the question of timber market integration for delivered southern pine logs and pine pulpwood in 21 Timber Mart South (TMS) price regions using quarterly price data from 1977 to 1998. They employed a two-step estimation procedure. The first step was to test for cointegration of price series between pairs of markets. They then ran a second-stage regression of the cointegration tests on factors that are hypothesized to influence timber market integration. They find that there was limited support for a single market for either product from their cointegration analysis for the whole market. However, a significant number of the markets were integrated in a bivariate sense. Based on these results and results from the second-stage regressions, they delineated the markets for the different products into integrated sub-markets.

While this approach is an improvement over the previous studies that relied only on correlations and cointegration analysis, it is still limited in a number of ways. First, by using the cointegration results to test factors determining market integration, the authors still assume that cointegrated markets are integrated markets. Therefore, factors that help explain a high degree of cointegration are interpreted as factors that explain market integration. However, other pricing schemes, such as collusive basing point pricing, which could yield the same cointegration results, will respond similarly to these hypothesized factors. As a result, the approach is still flawed in this respect. Secondly, the method is limited in that it does not allow for testing other spatial pricing schemes or behaviors.

The remainder of the dissertation is organized as follows: for the remainder of chapter I, we give a brief geographic and economic background for the timber industry. In Chapter II, we develop a theoretical model of timber procurement and pricing behaviors in spatial markets. Chapter III presents the empirical methods we employed to verify the predictions of our model and to answer some other questions asked in this dissertation. We then present the data and results in Chapter IV. Chapter V concludes with policy implications of this study.

1.2 Background of Timber Industry

Around 1630, when the first European immigrants arrived in North America, total forest land was estimated to be 1,037 million acres (Clawson 1979), which was about 46 percent of the total land area. This area has declined steadily, with most of the post-settlement loss occurring in the north and southern regions of the United States. For instance, forests occupied 72 percent of total land area in the north in 1630, but by 1907, forests covered only 32 percent of that area (Kellog 1909), rebounding to the current level of 42 percent as of 2007. For the southern region, forest area dropped from 66 percent in 1630 to 46 percent in 1907 and then to 40 percent in 2007. The total forest area of the United States today amounts to about 72 percent of the area it was in 1630. Clearing of forest land in the East between 1850 and 1900 averaged 13 square miles every day for 50 years; the period of greatest forest clearing in U.S. history. Not surprisingly, this period coincides with one of the most prolific periods of U.S. immigration. Since 1900, U.S. forest area has remained statistically within 745 million acres, +/-5 percent, with the lowest point in 1920 of 735 million acres (i.e. shortly before the great depression). U.S. forest area in 2000 was about 749 million acres, which is about six (6) percent of the world’s forest area and the fourth largest forest estate of any nation, exceeded only by the Russian Federation, Brazil and Canada.

For the last 100 years, forest cover has been relatively stable, following the period of heavy deforestation during the late 1800s. About 30 percent of the land is forested, and about two-thirds of the forests are classed as productive forests on which harvesting is not legally prohibited. Out of the total U.S. forest area, about 7 percent is reserved for non-timber uses and managed by public agencies as parks, wilderness preserves or similar areas. Federal lands comprise about one-third of the country's land area. The lobbying and advocacy activities of environmental groups resulted in a reduction in the contribution of U.S. federal lands to timber harvests to less than 6 percent, much less than 20 years ago. Private participation in forestry is high in the U.S. compared to most countries. Private lands supply 89 percent of the wood volume harvested in the United States.

Forests in the United States have developed in response to both changing human demands and changing climatic conditions. The different climatic conditions in the United States have led to the classification of forests by regions. There are four main ecoclimatic zones in the United States, namely polar, temperate humid, arid and tropical humid (Bailey 1996). By Bailey's classification, the south forest region[5] is predominantly in a subtropical humid climatic zone except for pocket areas in Kentucky, Tennessee (temperate humid) and South Florida (tropical humid) (Smith, et al. 2009). Because of the general climatic conditions of this region, forest is the natural vegetation. The southern forests account for 30 percent of the unresereved forest area of the United States and 27 percent of all forest land as of 2007. Oak pine mixtures are common in the western and northern fringes of the southern forest. Loblolly-shortleaf pine forests are the most prevalent, covering about 25percent of southern forests (Smith, et al. 2009).

Most forests in the United States are of natural origin, with the southern region having the largest percentage of planted forests (20 percent compared to 8 percent nationally). The United States is estimated to have one trillion cubic feet of timber, of which approximately 57 percent is softwood. Softwood growing stock is concentrated in the west, with the Pacific Coast alone

[5] The states that make the southern region by this classification are: AL, AR, FL,GA, KY, LA, MS, NC, SC, OK, TN, TX and VA.

accounting for 43 percent of the total and the south a little over 20 percent. When it comes to timber, the South is the largest timber producing region in the country, accounting for nearly 62 percent of all harvested U.S. timber. While significant, harvesting affects less than 3 percent of the South's forests annually. Timber harvesting impacts nearly 10 million acres in the United States per year, or about 1.3 percent of all forest land. But this rate is sustainable because of the increased number of planted forests.

1.3 Economic Importance of Timber: Production, Consumption and Trade.

According to Food and Agriculture Organization (FAO) estimates, the contribution of forestry to U.S. GDP has declined from 1.6 percent in 1990 to 1.3 percent in 2000, even though the country is the world's largest consumer and producer of forest products. Its share in world trade of forestry products is about 15 percent as of 2003. The value of solid wood shipments in 2000 was US$94 billion; the value of pulp and paper shipments was US$166 billion; and furniture manufacturers contributed another US$20 billion. U.S. per capita consumption of forest products is high, twice that of other developed countries and four times the world average, but this average has been declining steadily. While wood consumption increased by about 50 percent between 1965 and 1999, per capita consumption of most of these products has been falling. Domestic forests supply much of the demand. In terms of employment, the forestry sector accounts for about 8.5 percent of all U.S. manufacturing jobs.

Domestic production of industrial roundwood hovered around the 15,500 cubic feet mark between 1990 and 2005, until declining to 14493 cubic feet in 2008, - a 20 percent decrease between 1990 and 2008. The same story can be told of the softwood category of industrial roundwood production, which has averaged about 10100 cubic feet until 2008, when the figure was about 8389 cubic feet - a 24 percent decrease.

Table 1 displays percentages of total “Growing timber stock”, “Saw timber” and “Timber removals” accounted for by each region in the country for 2007.

Table 1: Timber Volume, Growth and Removal by Species Group and Region 2007

Region	Growing stock			Sawtimber			Timber removals		
	All	Soft wood	Hard wood	All	Soft wood	Hard wood	All	Soft wood	Hard wood
North	27	11	48	26	11	46	18	7	38
South	31	22	42	32	22	44	62	64	60
Rocky Mount.	15	24	3	16	26	3	3	5	0
Pacific Coast	28	43	7	26	42	6	16	24	2
Total	100	100	100	100	100	100	100	100	100

Computed from U.S. Forest Service, "RPA Assessment Tables," 2007

Table 1 shows that the southern region has the largest growing stock of all species (31 percent) and contributes about 62 percent to all timber removals in the country. When it comes to softwood, the Pacific Coast is dominant in growing stock (43 percent) and the South places third, yet the South contributes 64 percent to total softwood removals, compared to 24 percent from the Pacific Coast. In terms of hardwood, the north has the most growing stock (48 percent) and contributes 38 percent to hardwood timber removals, compared to the South which accounts for 42 percent of hardwood growing stock and contributes 60 percent to total timber removals for the year in review.

On sawtimber, the south is the largest contributor for all species combined, accounting for 32 percent of the total. However, it is second to the North in hardwood, with 44 percent compared to the North's 46 percent, and third (22 percent) in softwood after the Pacific Coast (42 percent) and Rocky Mountains (26 percent). The foregoing analysis indicates that trade intensity[6] is higher in the south for all species combined as well as for both softwood and hardwood considered separately.

Imports of industrial round wood have increased steadily, on average, peaking at 5805 cubic feet in 2004, until declining to 3065 cubic feet in 2008. This represents a reduction of about 47 percent between the 2004 peak and 2008. Canada is the largest trading partner of the United States when it comes to timber imports. As can be seen from Table 10 (in appendix C), both lumber and log imports from Canada have averaged over 94 percent of total imports between 1990 and 2000 and 88 percent between 2001 and 2007. Lumber imports are largely made up of softwood species. The share of softwood lumber in total imports has averaged over 97 percent between 1990 and 2007. For logs, the percentage of softwood in total log imports has increased steadily from 56 percent in 1990 to 91 percent by 2007. With the southern region contributing close to two-thirds of total softwood removals in the United States in 2007, it is the region that will tend to be affected the most by imports of softwood products and any policy changes that affect trade in softwood products.

The United States does not export much of its timber products. Most of it is processed locally. Exports of industrial roundwood have decreased steadily from 2307 cubic feet in 1990 to 1517 cubic feet in 2008, representing a 34 percent fall over that period. The lowest export figure occurred in 2007. Between 1990 and 1997, Japan was the largest importer of U.S. timber products. Exports to Japan of lumber constituted 30 percent of total U.S. exports, with Canada

[6] Trade intensity is defined to mean timber removals as a percentage of growing stock.

taking 20 percent between 1990 and 1997. However, in recent times, Canada has become the most important destination for U.S. lumber exports. Lumber exports to Canada have averaged 28 percent between 1998 and 2003, before falling to 12 percent in 2004, and then rising back to the 28 percent average. Japan's share of U.S. lumber exports has fallen steadily, to 4 percent as of 2008.

In terms of logs, Japan has been the United States' main trading partner, with an average share of 69 percent between 1990 and 2000, even though this share has fallen to 45 percent. Log exports to Canada have increased from 9 percent in 1990 to about 50 percent in 2007. Japan and Canada still account for over 90 percent of U.S. exports of logs.

U.S. consumption of industrial roundwood increased on average from 16361 cubic feet in 1990, to a peak of 19622 cubic feet in 2005, before decreasing steadily to 14041 cubic feet in 2008. Much of this variation is explained by trends in the softwood category, which rose and fell, peaked and bottomed out in line with total industrial roundwood consumption. The changes in hardwood consumption are less dramatic. Per capita consumption of industrial roundwood rose by 64 cubic feet between 1990 and 2002 until falling steadily from 2003 to 2008 to an average of 41cubic feet – a decline of about 37 percent from the previous average. This trend mirrors trends in the strength of the U.S. economy.

1.4 Timber Industry in the South: Production and Use

Industrial Timber Products Output (TPO) of roundwood for the Southern region decreased by 5 percent between 2005 and 2007. This resulted from a decline in output of softwood roundwood products of 5 percent (or by 302 million cubic feet to 6.09 billion cubic feet), and a 7 percent decline in output of hardwood roundwood products (by 150 million cubic feet to 2.13 billion cubic feet). In 2007, saw logs and pulpwood roundwood products alone accounted for 85 percent of the South's total industrial roundwood output.

Of the 13 southern states, Georgia led in total roundwood output with 1.25 billion cubic feet, followed by Alabama with 1.12 billion cubic feet. The two states combined accounted for 28 percent of the South's total production. Mississippi, Louisiana, and North Carolina followed with 908, 834, and 783 million cubic feet, respectively. Saw-logs account for about 42 percent of the South's roundwood total output. However, saw-log production has seen a decline of 11 percent between 2005 and 2007 (from 3.89 billion cubic feet in 2005 to 3.45 billion cubic in 2007). Softwood saw-log output declined even more (by 13 percent to 2.52 billion cubic feet)

Total receipts at southern mills, which included roundwood harvested and retained in the South and roundwood imported from other regions, declined by 5 percent to 8.26 billion cubic feet in 2007. The number of primary roundwood using plants in the South was down from 2,028 in 2005 to 1,882 in 2007. Between 2005 and 2007, the number of sawmills in the South declined by 129 mills (from 1,669 sawmills to 1,540). This consolidation could be due to mergers (in which case processing capacity will not be affected much) or to business failures and plant closings. The total number of sawmills does not include a number of one-man sawmills in the Southern Region. Of the 1,540 sawmills operating, 429 were classified as softwood sawmills, 1,009 were classified as hardwood sawmills, and the remaining 102 were classified as softwood/hardwood sawmills (Johnson, Bentley and Howell 2009). At the mills, total saw-log receipts dropped by 474 million cubic feet to 3.45 billion cubic feet. Softwood saw-log receipts declined 14 percent to 2.54 billion cubic feet; hardwood saw-log receipts were down from 996 to 916 million cubic feet. Of the operating mills in 2007, 23 percent of them received 85 percent of total saw-log receipts in the region.

Pulpwood production, including chipped roundwood, accounted for 43 percent of the South's roundwood TPO. Between 2005 and 2007, the total amount increased by 3 percent to 3.55 billion cubic feet and softwood output was up 6 percent to 2.45 billion cubic. Hardwood output declined to 1.10 billion cubic feet, representing a 4 percent decrease. Georgia led the 13 Southern states in total pulpwood production, with 611 million cubic feet. Alabama followed closely with 574 million cubic feet. These two states accounted for 33 percent of the Southern pulpwood production

Eighty-seven pulpmill facilities were operating and receiving roundwood in the South in 2007, the same as in 2005. Of the 87 pulpmills operating, 56 were classified as softwood pulpmills, 23 were classified as hardwood pulpmills, and the remaining nine were classified as softwood/ hardwood pulpmills. Total pulpwood receipts for these mills increased by 114 million cubic feet to 3.58 billion cubic feet, accounting for 43 percent of total receipts for all mills (Johnson, Bentley and Howell 2009). This goes to demonstrate the increased level of concentration in the industry within this time period. Thinking ahead, it should not be surprising that firms, with the increased market domination will engage in some non-competitive pricing behaviors.

1.5 Exogenous Shocks: Effects of Natural Disasters/Hurricanes

Natural disasters, especially hurricanes, have also had major effects on the timber industry. Table 11 (in appendix C) reports information on six severe hurricanes that made landfall in the United States over the past four decades. Between 1969 and 2005, there have been six major hurricanes which have affected six states the most. These states are all in the south (AL, SC, MS, FL, TX, and LA). Total estimated damage from these hurricanes is about 6000 million cubic feet, of which over 60 percent is softwood damage. Mississippi suffered the greatest total damage from all of these hurricanes, closely followed by South Carolina and Alabama. The damage to softwood as a percentage of total timber damage ranges between 53 and 76 percent of the total. With the exception of Texas (which is not in the study sample), almost all of the states that were severely hit by these hurricanes are being examined in this dissertation. Even if Texas were included, except for Hurricane Rita, (2005), all other hurricanes had minimal to no effect on timber in that region.

On average, 91 percent of the total timber damage from these six hurricanes occurred within the seven states being analyzed in this study.

1.7 U.S. – Canada Softwood Lumber Agreement

Trade agreements may affect the incentives available for international arbitrage in commodities. This in turn will affect the structure of the market being considered, especially if there is substantial trade between the countries in that commodity. The United States has entered into several trade agreements with some other nations under the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO). Others have been bilateral or multilateral, such as the North American Free Trade Area (NAFTA) and the Canada-United States free trade agreement. One such agreement which directly affects the U.S. softwood timber industry is the U.S. – Canada Softwood lumber agreement.

The United States and Canada have been in dispute for over two decades regarding bilateral trade in softwood lumber (Zhang 2007, Reed 2001). The U.S. claims that the Canadian lumber industry has been unfairly subsidized by the Canadian government. This claim stems from the fact that, in Canada, most timberland is publicly owned and stumpage prices are set administratively by the government at levels less than competitive prices. In the United States, on the other hand, most timberlands are privately owned and stumpage prices are auctioned competitively. The United States claims that the provision of government timber at below market prices constitutes an unfair subsidy, but the Canadian government disputes this claim. Under U.S. trade remedy laws, foreign goods benefiting from subsidies can be subject to a countervailing duty tariff to offset the subsidy and bring the price of the product back up to market rates.

Since 1982, there have been four major iterations of the dispute, the most recent agreement coming in 2006 after Canada refused to renew the 1996 agreement when it expired in 2001. However, the basic thing running through all of the iterations is that they all have sought to limit the amount of softwood lumber that comes into the United States from Canada using various forms of trade instruments, such as import and export tariffs, quotas and even voluntary export restraints to offset the subsidies received. With trade limited between these two regions as a result of this dispute, it is natural for one to expect changes in the market and the behavior of firms therein.

1.8 Summary

This introductory chapter presents the research problem(s) of this dissertation. We showed how the current study extends the literature on industrial organization and that of spatial timber markets in particular. Specifically, the study represents the first to directly model oligopsony behavior in the procurement of timber products and tests it on three forest products. It is argued that, price co-movements alone do not give unequivocal results as to the structure, conduct and performance in spatial markets. We use an updated data set capturing several shocks such as hurricanes, international trade agreements and consolidations that have directly affected the industry in this period. The last but not the least, we presented a brief overview of the timber industry in the United States and that of the South in particular. Forest area in the U.S. is now about 72 percent the area it was in 1630 and most forest lands are privately owned. The main trading partners with the U.S. in forest products are Canada, Japan and China.

CHAPTER II

THEORETICAL MODEL

2.1 Introduction and Theoretical Review of Spatial Market Integration

Spatial price behaviors in commodity markets convey important information about market structure, conduct and performance. In well-functioning spaceless competitive markets, changes in prices accurately and quickly reflect changes in demand and supply conditions. However only when spatial markets are integrated competitively will changes in prices convey information about changes in market (demand and supply) conditions. If markets are not competitively integrated, the price system will convey inaccurate information that will distort producer and consumer decision-making, thus leading to an inefficient allocation of resources.

To motivate the theoretical analysis, we start with a conventional definition of market integration and assess its implications for spatial market integration. According to Tomek and Robinson (1981), if two regions trade with each other, then prices in the regions for the same product will differ only by transportation costs. If the regions do not trade the product with one another, then price differences should be less than or equal to transportation costs.[7] If the price difference were greater than transportation cost, it would have elicited trade between the regions due to unexploited opportunities for arbitrage profits. Similarly, Goodwin and Schroeder (1991) say that if price changes in one market are fully reflected in alternative markets, then these

[7] Tomek and Robinson's evaluation of market integration is just another way of stating the law of one price, which says that in an efficient market, identical goods will sell at the same price net of transportation and transaction costs.

markets are said to be spatially integrated. Many past studies have adopted this definition and by extension the implicit assumptions that underlie it to test spatial market integration.

The definition assumes that price co-movement or cointegration in spatial markets is due to competitive arbitrage (trade). But competitive arbitrage implies non-discriminatory pricing. This is so because with competitive arbitrage, the price of the product is determined in a region's central market and arbitrageurs take the price as given and move the product where they believe they can make profit after transport cost. According to Scherer and Ross (1990), in spatial markets, non-discriminatory pricing is consistent only with F.O.B. pricing.[8] Therefore, according to the standard definition of market integration, F.O.B. pricing in spatial markets will yield results analogous to the usual familiar allocative efficiency results of spaceless competitive markets for a homogenous product differentiated only by location. In other words, firms price by equating price to marginal production cost plus actual transportation costs.

To get results in spatial markets that are analogous to the familiar allocative efficient results in spaceless competitive markets, the definition also implicitly presumes that all buyers and sellers are located at discrete points and that there are no intra-regional transportation costs (Takayama and Judge 1971). However, in the presence of significant intra-regional transportation costs, extending the results of the spaceless competitive market structure to geographically distinct markets may be mistaken because firms face a different profit-maximizing calculus. In reality, spatial markets endow firms differentiated by their geographic locations with market power (Stigler, 1949). According to McChesney and Shughart (2007), for a firm to set price as equal to marginal cost at the mill plus transportation costs as suggested by the standard theory of F.O.B. may be inconsistent with rational-profit-maximization. McChesney

[8] Specifically, they say, F.O.B. pricing "is the only pricing scheme that entails no geographic price discrimination, since the price paid by the buyers increases in direct relation to the shipping costs, while the seller receives a uniform net price after freight expenses are covered" Scherer and Ross (1990, p. 502).

and Shughart (2007) also noted that "… even if spatially dispersed firms price F.O.B. as the accepted theory suggests, … the prices that spatially dispersed, profit-maximizing firms actually charge might well be influenced by the potential competition each faces at the market boundary." This is especially true for bulky products like timber whose value relative to the cost of transportation is low. With high transportation costs relative to product value, the extent of spatial market integration as suggested by the standard definition of integration will be limited by distance (Murray & Wear 1998; Mulligan & Fik 1988). This means that the application of classical competitive theory to explain price integration in imperfect markets (such as spatial markets) may not square with the holy grail of profit maximization in economics and the realities of the business world.

Even though F.O.B. pricing (as suggested by the standard definition of integration), is a possible explanation for market integration and the most efficient pricing scheme in spatial markets,[9] it may not be the only reason underlying price comovements in spatial markets, especially given that firms may want to exploit their spatial market power.

An alternative explanation for spatial price cointegration therefore follows from the oligopolistic or collusive behavior of firms. Oligopolies or oligopsonies may, through explicit or tacit collusion, compete only within some defined geographic areas (Faminow & Benson 1990). Firms may adopt a limit-entry pricing scheme whereby each firm quotes a price to customers based on the price it thinks its nearest rival will charge given the rival's cost of shipping the product to the customer. Limit-entry pricing is consistent with a basing-point pricing system – a type of delivered pricing system in which price quotes are calculated using geographic locations

[9] It is efficient because F.O.B. pricing assumes that the markets clear or the prices move together because of arbitrage. Therefore, the product is moved from the low price (less valued area) to the high price (more valued area). Integration due to F.O.B. is integration emanating from arbitrage and thus involves physical movement of the product between markets.

other than the commodity's actual point of manufacture (Shughart 1997). For example, in an analysis of school milk procurement data for Ohio, Porta & Zona (1999) found that some firms colluded to artificially raise bids for defined territorial areas leading to a 6.5% increase in prices. The nature of basing-point pricing allows prices in all markets to be perfectly linked (in the case of complete basing point or perfect basing point pricing), thus, suggesting that in line with the standard theory the market structure is competitively integrated, when actually it may not.[10]

Limit-entry pricing may, under some plausible conditions, be pro-competitive. One case in point is where firms discriminate to capture customers instead of to collude against them. In other words, if firms compete only for customers further away and into the territory of another by absorbing frieght charges, i.e., charge prices to distant customers lower than the prices charged to nearer customers - a form of discrimination, then limit entry pricing may be pro-competitive.

In general, products with high value relative to transportation costs will be expected to lend themselves more to arbitrage and F.O.B. than products with low value relative to transportation costs, especially if we observe high price volatility between regions. This is so because for high-value products, more opportunities for profitable arbitrage emerge with price changes. For example, assume that gold and timber are two products traded between Mississippi and Virginia. Also assume that the cost of transporting the two goods between regions is the same. If the price of gold is a lot higher than the price of timber, then a 1 percent increase in the prices of both gold and timber in, say, Mississippi will cause more gold to be moved from Virginia to Mississippi than we will observe of timber moving from Virginia to Mississippi. In fact timber may not be moved at all if the price change does not exceed the cost of

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[10] Integration due to basing point pricing does not involve physical product movement. This implies that observed price co-movements in the system are not reflective of underlying market conditions.

transportation. In this case, observed price co-movements in timber may be explained by other forms of pricing schemes, such as collusive basing point pricing.

2.2 Model: Spatial Pricing Behavior in Timber Markets

In what follows, we extend the analyses thus far on spatial market structure within an oligopoly setting to the case of oligopsony with a model assuming significant intraregional transportation costs, as is the case with most timber products. The spatial pricing models considered are F.O.B. pricing, price discrimination and basing point pricing (BPP).

2.2.1 F.O.B. Pricing

Mill (F.O.B.) pricing within an oligopsony setting dictates that each buying firm offers a mill price $P_{T,}$ at the factory gate/buying site and sellers are responsible for paying shipping costs from their specific locations to the buyer's mill. If the buyer is to be responsible for shipping costs, then sellers will receive the mill price less actual shipping costs from seller’s site to buyer’s site. The implication is that a seller nearer the factory gate receives a higher net price than a seller further away from the factory gate, assuming identical cost structures (both transportation and processing).

In this chapter, we follow the lead of Faminow and Benson (1990) and develop an *oligopsony* model of pricing behavior in spatial markets. To do this, we make several assumptions about the nature of the supply function facing buyers and the production technology by which inputs are converted into finished goods. The critical and distinguishing assumption of Faminow and Benson's *oligopoly* model is that intraregional transportation costs are significant. According to them, previous studies assumed away intraregional transportation costs when examining spatial market integration (competition). Since the timber industry is more likely to lend itself to significant intraregional transportation costs owing to the bulkiness of the product, we find their specification quite appropriate for the present analysis.

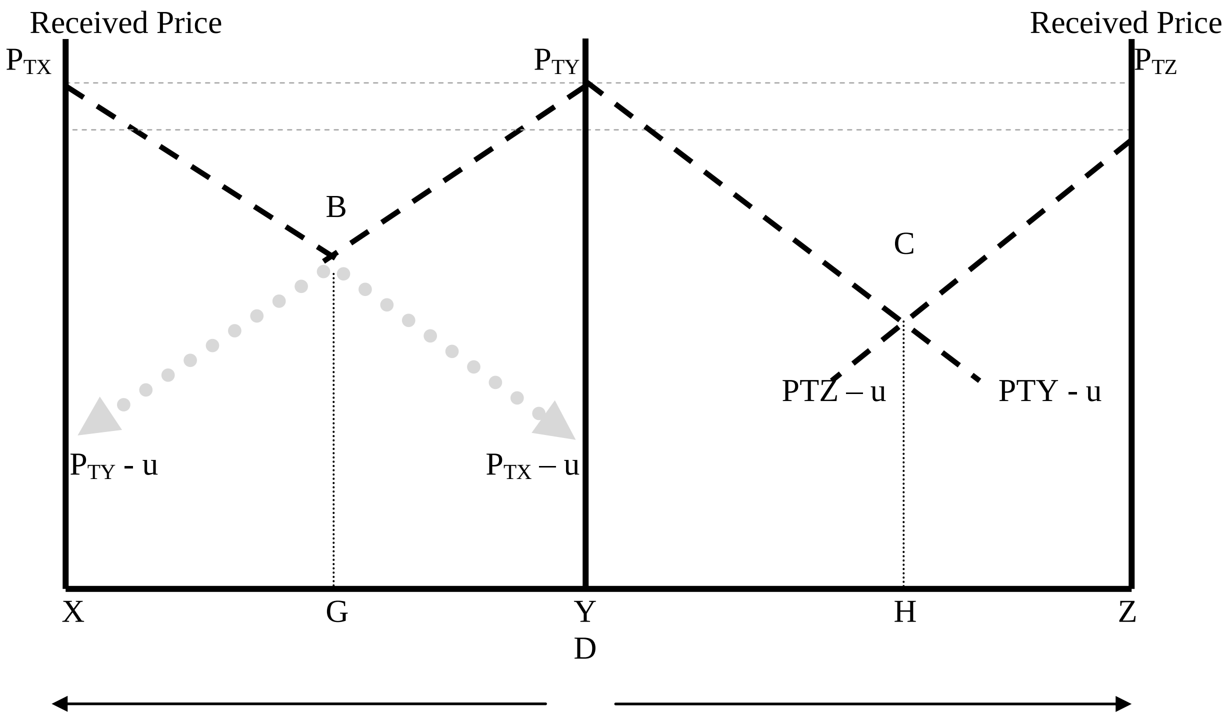

Figure 1: Oligopsony F.O.B. Pricing

Assume that there are three spatially distributed firms X, Y and Z that buy and process timber. Timber sellers are located uniformly and continuously over the linear distance D as shown in Figure 1., where P_{Tx}, P_{Ty} and P_{Tz} are mill prices offered by firms X, Y and Z and *u* is transportation cost measured in units per distance. A seller will ship timber to whatever buyer offers a higher purchase price net of transportation costs. Given constant transportation costs per unit distance and identical production functions for the buyers, the seller will ship its product(s) to the closest buyer under a system of F.O.B. pricing because that is what going to give the seller the highest price net of transportation (assuming that the seller is responsible for the cost of transportation).

However, for our analysis, we do not assume that the buying firms have identical cost structures. This means that the seller does not necessarily ship to the closest buyer. In this way, we allow some firms to enjoy larger market shares either because of cost advantages or locational advantages. For instance, in Figure 1, firms X and Y have identical marginal costs and they have lower costs of production than firm Z.[11] As a result firms X and Y offer higher mill prices to their sellers than firm Z offers. This means that timber sellers on the horizon YZ (D minus Y) do not necessarily sell to the closest firm but rather to the firm that offers a higher net price. A seller close to Z may for example, offer to sell to Y if the cost of shipping to Y is less than the price difference between P_{TY} and $P_{TZ.}$

In terms of location, firm Y has an advantage over firms X and Z because it is located at the center of the uniformly distributed supplier stream.[12] Firm Y can be a market leader based on its costs and service area – the service area being a proxy for size.

Further assume for the current analysis that timber processing firms (buyers) are competitors in the output (finished product) market and thus take the price of the finished product (P) as given. This assumption simplifies the analysis and enables us to focus on the input market and its price dynamics. Even though this second assumption is a simplifying one, in the case of timber products it is also realistic because the final good market can be said to be at least national if not international in scope and served by many different firms. In that sense, the firms are more likely to be price takers in the final product market. This is particularly true for high valued products relative to transportation costs because a small percentage change in product value translates into higher absolute values thus eliciting arbitrage activity.

[11] This is depicted by the different vertical intercepts for their respective net price schedules (P_{Ti} - u). Buyers X and Y are able to offer higher prices because they have lower production costs.
[12] This locational advantage holds only if sellers are uniformly distributed along D with the market space bounded to the left of X and the right of Z.

General form of model

Let sellers have an identical input supply function of the form

$$q_{Ti}\left(u, P_{Ti}\right) = \bar{P}_{Ti} \quad (1)$$

where P_{Ti} = the F.O.B. mill price of timber offered by firm i, $\bar{P}_T = \bar{P}_T\left(u, P_{Ti}\right)$ is the price of timber received by the seller after netting transportation costs from the mill price, and u is as defined earlier. The aggregate supply facing firm *i* over its economic (market) space will be

$$Q_{Ti} = \int_k^l q_{Ti}(P_{Ti,} u)du \quad (2)$$

with the limits of integration, k *to* l, representing the boundaries of the firm and its competitors. A firm, *i* (buyer of timber), converts the timber inputs (Q_{Ti}) into finished product *(Q_i)* by the following fixed-proportions production technology

$$Q_i = min\left\{\frac{Q_{Ti}(P_{Ti})}{\varphi}, k\left(M\right), F_i\right\} \quad (3)$$

and with cost function,

$$C(Q_i) = P_{Ti}.Q_{Ti}(P_{Ti}) + c\left(Q_{Ti}(P_{Ti})\right) + F_i, \quad (4)$$

where M = vector of all processing inputs other than timber, F = fixed costs, $\varphi =$ the fixed conversion factor between the raw timber input and the finished product and $c(Q_{Ti}) =$ processing cost of inputs associated with input vector M.

Let i and j be the only two firms in the market and D be the distance between them. The market boundary, say G_i, between these two firms will be defined by

$$\bar{P}_{Ti}(P_{Ti}, G_i) = \bar{P}_{Tj}(P_{Tj}, (D - G_i)) \quad (5)$$

The profit function for firm i will be given by

$$\pi_i = P.Q_i(P_{Ti}) - \left\{P_{Ti}.Q_{Ti}(P_{Ti}) + c\left(Q_{Ti}(P_{Ti})\right) + F_i\right\}$$

where P = price of the finished good.

If we assume that $\varphi = 1$ in equation (3), and $c\left(Q_{Ti}(P_{Ti})\right) = cQ_{Ti}$, in (4) then

$$Q_i = Q_{Ti} \tag{3'}$$

and[13]

$$C(Q_i) = P_{Ti}.Q_{Ti}(P_{Ti}) + cQ_{Ti} + F_i\,. \tag{4'}$$

Substituting $(1')$ and $(4')$ into the profit function and maximizing with respect to Q_{Ti}, we have

$$\left(P - c\right) = P_{Ti} + P'_{Ti}.Q_{Ti}(P_{Ti})\,. \tag{6}$$

The left-hand side of equation (6) is the marginal revenue product (MRP) of employing additional timber and the right-hand side is the marginal factor cost (MFC) of an additional unit of timber.[14] Since Q_{Ti} is evaluated over market boundaries (distance), then the price that the firm pays to sellers will be a function of these boundaries. Larger market boundaries imply the firm servicing a wider geographic area. This is similar to saying the limits of the markets are wide, thus, sellers further away to the limit will receive much lower net prices under an F.O.B. pricing scheme.

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[13] Equation (3') depicts a constant returns to scale production function such that every unit of the input q_{Ti} yields one unit of the output $Q_i = Q_{Ti}$

[14] The marginal factor cost has two components: P_{Ti} is the price paid to the input supplier and $P'_{Ti}.Q_{Ti}$ is the additional cost incurred on all quantities that were previously being purchased as a result of the change in input prices due to the change in the amount of the input now being employed.

Illustrative Example

Assume the following specific timber supply function facing the firm at each selling point in the market

$$\bar{P}_{Ti} = \frac{b}{v} q_{Ti}^{v}, \tag{7}$$

where

$$\bar{P}_{Ti} = P_{Ti} - u$$

and u, $\bar{P}_{Ti}$ and q_{Ti} are as defined earlier; b *and* v are positive parameters.[15]

Substituting $\bar{P}_{Ti} = P_{Ti} - u$ into (7) and solving for q_{Ti}, we have

$$q_{Ti} = \frac{v}{b}(P_{Ti} - u)^{1/v} \tag{8}$$

Given equation (8), the market supply of timber facing buyer i is given by

$$Q_{Ti} = \int_{k}^{l} \left[\frac{v}{b}(P_{Ti} - u)\right]^{1/v} du = \left\{ -\frac{b}{v+1}\left[\frac{v}{b}\left(P_{Ti} - u\right)\right]^{\frac{v+1}{v}} \right\}_{k}^{l}. \tag{9}$$

When $i = X$, as in Figure 1,

$$Q_{TX} = \frac{b}{v+1}\left\{ \left[\frac{v}{b}\left(P_{TX}\right)\right]^{\frac{v+1}{v}} - \left[\frac{v}{b}\left(P_{TX} - G\right)\right]^{\frac{v+1}{v}} \right\} \tag{10}$$

The profit function and first-order condition for firm X are given below

$$\pi_X = \left(P - P_{TX}\right)\left[\frac{b}{v+1}\left\{ \left[\frac{v}{b}\left(P_{TX}\right)\right]^{\frac{v+1}{v}} - \left[\frac{v}{b}\left(P_{TX} - G\right)\right]^{\frac{v+1}{v}} \right\} \right] - F_i \tag{11}$$

[15] Theoretically, v can be negative but it will imply a negatively sloped (backward bending) supply curve.

$$\frac{d\pi_X}{dP_{TX}} = \frac{b}{v+1}\left(P-P_{TX}\right)\left\{\frac{1}{v}\left[\left[\frac{v}{b}\left(P_{TX}\right)\right]^{\frac{1}{v}} - \left[\frac{v}{b}\left(P_{TX}-G\right)\right]^{\frac{1}{v}}\left\{1-\frac{dG}{dP_{TX}}\right\}\right]\right\}$$
$$-\frac{b}{v+1}\left\{\left[\frac{v}{b}\left(P_{TX}\right)\right]^{\frac{v+1}{v}} - \left[\frac{v}{b}\left(P_{TX}-G\right)\right]^{\frac{v+1}{v}}\right\}. \quad (12)$$

The term $\frac{dG}{dP_{TX}}$ characterizes oligopsonistic interdependence. To be able to solve (12), we need to find the boundary conjecture for $X = \frac{dG}{dP_{TX}}$. Consider locations between X and Y. The boundary G is defined by the equalization of net prices offered to sellers. This means from Figure 1 that

$$P_{TX} - u_X = P_{TY} - u_Y \text{ at G,} \quad (13)$$

where

$$u_X = G, \text{and } u_Y = D - G \quad (14)$$

Therefore,

$$P_{TX} - G = P_{TY} - (D - G)$$

Solving for G from (14) and differentiating with respect to price, we have

$$\frac{dG}{dP_{TX}} = \frac{1}{2}\left(1 - \frac{dP_{TY}}{dP_{TX}}\right). \quad (15)$$

The boundary conjecture $\frac{dG}{dP_{TX}}$ is thus dependent on X's expectations of Y's reaction to changes in the price X offers to sellers. Therefore, the price set by X depends on the parameters of the model, its own boundary and the global boundary condition. Formally, we can write firm X's price reaction function as

$$P_{TX} = (b, v, mfc, G, \frac{dG}{dP_{TX}}) \quad (16)$$

By assuming specific parameter values, we will be able to solve (16). We can derive results for firms Y and Z similarly (see appendix A).

Comparative Statics

A change in the price X offers to its sellers will most likely ripple through the whole market as firms Y and Z respond according to their reaction functions given by (22) and (23) (see appendix A). See Figure 2, for instance. If firm X increases its price to P'_{TX} (for any reason ranging from lower processing costs to other supply or demand shocks), it will cause firm X's market area to expand from G to G' and Y's market area to shrink by G' - G. Firm Y, noticing this, may react to firm X's price increase by increasing its price, too.

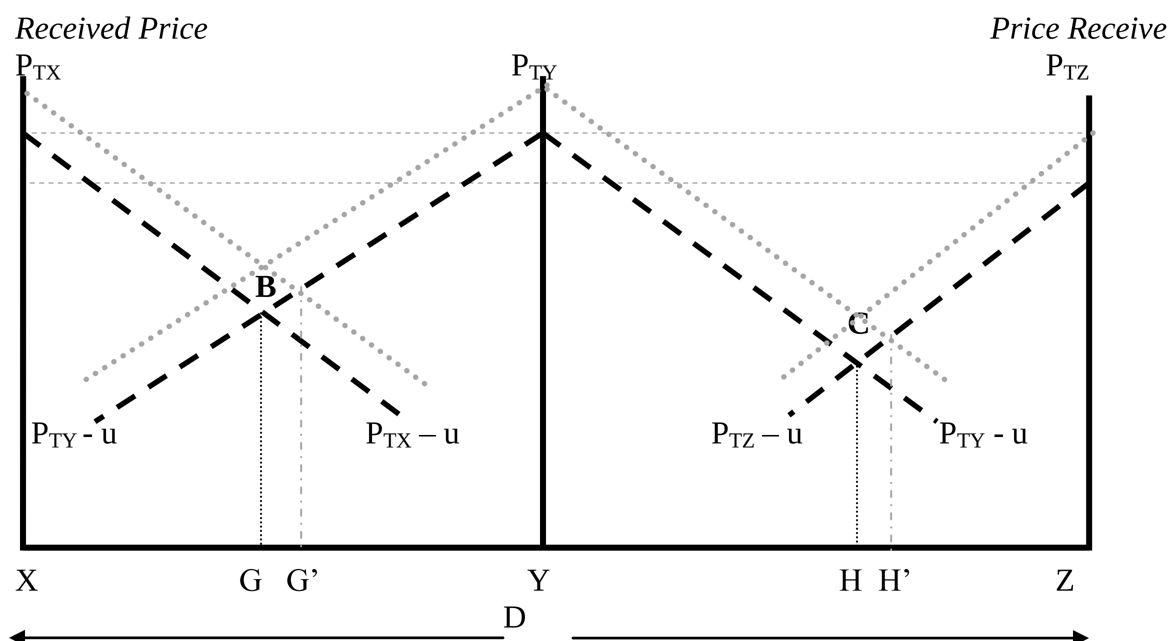

Figure 2: Oligopsony F.O.B. pricing: Comparative Statics

Figure 2 is drawn in such a way that firm Y matches X's price increase in order to recapture its lost market area. As firm Y tries to recapture its lost suppliers by increasing P_{TY}, it expands its market space by H' - H at the expense of Z. Firm Z may also respond by increasing price. This process may lead to further reactions from X, Y and Z and the full adjustment may take time to reach a new equilibrium. This means that irrespective of the cause of the initial price increase by X, prices in all the other markets tend to be affected by it. This puts X, Y and Z in the same market. However, it may be the case that firm Y does not match the increase in X's price. It could offer to pay either less or more, bearing in mind that whatever action it takes will prompt firm Z to react.

The cost to reacting and reclaiming one's lost market area under oligopsony is the increased expenditure on inputs in the previously lost market area and any other market area that was controlled by the firm but not affected by X's initial actions. For instance, if Y does match X's price, it increases expenditure on its inputs in line with the increase in price not only in the market space it shares with X but also in the market space it shares with Z (assuming that Z matches Y's price). So, if firm Y realizes that the increased cost of reclaiming the lost market area is greater than the benefit in terms of the value of reduced output resulting from the purchase of fewer inputs, it may react less or not react at all, thus acting as a buffer between itself and the next firm, Z. The larger the number of intermediate buying firms between two buying sites, the weaker will be the price reactionary effects because some firms may respond to a lesser degree, thus moderating the initial price effect. It is also worth noting that even after the adjustment is fully complete, the net prices need not be equal across space or differ exactly by transportation costs despite the interdependence of the prices in the different markets. Arbitrage guarantees only that prices do not differ by more than transportation costs but, indeed, can differ by less than transportation costs (Tomek and Robinson 1981).

Empirically, if the predictions of competitive F.O.B. hold, price changes in, say, region X will net out and exactly match price changes in the other regions in a dynamic fashion in the long run. But as explained earlier, because of market power, firms in economic space have reason to behave differently from what is expected of them under F.O.B. pricing. We next consider spatial price discrimination as a possible explanation for observed prices in timber markets.

2.2.2 Spatial Price Discrimination

For a firm to be able to price discriminate in an oligopsony setting, it must have market power, be able to segregate its supplier base into submarkets corresponding to supply elasticities and be able to prevent arbitrage. Spatial markets by their very nature offer firms some degree of market power within their geographical territories. This allows them to discriminate based on the locations of their suppliers[16] and, under some conditions, to make arbitrage unprofitable. This ability to discriminate is even more evident in markets for bulky products like timber, as observed by Scherer and Ross (1990, p. 504) - "When producers are located at different points on a map, their products are said to be spatially differentiated. When in addition transport costs are significant in relation to total product value, as in steel, cement ... and many other commodities, pricing practices often entail significant elements of discrimination".

Following from our work on F.O.B. pricing above, we will consider a simple model of oligopsonistic price discrimination. A spatial oligopsonist that wants to discriminate will set price ($\bar{P}_T^u$) for a seller located at distance u from its factory gate by equating the marginal revenue product (MRP) to the marginal factor cost (MFC) at that point. By replacing P_{Ti} with $\bar{P}_T^u$ in (6) and then rearranging, we have

$$\left(P - c\right) = \bar{P}_T^u \left[1 + \frac{1}{\varepsilon_T^s}\right], \qquad (24)$$

where $\varepsilon_T^s = Q_T^{'}\left(\bar{P}_T^u\right).\dfrac{\bar{P}_T^u}{Q_T}$ = input supply price elasticity. Now rewrite equation (7) as (i.e., replace $\bar{P}_{Ti}$ with $\bar{P}_T^u$)

$$\bar{P}_T^u = \frac{b}{v} Q_T^v \qquad (7')$$

and then differentiate with respect to $Q_{T.}$ This gives

[16] We assume that the firm knows the locations of all its suppliers.

$$\frac{d\bar{P}_T^u(Q_T)}{dQ_T} = \bar{P}_T^u{}'(Q_T) = bQ_T^{v-1}$$

We can then write ε_T^s as,

$$\varepsilon_T^s = \left[bQ_T^{v-1} . \frac{Q_T^v}{\bar{P}_T^u} \right]^{-1} = \left[\frac{bQ_T^v}{\bar{P}_T^u} \right]^{-1} = \frac{\bar{P}_T^u}{(\bar{P}_T^u)v} . \tag{25}$$

Substituting (25) into (24) and simplifying the right-hand side yields

$$(P-c) = (1+v)\bar{P}_T^u \Rightarrow P = c + (1+v)\bar{P}_T^u \tag{26}$$

For sellers located at distance u from the factory gate, a portion of transportation cost will be subtracted from marginal factor costs or added to marginal revenue product in the case of discrimination. Therefore,

$$P = c + (1+v)\bar{P}_{TF}^u + \delta u \tag{27}$$

where $\bar{P}_{TF}^u$ = the final (net price) received by sellers of timber and δ is the fraction of transportation cost subtracted from the MFC. Theoretically, δ can take any value but practically should be between 0 and 1.

Solving (27) for $\bar{P}_{TF}^u$, gives us

$$\bar{P}_{TF}^u = \frac{1}{(1+v)}[P-c] - \frac{1}{(1+v)}\delta u . \tag{28}$$

The value that v (a parameter of the model) takes determines whether a firm can price discriminate and whether or not it is profitable to do so.

Comparative Statics and Analysis

The first term in equation (28) is the price offered at the factory gate, as can be seen from (26). From (28), the slope of the net price received by sellers of timber as the distance between the seller and the buyer varies is

$$\frac{d\bar{P}_{TF}^{u}}{du} = -\frac{\delta}{(1+v)}$$

The larger the slope (in terms of absolute steepness), the lower will be the price paid to a seller as the distance increases between seller and buyer. Obviously, the sign and magnitude depend on what value we assume for *v.* In the F.O.B. case, because of the assumption of unit transport costs, the slope of the net price schedule with respect to *u* is –1. This means that $v = 0 \; and \; \delta = 1$ with F.O.B. pricing. A discriminatory price schedule with slope less than – 1 implies that the buying firms are undercutting transportation costs to distant sellers, i.e., absorbing freight.[17] In other words, the firm is discriminating in favor of distant sellers or against closer sellers. This will hold true for any value of $v > 0$.[18] Conversely, when the slope of the discriminatory price schedule is greater than –1, this implies "phantom freight", meaning that the firm is discriminating against distant sellers and in favor of the closer sellers. This will be true for values of *v* that lie between -1 and 0.[19]

With freight absorption,[20] arbitrage is not profitable because buyers will be able to offer distant sellers the best possible price. However, in the case of phantom freight, arbitrage will

[17] The statement "a discriminatory price schedule with slope less than -1" is used to mean a smaller negative value for the slope and not the absolute value of it.
[18] Another theoretical possibility leading to freight absorption will be the case where the value of v < -2 (in integer terms). In this case the discriminatory price schedule will be positive in slope. Intuitively, what this means is that the firm will absorb more than the actual amount of freight. This does not make economic sense because the firm would maximize profits by equating MRP to MFC at its base.
[19] If $v < -1$ (i.e., more negative) the slope of the discriminatory price schedule will be positive meaning that the firm pays distant sellers prices higher than the case when transport costs equal zero. That is counterintuitive.
[20] Freight absorption under oligopsony is the situation where the buyer pays part or all of the cost of transportation.

make it impossible for the buyer to profit from that policy and thus prevent discrimination in favor of nearer sellers. As a result, the theoretical analysis of price discrimination is based on the assumption that $v > 0$. When $v < 0$, since the firm will be prevented from discriminating in favor of nearby sellers, the best the firm can do will be to price F.O.B. Therefore, given the theoretical restrictions, discriminatory pricing with $v > 0$ will produce lower price intercepts and flatter delivered price schedules than F.O.B. pricing, as depicted in Figure 5 (Appendix B). The boundaries of the market will then be at the point where the delivered prices are equal because sellers will sell to the buyer offering the highest net price.

Given the independence of the price-setting behavior by buyers, interactions (interdependence) will occur only at the boundaries where the net prices are equal. With discrimination, firms can penetrate the "natural" markets of their competitors beyond the boundaries where their price schedules otherwise would meet. It is in this sense that “discrimination may break the linkage that implies extensive market integration, as under F.O.B. pricing” (Faminiow and Benson 1990, p. 54).

2.2.3 Basing Point Pricing

Within the context of an oligopsony, basing point pricing (BPP) is a pricing scheme in which the price quoted for any seller equals a base (mill) price set at a particular site minus the transportation costs from that site to the seller. In other words, if by common consent one point is chosen as the base, then the BPP will be the announced base price minus the cost of transporting the good from the seller's site to the base point irrespective of the proximity of the actual point of sale to the firm (buyer).

In Figure 3, X is the chosen base in a three-firm market. Firm X can buy all the way to Z using the adopted price schedule $P_{TX} - u$. All other firms in the market (Y and Z) will adopt the price schedule announced by X. At their respective bases, Y and Z price as if they were located at X using X's price schedule. Therefore, prices net of transportation costs are the same across regions. This means that firms Y and Z offer sellers a lower price at their locations than they otherwise would have offered under a system of F.O.B. by over-charging them for shipping costs. Firms Y and Z can buy to the left of their locations either because they have lower production costs or because they want to cheat on a tacit or explicit price agreement, but purchases to the left of their locations will demand freight absorption. If Z buys all the way to X, for instance, it would have absorbed freight equaling the sum of the areas A, B and C; for Y the total amount of freight absorbed when it buys all the way to X will be, the area, "A" as in Figure 3.[21] Sales to the right of the locations of Y and Z will demand absorbing "phantom freight" since buyers normally will pay a price higher than the price at the mill less unit transportation costs. But as a result of BPP, they pay an artificially lower price.

The adopted basing point price (BPP) schedule (P_{TX} - u) will change only when a different basing point is chosen or only when the announced basing point price changes. In either case, the change will be transmitted uniformly and instantaneously throughout the market. Changes in the prices of other regions (be they due to demand or cost reasons) will not affect the BPP. This means that price changes can be one-directional only under BPP. In the sense that price changes at the base are uniformly transmitted throughout the market, then one will expect a higher degree of price integration in markets where BPP is used than in markets where F.O.B. is the pricing scheme.

[21] Firms will not have an incentive to buy to the left of Y under BPP if the input is characterized by constant costs. In other words, no actual shortages at the prevailing price.

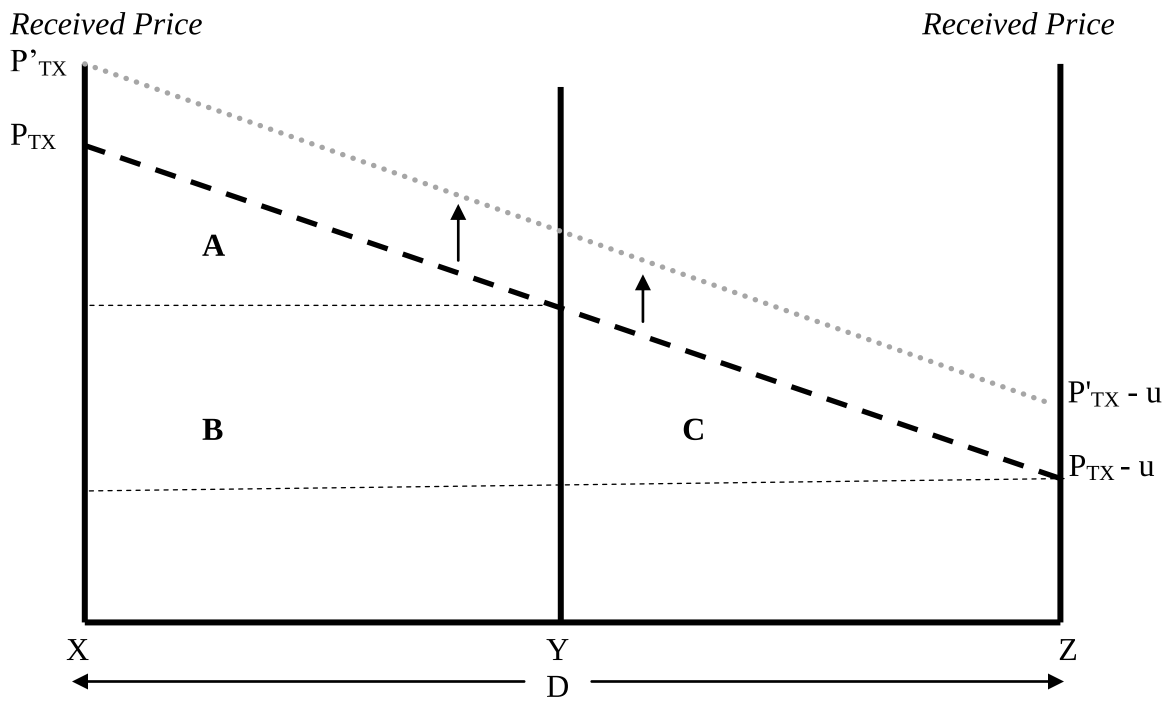

Figure 3: Oligopsony Basing Point Pricing

Basing point pricing is usually the result of some oligopoly or, for that matter, oligopsony arrangement or some form of price leadership (Scherer & Ross 1990). It typically is adopted by oligopolists (oligopsonists) when the product concerned is homogenous , with high transportation costs relative to the value of the product and where marginal production costs are low (at less than capacity operation) relative to total unit cost (Nin 2001).

These conditions for BPP fit well the timber industry, too, thus suggesting the possibility of a BPP regime in describing pricing behaviors. Lower valued timber products with high transportation costs are expected to exhibit more instances of BPP. Since an effective BPP requires considerable cooperation, the effectiveness of the system varies inversely with the number of independent buyers in a properly defined market. A single-firm multi-plant BPP system is likely to be more effective than a multi-firm (independent) BPP system since there will be incentives to cheat in the latter. Empirically, therefore, one will expect basing point pricing where one buyer (firm) is dominant in the different trading regions.

2.3 Empirical Implications

In

Table 2, we summarize some of the empirical relations or regularities we expect given the models presented. In general, markets characterized by F.O.B. are less integrated than those characterized by BPP. Also, we are more likely to observe F.O.B. pricing in markets where the value of the product is high relative to the cost of shipping it than in markets where the reverse is true. Price intercepts (price at the base) in F.O.B. markets are higher than those observed in markets characterized by price discrimination. Finally, distance between markets reduces price relationships between F.O.B. pricing regions while distance has no effect on price relationships under basing point pricing.

Table 2: Summary of Empirical Implications

ISSUE	F.O.B.	BPP	Discrimination
Degree and Extent of Price Integration	Markets will be less integrated than under BPP	Markets more integrated than under F.O.B.	Prices will be independent of other markets
Pattern and Direction of price interactions	The price interactions between markets will not have a defined pattern.	Price interactions between markets have a clear pattern - from the basing point to the other markets	No Pattern

Time Span for Price Adjustments	Price adjustments should be weaker in the short-run under a system of F.O.B. This means that there will be lagged effects in the long run.	Price adjustments are instantaneous and observed within a very short period of time. Thus no lagged effects observed in price adjustments	Prices hardly adjust if not for a common cause
Distance between markets and degree of integration	The longer the distance, the smaller will be the degree of market integration.	Distance has no effect on the degree of integration - prices are announced & adopted.	Distance should have a positive significant effect on the degree of discrimination
Product value and Market Integration	For higher valued products, F.O.B. is likely to be reason behind price co-movements between regions	For lower valued products, significant price co-movements are likely to be explained by BPP	A priori, an effective discriminatory scheme should not depend on the value of product
Market Concentration and Market Structure	We expect more F.O.B. for markets with low concentration indexes.	We expect more BPP for markets with high concentration indexes.	More discrimination in highly concentrated markets
Price at Mill	The mill price offered at the factory gate should be higher than that offered at the factory gate under discriminatory pricing	The base price should equal the mill price under F.O.B. but lower for other firms at factory gate.	Lower prices offered at mill than under F.O.B.

2.4 Summary

In this chapter, we developed the theory of spatial pricing behavior in timber markets assuming that transportation costs are significant relative to product value. We considered three main spatial pricing schemes - F.O.B. pricing, Price Discrimination and Basing Point Pricing. We showed that F.O.B. pricing, which is consistent with actual spatial market integration (within the context of competition) tended to fall as the distance between spatial markets increase. This is so because opportunities for arbitrage profits decline as distance increases and arbitrage is assumed to be the error correction mechanism under F.O.B. pricing. Not surprising, price discrimination on the other hand increase with increasing distance between the markets. This goes to show firms in spatial settings are endowed with market power and this power will increase the further away they are from a competitor. Finally, basing point pricing (in the strict form of the concept) even though exhibited price behaviors similar to that of F.O.B., did not change as distance between markets change. This goes to confirm that it is possible to have price co-movements that are not consistent with competitive pricing or market integration.

In the next chapter, we test empirically, the predictions of our theory on three timber products for seven U.S. southeastern and southcentral states.

CHAPTER III

EMPIRICAL METHODOLOGY

3.1 Introduction

In this chapter, we present the estimation strategies we employ to answer the following research questions:

- Are timber markets for three timber products (PST, PPW and CNS) integrated for seven southeastern and southcentral states in the U.S?
- What is the market structure and the pricing behavior that characterize the trajectory of observed prices in these products' markets?
- Can price cointegration or correlations be interpreted to be indicative of the degree of competitive market integration for these three products?".

Before outlining our empirical approach, we briefly review approaches of past studies.

Review of Previous Studies' Methods

Empirical investigation of market integration has taken various forms depending on the availability of data. Some studies that have access to data on transportation costs have sought to determine the extent of market integration by testing whether price differences equal transportation costs, as hypothesized by Tomek and Robsinson (1981).[22] Pioneering studies

[22] Alternatively, prices could be compared to what will pertain under competitive conditions in spaceless markets.

using this approach include Stout & Feltner (1962) and Hays & McCoy (1977). The problem for scholars following the pioneers' trail is that it is very difficult to get data on transportation costs for most products. Data on transportation costs, even if available, are likely to be poor. Also, this approach gives an "either-or" answer to the question of integration. Markets are either integrated or not. However, there is a grey area between the two. Markets can be integrated by BPP or the price formation process could be characterized by discrimination.

Other studies have used bivariate correlations between price series to predict market integration. The economic justification for doing so, as noted by Monke & Petzel (1984), is that if two markets trade with each other, then price changes in one market should lead to identical price changes in the other, irrespective of the cause of the initial price change. In other words, the hypothesis of Monke and Petzel is that markets are said to be integrated if the prices of products differentiated in space do not behave independently. A large correlation coefficient is taken to imply that markets are integrated. Examples of studies using this approach include: Jones (1968), Blyn (1973), Harriss (1979), Stigler & Sherwin (1985), Uri & Rifkin (1985), Neal (1987) and Daniels (2011). The problem with this approach is that it does not reveal the underlying mechanism by which prices are correlated. Price correlations can be consistent with other forms of market structures, as discussed in previous chapters. Also, if the time series properties of the data are not accounted for, the observed price correlations could be spurious.

Recent studies in the area of market integration have employed cointegration analysis, which takes into account the time series properties of the data. There are quite a number of studies using this approach, examples of which include Goodwin and Schroeder (1990), Nanang (2000), Nagubadi et al. (2001), Bingham et al. (2003), Kainulainen & Toppinen (2006), Niquidet & Manley (2008) and Daniels (2011). Markets that are found to be cointegrated usually are presumed to be integrated. This means that by using cointegration analysis to test market integration, it is implicitly assumed that F.O.B. pricing is the benchmark since that is the form of price integration that is consistent with actual market integration in spatial markets - where arbitrage is the error correction mechanism.

There are a few problems with relying solely on cointegration tests to accept or reject spatial market integration. First, while cointegration may be able to tell whether prices in two regions are linked, it is not very flexible for identifying the underlying mechanism for the observed price linkages. This means that some price co-movements, such as collusive basing point pricing not due to competitive arbitrage but which have been around for a long time, will be captured by cointegration as indicative of the competitiveness of markets.

Secondly, the concept of cointegration is not an absolute finding but actually can change with structural innovations (breaks) in market conditions. This means that the cointegration relation could have been affected by other reasons, such as technological innovations, macroeconomic fluctuations, demand or supply shocks and policy regime changes, especially if the sample covers a long period of time. Structural breaks make the use of cointegration analysis over long sample periods problematic.

In addition, as pointed out earlier, while cointegration will tell us if there is a long term price co-movement, it does not have the flexibility to test other pricing schemes; some of which could be consistent with long term price co-movements (such as a stable basing point pricing system) and others consistent with other pricing schemes consistent with spatial profit maximization (such as spatial price discrimination). Spatial price discrimination as we know does not cause price co-movements between markets due to its ability to make arbitrage unprofitable.

Estimation Strategy/Procedure

We employ following estimation procedures to examine the questions of interest.

STEP 1: First, we estimate a multivariate dynamic time series model. We then impose specific bivariate market integration or pricing behavior tests as restrictions for market pairs. We save the P-values and Wald-statistics from these tests.

STEP 2: We validate the results from STEP 1 by running a second-stage model based on the test statistics from the pricing behavior tests imposed on the dynamic time series model as to the factors that potentially influence the observed price behaviors. The most important of these factors is distance between the spatial markets.

STEP 3: We also estimate cointegration relations for all market pairs and test for cointegration for each pair.

STEP 4: We next compare the results from the dynamic time series model and the cointegration model and examine them for theoretical consistencies as predicted by our model and the characteristics of the three products.

3.2 GMM Dynamic Time Series Model and Market Integration Tests

In this section, we outline the framework within which we test different pricing schemes as possible explanations for the trajectory of observed prices within the dynamic time series model. Ravallion (1986) developed market integration tests to analyze both short-run and long-run price adjustments between a dominant market and other smaller, "satellite" markets. In his model, the dominant (urban) market acts as a price-leader and the satellite (rural) markets, which trade mainly with the dominant market and not with other satellite markets, are price-takers. Below is a sketch of Ravallion's model

$$P_D = f\left(P_1, P_2, \ldots, P_N; Z_D\right) \tag{31}$$

$$P_i = f\left(P_D; Z_i\right) \quad i = 1, \ldots, N \tag{32}$$

where P_D is the price in the dominant market, P_i is the price in satellite market i, Z_D are other factors that affect the price in the dominant market and Z_i are factors that affect price in market i.

From equation (31), it can be seen that the price in the dominant market is determined by prices in all of the satellite markets and factors peculiar to the dominant market, while (32) says that the price in any individual satellite market is dependent on the price in the dominant market and factors peculiar to that satellite market. Ravallion's formulation implies that there are no intra-regional transportation costs, as the satellite markets are assumed to trade only with the dominant urban market - there is no intraregional trade. While these assumptions may hold for the market for hogs studied by Ravallion, the same assumptions cannot be said to hold for the timber industry, where intra-regional transportation costs are significant and where buyers and sellers in our model are assumed to be distributed uniformly over economic space. We therefore modify Ravallion's approach to fit the circumstances of our theory and data. We do this by extending his formulation to the case where markets are interlinked. This modified formulation is also consistent with our theoretical model, where we do not assume a dominant central market served by price-taking satellite markets.

Let P_i and P_j be prices in markets i and j in an n-market region where neither i nor j is assumed to be dominant. With this assumption, we can write the price in market i as

$$P_i = f(P_1, P_2, ..., P_{n-i}, P_{n+i+1}, Z_i) \tag{33}$$

and similarly for j as

$$P_j = f(P_1, P_2, ..., P_{n-j}, P_{n+j+1}, Z_i) \qquad (34)$$

For purposes of econometric estimation, we can linearize either of equations (33) or (34), and make them dynamic by adding an appropriate number of lags of the dependent and independent variables and an error term. This gives (assuming market $i = X\ and\ j = Y$ and Z = all other markets)

$$\mathrm{P_{Xt}} = \sum_{j=1}^{\mathrm{n}} \alpha_j \mathrm{P_{Xt-\mathit{j}}} + \sum_{\mathrm{k}=0}^{\mathrm{m}} \beta_{\mathrm{k}} \mathrm{P_{Yt-k}} + \sum_{i=3}^{\mathrm{n}} \sum_{r=0}^{h} \varphi_{ir} \mathrm{P_{i(Zt)}} + \sum_{h=1}^{s} \eta_h W_X + \sum_{i=1}^{r} \Phi_i \mathrm{D}_i + \mu_{\mathrm{t}} \qquad (35)$$

where P_{Xt} and P_{Yt} are the prices in locations X and Y and P_{iZt} prices in all other markets at time t, D_i is an appropriate dummy variable for identified shocks, such as hurricanes, international trade rules and policy regime changes, that affect the industry, W_X are other factors specific to market X that affect the price there with the error process, ε_t is distributed *white noise* and α, β, η, φ and Φ are the parameters of the model to be estimated. This extensive formulation controls for omitted variable bias if the prices in regions X and Y also are correlated with prices in the other regions - a consideration to which little attention has been paid in the empirical literature.

However, for the estimates from equation (35) to be meaningful, we require stationarity in the price series. Most time series data are not stationary because they contain unit roots.[23] Regression analysis based on non-stationary data could lead to spurious (useless) regressions, as was first noted by Yule (1926) and later formalized and popularized by Granger & Newbold (1974). There are many tests for stationarity, but the most common is the Augmented Dickey-Fuller (ADF) Unit roots test (Dickey & Fuller, 1979).[24] The general form of the test is given as:

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[23] A linear stochastic time series process is said to have a unit root if one (1) is a root of the characteristic equation of the process.

[24] Other unit root tests include Pantula, Gonzalez-Farias, & Fuller (1994) and Phillips & Perron (1988)

$$\Delta Y_t = \alpha_0 + \alpha_1 T + \delta Y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + e_t \qquad (36)$$

where Δ is the first-difference operator, Y_t is the time series variable (in this case timber price), T is time trend, $\alpha_0, \alpha_1, \delta$ *and* β_i are the parameters and *k* the number of lags needed to whiten the noise ($e_t \sim N(0, \sigma^2)$) and remove serial correlation. This test has the null hypothesis $H_0: \delta = 0$ (unit roots do not exist) against $H_1: \delta < 0$. If we fail to reject the null hypothesis (existence of unit roots), then the data are said to be non-stationary.[25] The ADF *t*-distribution does not have an asymptotic normal distribution, therefore the standard critical values are not valid. We therefore use the Dickey-Fuller distribution which has the more demanding critical values.

After Granger and Newbold's 1974 paper, analyses involving non-stationary data are done by first-differencing the data and using the differenced values in the regression analysis. If the data are non-stationary, purely due to unit roots, then differencing can induce stationarity and make regressions using the differenced data non-spurious. For example, if P_{xt} and P_{yt} are two price series integrated of order one $[I(1)]$, then by definition $\Delta P_{xt} \sim I(0)$, and similarly for ΔP_{yt}.

We tested for stationarity in our data using equation (36). Using Mackinnon (1994) critical values and significance levels, we found that the price series were all non-stationary while their first differences were not, as shown in

[25] The limitation of the ADF test is that the autoregressive model for $\hat{y}_t$ is equivalent to imposing a common dynamic factor on the static regression:

$$(1 - \rho L) y_t = \beta_0 (1 - \rho) + (1 - \rho) x_{t-1} + \mathcal{E}_t.$$

The ability of the ADF test to have power to reject $H_0: 1 - \rho = 0$ when it is false depends on the common factor restriction corresponding to the properties of the data (see Engle, Hendry, & Richard 1983 for detailed discussion of this drawback).

Table 12 (in the appendix).[26]

As a result of the non-stationarity in the levels of the series, we estimate

$$\Delta P_{Xt} = \sum_{d=1}^{m} \pi_d \Delta P_{Xt-d} + \sum_{k=0}^{g} \lambda_k \Delta P_{Yt-k} + \sum_{i=2}^{n-2}\sum_{r=0}^{h} \theta_{ir} \Delta P_{iZt} + \varepsilon_t \qquad (37)$$

The dynamic process or lag length of the model in (37) cannot be determined theoretically. We therefore use Hannan-Quinn information criteria (HQIC) to select lag lengths. We decided on HQIC because, according to Ivanov and Killian (2001)[27], it works better on quarterly data with samples of more than 120.[28] It also is parsimonious in terms of the number of lags it suggests, thus saving on degrees of freedom.

More importantly, we need the residuals in (37) to be serially uncorrelated and to be white noise. We tested for serial correlation using both Durbin's alternative test and the Breusch–Godfrey tests. We also tested for white noise of the residuals using the Portamanteau test (Q-test). The Breusch-Pagan test of heteroscedasticity suggests that there was some heteroscedasticity in a few of the market pairs even after including the appropriate number of lags to whiten the errors. After including the appropriate number of lags to whiten the noise in (37), we estimate (37) with using robust Generalized Method of Moments (GMM) estimator with the instruments being lags of the price series.

We considered using VAR to estimate equation (37). But given that our market integration tests (shown below) include contemporaneous relationships between some of the variables, VAR will be invalid as it will induce endogeneity. In addition, we run the risk of introducing severe or perfect multicollinearity into the model if we use VAR thus making the

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[26] We also tested other specifications of unit root and the results were not sensitive to the inclusion of a constant or trend term.

[27] In a paper by the CEPR (Ivanov & Kilian 2001), *Akaike information criterion* (AIC) is more accurate with monthly data, HQIC works better for quarterly data on samples over 120 and Bayesian Information Criterion (BIC) works fine with any sample size for quarterly data.

[28] Our data have a 131 observations for each of the 14 regions.

estimates unreliable (if they can be estimated at all).

The market integration (pricing behavior) tests we use are restrictions proposed by Ravallion that we imposed on (37). These restrictions are based on our theory and what to expect given the market structure that is assumed to be tested. They are discussed below.

Spatial Price Discrimination: Independence

Spatial price discrimination is tested by imposing the following restriction on

$$\lambda_k = 0, \; (k = 0, 1, \ldots, m)$$

This formulation implies that all lagged and contemporaneous price effects in one market are independent of those in another market. In other words, firms, when discriminating, act based on their own cost conditions and the supply elasticities they face. They are able to offer each seller the "best price" possible so as to make arbitrage unprofitable thus preventing arbitrage-driven price co-movement. In essence, we will not observe any price co-movement between the markets as a result of effective spatial price discrimination by the firm.

Perfect Basing Point Pricing (BPP): Strong short-run integration

In the presence of significant intra-regional transportation costs, arbitrage is unlikely to be the cause of instantaneous price adjustments across markets. Therefore, as in our model, when it is observed that prices adjust instantaneously across markets, it is more likely to be a case of BPP rather than of competitive arbitrage.[29] To test this hypothesis, the following restriction is imposed on the model.

$$\lambda_0 = 1;$$
$$\pi_j = \lambda_k = 0, \; (j = 1, 2, \ldots, n; k = 0, 1, \ldots, m)$$

[29] There are instances where BPP can arise in non-collusive or non-price leadership settings. But as Benson et al. (1990) noted, the necessary conditions are very limiting.

The restriction here implies that price adjustments are reflected fully in the same period, with no lagged effects. The reason being that firms in the collusion just take the announced prices and immediately put them into effect without the need for adjustments.

Incomplete Basing Point: Short-run integration: Cartel or Tacit Collusion

What if there are lagged effects in the short term? If the lagged effects in the different markets vanish on average, then this suggests the case of tacit collusion (if it applies to all markets) or a cartel (if it applies only to a subsection of the markets). The reason here being that for tacit collusion to persist, the parties to it will need time to respond to the price signals (changes) of the leading firm as the market moves to a new equilibrium. In the case of a cartel, only one section of the market will respond and the adjustment is likely to be slightly faster than in tacit collusion, provided that members do not try to cheat. The test for this hypothesis is given below

$$\lambda_0 = 1;$$
$$\sum_{j=1}^{n} \pi_j + \sum_{k=1}^{m} \lambda_k = 0, \ \left(j = 1, 2, \ldots, n; k = 1, \ldots, m \right)$$

Long-Run integration: Long-run price matching/F.O.B.

For long-run market integration, the test requires that all contemporaneous and lagged effects sum to one. This means that equilibrium price changes in one market net out on average over time to match exactly the equilibrium price changes in other markets. The test implies the following restriction

$$\sum_{j=1}^{n} \pi_j + \sum_{k=0}^{m} \lambda_k = 1$$

According to Ravallion (1986), each short-run test implies long-run integration. Therefore, the long-run integration test can be looked at as a feature of the BPP system. In the case that the short-run tests are rejected and the long-run tests accepted, then the empirical results will be consistent with either a competitive F.O.B. pricing system or increasing marginal cost price-discriminatory models (Faminow and Benson 1990).

Decision Rule on Pricing Behavior Tests

For each pricing behavior or market structure test, we report the chi-square from the Wald-Statistic[30] and the corresponding *P*-value. If the reported *P-value* is significant (i.e., less than 0.05), we reject the hypothesis that the market is characterized by that pricing scheme/behavior. If the *P-value* is insignificant, we fail to reject the null and conclude it is plausible. A small p-value casts doubt on the null hypothesis (hypothesized pricing behavior) while a big p-value lends support to it. Further tests will be employed to confirm the plausibility of the null in cases when it is not rejected. The next section presents how we do this and the methods we employ.

3.3 Validation: Market Integration Tests and Determinants of Integration

We next estimate a model to help explain the factors that influence market integration and to validate the results from the pricing behavior tests imposed on (37). Market integration tests from the dynamic time series model (37) provide evidence on market integration and price relationships in the market pairs. In cases that the hypothesized (null) price relationship is not rejected, we note that it is still not sufficient to conclude that a particular market pair is characterized definitely by that pricing behavior. We use the results from the pricing behavior (market integration) tests to estimate a second-stage model that examines the relationship between the pricing behavior tests and economic factors that could help explain the trajectory of

[30] The traditional F-statistic is not valid under a GMM estimation.

the observed prices. If the parameter estimates (especially distance) are significant and conform to the a priori expectations (as predicted by theory) for the particular pricing behavior being tested, then we can conclude that the observed pricing behavior characterizes the market.

As our theoretical model did indicate, distance (cost of transportation) between spatial markets has important implications as to the kind of market structure likely to be observed. The sizes of firms or the degree of concentration of the markets may also influence the trajectory of observed prices. We construct a Herfindahl-Hirschman index from the capacities of processing plants in each region to use as proxy for market concentration. Another factor that could influence the link between markets, according to the empirical literature is the volume of activity in the separate markets. We can examine the effects of these factors by estimating the model

$$\Pi_{xy} = f(Dist_{xy}, Vol_x, Vol_y, Con_x, Con_y, Z), \tag{38}$$

where Π_{xy} = Wald statistic (Chi-Square) arising from the pricing behavior tests from the dynamic time series model of (37) estimated using GMM.

$Distance_{xy}$ = the distance, in miles, between market centers of y_t and x_t;

Vol_x = average volume of output from region x;

Vol_y = average volume of output from region y;

Con_x = market concentration in region x;

Con_y = market concentration in region y;

Z = product dummy variables.

Estimation Method(s)

Normality tests using the Jarque-Bera test indicate that the dependent variable is not normally distributed. This could be because the values of the dependent variable are restricted as are the Wald-statistics to be nonnegative positive values. Wooldridge (1992) argues that if the dependent variable is strictly nonnegative, then it is advisable to model the expected regression model directly rather than using a transformation (usually the natural log) and specifying a model linear in parameters with an additive error. As a result, we estimate (38) using a Poisson Regression Model optimized using quasi-maximum likelihood estimator (QMLE) and a Gamma (Exponential) Regression Model, also optimized using a quasi-maximum likelihood estimator (QMLE). Regardless of the nature of the dependent variable - provided that it is nonnegative and has no natural bound we can always apply the Poisson QMLE (Wooldridge 2010, p. 741). Wooldridge makes the case that both the Poisson and Gamma QMLE are fully robust to distributional misspecifications other than those of the conditional mean thus making them appropriate for our analyses.

The a priori expectations of the parameters in equation (38) depend on the pricing behavior test being validated. Recall that a small Wald statistic or chi-square (a high p-value) from the GMM pricing behavior tests of 37 will imply that the null hypothesis of the posited pricing behavior is supported (not rejected). Therefore, if an explanatory variable has a positive effect on the dependent variable (chi-square), then evidence is shifted towards rejecting the hypothesized pricing behavior. This is so because an increase in the chi-square (due to an increase in the explanatory variable) will decrease the p-value and, hence, lead to a rejection of the null of the hypothesized pricing behavior.

A priori Expectations

If our F.O.B. market integration test is valid, then we will expect a negative relationship between F.O.B. pricing and distance (i.e., a positive relationship between the chi-square value of the F.O.B. pricing behavior test imposed on all three products and the distance between the markets being tested). This means that as distance increases, opportunities for arbitrage decline hence F.O.B. decreases - a prediction in our theoretical model that integration decays with distance between markets.

For our tests on BPP to be valid, we should expect that distance should not have a significant effect on the BPP chi-squares.

In the case of incomplete basing point pricing, the effect of distance will depend on whether prices are determined by a cartel or collusion. In the case of a collusion (where the entire market is involved), distance should not have a significant effect. However, in the case of a cartel, where opportunities to cheat rise with distance, we will expect that as distance increases, that cartel-like pricing is less salient as members try to cheat. (i.e., there is a positive relationship between distance and the chi-square value of the incomplete BPP test).

As described in chapter 2, firms in spatial markets have market power. This power will be stronger the greater the distance between the spatially dispersed firms and the larger is the relative cost of transporting the product between markets .Therefore, we expect a negative relationship between the chi-square statistic from the test of price discrimination across markets and the distance between the markets. This will go to confirm that market power for spatially located firms increase with distance. As a result of this market power, they can adopt non-competitive pricing schemes such as price discrimination.

The effect of the volume of output on market integration is not very clear. According to Lang and Rosa (1981) and Buccola (1985), high volume regions are usually more efficient because information about prices is more frequently observed and readily available. Low volume markets, on the other hand, may experience price swings not in line with other markets. For instance, shutting down one processing plant in a low volume market could have dramatic effects on price swings in that region. Therefore, the a priori expectations with respect to volume of output will be a fact of the data.

Finally, the degree of buyer concentration in timber markets may influence the kind of pricing behaviors observed in these markets. In highly concentrated markets, if the buyers compete without geographic restrictions (i.e., no defined market boundaries), then one will expect more efficiency and price stability. The story is similar for concentration in the "away" market. Since we do not have enough data to delineate these effects, we will rely solely on our empirical estimates of the effect of concentration on pricing behaviors in spatial timber markets.

3.4 Cointegration Tests of Spatial Price Relationships

Cointegration analyses have been used widely to draw conclusions with respect to integration or otherwise of timber markets. Cointegrated markets are usually termed as integrated and vice versa. In what follows, we briefly outline the idea of cointegration and its application to timber markets.

In general, two series are cointegrated of order (d, b) if the individual series are integrated of order (d) and their linear combination is integrated of order (d-b) (Engle and Granger, 1987). According to Hamilton (1994), cointegration implies that although there may be developments that cause permanent changes in the series, there is some long-term equilibrium relation that ties the individual series together.[31] Cointegration analysis makes it possible to derive useful results from two or more non-stationary variables that have a stable long-run equilibrium relationship

[31] An equilibrium relationship in the context of cointegration is not the same thing as market clearing, but rather is a long term stable relationship between the variables.

from which they cannot drift too far apart.[32] Deviations from this long term equilibrium relationship as a result of random shocks therefore will be corrected over time.

Analyses of spatial market integration usually posit a parity relationship in which price changes in one market are reflected in equilibrium price changes in another. Given two non-stationary price series P_{yt} *and* P_{xt}, we can write this relationship as:

$$P_{yt} - \beta_1 P_{xt} - \beta_0 = u_t \qquad (39)$$

If u_t is stationary, then the price series are said to be cointegrated. This requires that we test for the stationarity of u_t. Testing for the stationarity of u_t can be done using the ADF test presented in (36) by replacing Y_t with u_t as below

$$\Delta u_t = \alpha_0 + \alpha_1 T + \delta u_{t-1} + \sum_{i=1}^{k} \beta_i \Delta u_{t-i} + e_t \qquad (40)$$

If $u_t \sim I(0)$, then P_{yt} *and* P_{xt} are said to be cointegrated of order 0 with cointegrating vector $\boldsymbol{\beta}$, and equation (39) is referred to as the cointegrating regression.[33] For there to be a genuine causal link between the two integrated price series P_{yt} *and* P_{xt} then u_t from (40) must be $I(0)$ or a "nonsense" regression has been estimated (Henry and Juselius, 2000).

There are many tests for cointegration but the two main tests are the Engle-Granger two-step method and the Johansen procedure.[34] It is usually not obvious which testing procedure is best because cointegration does not say anything about the direction of causality. For example, between the price series P_{xt}, P_{yt} *and* P_{zt} for markets X, Y, and Z, if one of the markets is a price

[32] A similar concept was first mentioned by Davidson et al. (1978), in which the authors argued the need for a model to estimate time series that tend to move together with a stable long-run equilibrium relationship (Davidson, Hendry, Srba, & Yeo, 1978).
[33] According to Henry and Juselius (2000 p. 16), "... unlike differencing, there is no guarantee that $y_t - \beta_1 x_t - \beta_0$ *is* $I(0)$ for any value of $\boldsymbol{\beta}$ ...". Note: $\boldsymbol{\beta}$ is k *by* 1 vector of coefficients.
[34] Another commonly used test for cointegration is the Phillips-Ouliaris (1990) Cointegration Test, which has a null hypothesis of no cointegration.

leader, the leader's price would influence prices in the other markets. This way, cointegration could be analyzed from the equations for the followers', given the price of the leader using bivariate methods. On the other hand, if no market is a leader, all prices would be ‘equilibrium adjusting’ and, hence, all equations would contain information about the cointegration relationships, which means that a simultaneous equations method will be required to determine cointegration.

However, for the current analysis, an exhaustive bivariate approach is appropriate for comparison purposes and for threshing out the questions, we ask in this dissertation. For example, a bivariate analysis allows us to examine subtle price relationships between pairs of markets that will otherwise not be obvious in a systems approach.

Engle-Granger Causality Test

Engle and Granger (1987) suggest a two-step OLS procedure for evaluating the cointegration properties of I(1) times series data.

Step 1: Estimate the parameters of the cointegration relation

If P_{xt} and P_{yt} are integrated of the same order (specifically $I(1)$), we estimate the static regression model

$$P_{yt} = \beta_0 + \beta_1 P_{xt} + u_t$$

where $\hat{\beta}$ is the OLS estimate of the long-run parameter vector β and save the residuals $\hat{u}_t$. The estimates from the cointegrating equation are superconsistent (Hamilton, 1994), but they are non-normally distributed, which means that they cannot be used for hypothesis testing (Brooks, 2008).

Step 2: Test stationarity of cointegratting vector (Error Correction Model)

Use the residuals from step 1 and test that $\hat{u}_t \sim I(0)$, i.e., testing that the residuals from step (1) are stationary using the ADF test. If $\hat{u}_t \sim I(0)$ is found to be true, then the series are said to be cointegrated. If that is not true, the series are not cointegrated and the estimates from the first stage are not usable because they might have been spurious.

The Engle-Granger procedure, even though simple, comes with some limitations. First, it requires treating one of the variables as exogenous, i.e., a one-way causal relationship. If this assumption is not true, then the estimates would be inefficient and seriously biased, depending on which variable is used as dependent variable and which is the independent variable. Closely related to the first is the fact that the technique does not allow for testing cases where there is more than one cointegrating relations/vectors. Also, the estimates from the cointegrating equation, as mentioned earlier, are not normally distributed and thus do not support any hypothesis testing. Finally, the power of the test is compromised when the sample size is small (Brooks, 2008 p. 340).

As discussed earlier, most recent studies on timber market integration have tested market integration using cointegration analysis. But competitive market integration in spatial markets implies F.O.B. pricing. Therefore, testing and drawing conclusions about spatial market integration using cointegration analysis assumes that F.O.B. pricing is being tested. However, because quantity data are usually not available, most of the tests are done using price series alone. We therefore run the risk of interpreting price integration as market integration when we rely only on cointegration analysis.

3.5. Summary

This chapter outlined the empirical approach we adopt to answer the questions of this dissertation. Generally, we use a dynamic multivariate GMM estimation procedure to test bivariate price behaviors for all market pairs. We then validated the use of these tests by estimating a second-stage multivariate regression using both a Gamma and Poisson Generalized Linear Methods on the factors that are hypothesized to determine spatial pricing behaviors. For comparison and to point out the inadequacies of conventional methods, we also presented a conventional method used by previous studies - bivariate cointegration analysis.

CHAPTER IV

DATA, RESULTS AND ANALYSES

4.1 Data

Data for the dynamic time series model (GMM) and the cointegration analysis are quarterly delivered price data for PST, PPW and CNS obtained from Timber Mart-South (TMS) spanning the period from the last quarter of 1976 to the second quarter of 2009. This gives a total of 131 observations per series - the longest series yet used in any analysis of the industry. TMS at the moment reports data for two price regions within each state in the U.S. South (Figure 4). This means that for our seven states, there are 14 series of regional price data for PST and PPW. Price data on CNS for Arkansas region 2 has too many missing values. As a result, CNS price data for Arkansas region 2 is dropped, thus leaving 13 regions to carry the analysis on.

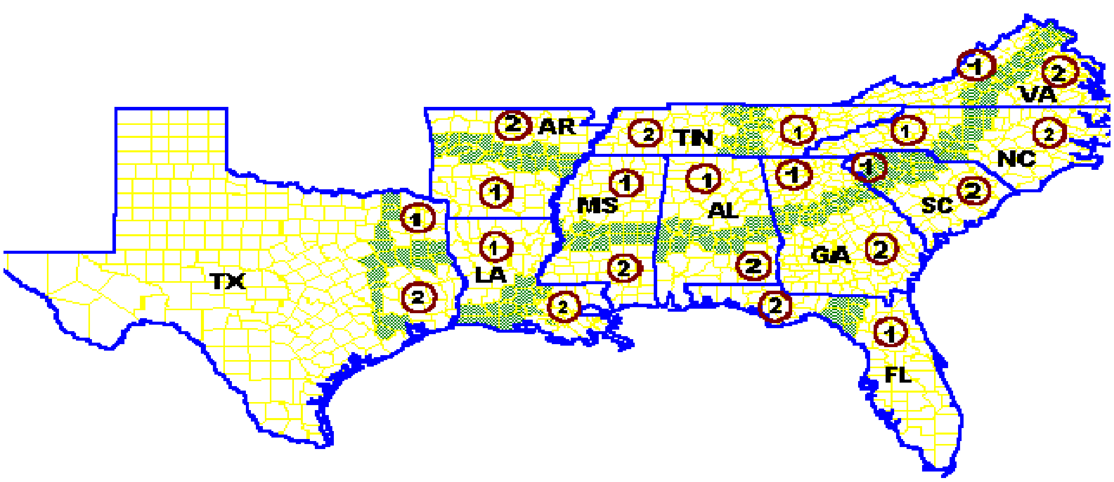

Figure 4: Timber Mart South Price Regions

Summary statistics for the price series are presented in Table 3. From the table, it can be seen that PST prices are consistently higher than those of both CNS and PPW for all regions while the prices of CNS exceed those of PPW. Georgia region 2 (GA2) has the highest average price for PPW, while Alabama Region 2 (AL2) has the highest price both for CNS and PST.

Table 3: Summary Statistics of Product Prices by State

REGION	PINE PULPWOOD				PINE CHIP N SAW				PINE SAW TIMBER			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
AL1	20.0	4.6	11.9	33.3	31.0	10.3	11.9	57.4	39.5	15.6	15.0	67.8
AL2	20.6	3.8	12.6	30.6	33.4	10.9	16.7	59.2	42.3	14.5	18.9	68.6
AR1	20.2	5.0	11.4	34.5	29.7	9.2	15.0	52.5	39.0	13.7	17.3	66.2
AR2	19.0	4.5	11.2	34.7	na	na	na	na	34.7	13.1	13.8	63.5
FL1	21.1	4.1	12.3	32.9	31.1	9.0	16.3	50.0	38.5	13.3	17.7	65.6
FL2	20.5	3.8	13.1	29.0	30.1	8.4	14.0	45.3	37.8	12.5	15.3	66.7
GA1	19.9	4.5	11.8	29.5	31.6	10.7	13.3	55.9	37.7	14.6	13.3	63.8
GA2	21.3	4.4	11.9	32.7	33.3	10.2	18.0	56.5	41.8	13.9	19.3	66.0
LA1	20.9	4.9	10.3	34.7	29.9	10.2	12.4	56.2	38.1	13.6	18.8	67.3
LA2	20.5	4.4	11.8	30.0	29.2	9.0	13.8	56.2	36.7	12.2	17.2	65.0
MS1	19.9	4.6	11.4	31.0	30.0	9.9	15.3	50.0	37.0	14.0	15.6	60.0
MS2	19.8	4.0	12.0	32.0	31.0	9.5	14.7	52.5	38.5	12.6	18.0	61.0
SC1	18.6	3.7	11.8	28.9	29.0	8.3	10.7	46.7	36.4	13.5	14.3	59.3
SC2	20.4	3.9	12.0	29.6	30.9	8.0	17.1	50.4	39.9	12.4	19.3	63.2

We report the percentage differences between product prices, by region, in Table 4. PST has a price premium over CNS that lies between 19.1 percent (in GA1) and 31.3 percent (in AR1). The premium is even greater when we compare PST to PPW - as much as 105.2 percent (in AL2). When we compare CNS to PPW, CNS has a price premium over PPW of between 42.7 percent (in LA2) and 62.1 percent (in AL2).

Table 4: Percentage Differences in Average Prices by Region

REGION	PST and PCNS	PST and PPW	PCNS and PPW
AL1	27.48443	97.68813	55.06845
AL2	26.60026	105.2086	62.09181
AR1	31.2596	92.92839	46.98231
AR2	Na	82.90812	na
FL1	23.7761	82.34394	47.31757
FL2	25.73299	84.60812	46.82552
GA1	19.07157	89.09266	58.80587
GA2	25.62422	96.06274	56.07082
LA1	27.52353	82.67834	43.2507
LA2	25.87834	79.60681	42.68285
MS1	23.26414	85.82267	50.75161
MS2	23.95669	94.16381	56.63842
SC1	25.66885	95.56202	55.61694
SC2	29.0369	95.95899	51.86276

As an empirical note and in line with our theory that products with higher prices (relative to transportation costs) are more likely to be shipped across regions, we expect to see absolutely larger F.O.B. price relations in the PST markets than in, say, the PPW markets.

For the GLM analysis on factors determining market integration, we required data on transportation cost between regions, market concentration and volumes of output in each region. Data on distance (which is our proxy for transportation costs) was obtained using Google maps, calculating the distances between the geographic centers of Timber Mart South regions (Bingham et al. 2001). We use ground distance because we believe that most timber is carted by land for the regions concerned.

Timber volume data was obtained from the yearly reports for each region from the resource bulletins of the Southern Research Division of the United States Department of Agriculture and Forestry Service for each state. The data are reported for each county in a state.

To get the data by TMS market regions, we code and categorize the counties by the classifications given for TMS price regions.

The market concentration measure used in our analysis for each TMS region is the Herfindahl-Hirschman index. These were computed from capacity data, also gathered from resource bulletins of the Southern Research Division of the United States Department of Agriculture and Forestry Service for each state. Summary statistics are given in Table 14 (Appendix C).

4.2 Results and Analysis

4.2.1 Pricing Behavior (Market Integration) Tests

Equation 37 was estimated using GMM for each of the three products. This led to a total of 519 regression equations (PST - 181, PPW - 181 and CNS - 155). For each estimated regression equation, we separately imposed bivariate market integration tests and reported the Wald-Statistic as well as the p-values for the various tests. This exhaustive approach results in a total of 2068 bivariate restrictions for all three products. The results for the integration tests are reported in Table 15, 16 and 17 for CNS, PPW and PST, respectively. If the reported p-value is small (less than 0.05 in this case), we reject the null hypothesis (hypothesized pricing behavior) and conclude that the alternative is true. If the reported p-value is greater than 0.05, it means that we fail to reject the null and conclude that it is plausible.[35]

In Table 5 we report the number of regions for which the hypothesized pricing behavior could not be rejected and the percentage of the market that this represents - a summary of the extensive results from Table 15, 16 and 17. It is obvious from Table 5 that no one pricing scheme

[35] At this stage, it will be premature to conclude that the null is true or that the alternative is false. We can only say that the null is plausible.

completely characterizes the trajectory of observed prices for any of the products for the whole of the South-East South Central States of the United states being considered in this study. However, a significant number of the markets are characterized by some form of pricing behavior or the other. These results are presented in Table 5.

Table 5: Summary of Decision Rules on Pricing Behavior Tests

PRICING BEHAVIOR	PST (181)		CNS (155)		PPW (181)	
	Number of Regions	Percentage of Market	Number of Regions	Percentage of Market	Number of Regions	Percentage of Market
FOB	60	33	32	21	10	6
Price Discrim.	36	20	37	24	35	19
Incomp. BPP	25	14	20	13	33	18
Complete BPP	2	1	0	0	9	5

Price Discrimination

There is evidence of price discrimination for all three products. Between 19 to 24 percent of the markets (depending on the product considered) exhibit signs of price discrimination

Complete Basing Point Pricing

Complete basing point pricing was rare. There was no evidence of complete(perfect) basing point pricing in the market for CNS. However, nine market regions (about 5 percent of the market) for PPW were deemed to be practicing some form of basing point pricing. In the market for PPW, South Carolina Region 1 (SC1) bases on SC2 while SC2 bases on AR1. Florida

Region 1 also bases on LA1 and AR2 while Florida Region 2 bases on LA1 and AR2. There also was evidence of AL2 basing on LA1. There are also two complete basing point regions for PST where FL2 and AR2 were both basing on SC2.

Incomplete Basing Point Pricing

Incomplete basing point pricing (the weaker form of basing point pricing), was rejected in a majority of the cases. However, there was some anecdotal evidence of incomplete basing point for all products. For PST, 14 percent of the market (25 regions) practiced some form of basing point pricing while 13 and 18 percent practiced some form of basing point pricing in the markets for CNS and PPW respectively. Recall that collusive basing point pricing can be complete (in which case the whole market is involved in a collusion) or incomplete (in which case only a section of the market is a involved in a collusion (cartel). Since basing point pricing was not widespread and did not cover the whole market, we conclude that some form of a cartel is being operated.

Long-Run Price Integration (F.O.B.)

Long-run price matching (F.O.B.) was not rejected in a number of markets. There was evidence of F.O.B. pricing in about 33 percent of the market for PST, 21 percent for CNS and 6 percent for PPW. The higher valued products tend to exhibit more F.O.B. pricing than the lower valued products - consistent with our theory.

Recall from Table 4 that PST is the most valued of the three products, followed by CNS. PST prices averaged two times the prices of PPW while CNS averaged one and a half times the price of PPW. Therefore, the observation that PST has more F.O.B. pricing regions than both

CNS and PPW is consistent with our a priori expectations that higher valued products are more likely to exhibit F.O.B. pricing (because the opportunities for arbitrage profits are higher) than lower valued products. In other words, for the same percentage change in prices, opportunities for arbitrage profits increase more for the higher valued timber product than the lesser valued timber products.

Market Efficiency

There is no complete spatial market integration for any of the three products in the sense of F.O.B. pricing. This can be seen from the fact that no product has all market regions pricing F.O.B. However since there are more PST markets characterized by F.O.B. pricing than CNS and PPW, the evidence suggests that PST markets are more efficient than those for CNS and PPW, probably due to arbitrage. This argument is supported by the fact that CNS and PPW markets are characterized by more non-competitive pricing behaviors/schemes than those of PST. It must however be noted that the fact that PST has more markets that price F.O.B. than CNS and PPW (or less markets that price non-competitive than CNS and PPW) does not mean that PST is an efficient market. There are more regional markets for PST that do not subscribe to F.O.B. It is an efficient market relative only to CNS and PPW.

4.2.2 Determinants of Spatial Market Integration and Validation of Market Integration Tests

So far, the results from the pricing behavior tests are consistent with predictions of our theoretical model - higher valued products are more likely to price F.O.B. than lower valued products, assuming the same transportation costs. But as stated earlier, failure to reject the null hypothesis of a particular pricing behavior is not enough evidence to conclude that the null is not rejected or as to the validity of the market integration test imposed on the model. For instance, the results may not be valid if the market integration tests do not maintain a certain minimum empirical relation with factors deemed to be determinants of pricing behaviors in spatial markets - important amongst them is the distance between the markets. We therefore provide further evidence on the validity of our model and tests by estimating model (38), as described earlier. The model was run using both Poisson and Gamma distributions in a quasi maximum likelihood optimization framework. The results are qualitatively similar for both estimation procedures. We report the results from the Poisson distribution in Table 6 and those of the gamma distribution in Table 7.

Since our dependent variable is the Wald-Statistic (chi-square) from the pricing behavior test, a positive parameter estimate will increase the chi-square (decrease the p-value), which reduces the likelihood of that particular test being accepted. Positive parameter estimates therefore imply a decrease in the likelihood of observing the posited pricing behavior, and vice versa.

Table 6: Poisson GLM Quasi Maximum Likelihood Estimates

	F.O.B	Price Discrimination	Complete BPP	Incomplete BPP
Distance	0.000467*	-0.000577***	0.000365	0.00175***
	(0.028)	(0.001)	(0.109	(0)
Concentration Home	-0.0000213	0.0000125	-0.0000374*	0.000121***
	(0.233)	(0.423)	(0.036)	(0)
Concentration Away	0.0000295	-0.00000464	0.000036	0.000165***
	(0.222)	(0.74)	(0.106)	(0)
Volume Home	0.00000161	0.00000281	-0.00000312	0.000001.16***
	(0.176)	(0.746)	(0.072)	(0)
Volume Away	-0.0000028	0.0000001.14	-0.0000009.78	0.000007.31
	(0.053)	(0.907)	(0.576)	(0)
PSTD Dummy	-0.385***	-0.498***	-0.724***	0.0285
	(0)	(0)	(0)	(0.811)
PPWD Dummy	-0.542***	0.0372	0.225*	-0.0114
	(0)	(0.637)	(0.024)	(0.921)
Constant	2.516***	2.245***	4.681***	3.220***
	(0)	(0)	(0)	(0)
N	520	520	520	520

p-values in parentheses * p<0.05, ** p<0.01, *** p<0.001

Table 7: Gamma GLM Quasi-Maximum Likelihood Estimates

	F.O.B	Price Discrimination	Complete BPP	Incomplete BPP
Distance	0.0000382*	-0.000114***	-0.0000034	0.000650***
	(0.024)	(0)	(0.115)	(0.001)
Concentration Home	0.00000198	0.0000035	0.000000365*	-0.0000334*
	(0.239)	(0.069)	(0.034)	(0.037)
Concentration Away	-0.00000209	0.00000616***	-0.000000312	0.0000364
	(0.227)	(0.001)	(0.094)	(0.123)
Volume Home	-0.000001.2	0.000000295**	0.000000298	0.00000155
	(0.205)	(0.004)	(0.059)	(0.252)
Volume Away	0.000000274*	0.00000327**	0.000000112	-0.00000239
	(0.028)	(0.004)	(0.514)	(0.083)
PSTD Dummy	0.0301***	0.0904***	0.0104***	-0.307***
	(0)	(0)	(0)	(0.001)
PPWD Dummy	0.0463***	0.0054	-0.00190*	-0.347***
	(0)	(0.526)	(0.022)	(0)
Constant	0.0797***	0.102***	0.00909***	3.220***
	(0)	(0)	(0.001)	(0)
N	520	520	520	520

p-values in parentheses: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Distance between markets

For F.O.B. pricing, we observe that distance has the expected a priori expected sign and also is significant at the 5 percent level. This means that as the distance between markets increases, we are less likely to observe efficient spatial market integration (F.O.B.). This finding is consistent with our theory that market integration decays with distance i.e. opportunities for arbitrage diminish with increasing distance.

Firms in spatial markets hold market power due to their geographic locations. Therefore, as the distance between markets increases (assuming that suppliers are uniformly distributed over that distance), we will expect price discrimination to increase. This prediction is confirmed by our empirical test, which has the expected a priori sign and also is significant at the 1 percent level.

Complete basing point pricing, by its very nature, is not expected to depend on distance. Therefore, for there to be support for our test of basing point pricing, we expect that distance between markets should not be a significant determinant of the observed pricing behavior. This also is confirmed by our estimates.

Finally, incomplete basing point pricing arising from collusion should not depend significantly on distance between the markets. However, if there is no perfectly functioning basing point pricing system that encompasses the whole market (in which case we are talking about a cartel), then distance may be a significant determinant of the feasibility of that system. As distance between cartel members increase, the incentives to cheat also increase (because of less supervision). Therefore, one will expect incomplete basing point pricing to decrease with increases in distance as confirmed, by our estimates.

Volume of output

The volume of timber production did not have significant influences on F.O.B. pricing, price discrimination and the theory of complete basing point pricing. However, high volume in the home market was found to be negatively related to incomplete basing point pricing. A possible explanation is that, if the volume of output available to a "home" firm increases, it has less incentive to maintain a collusive agreement because they can do better by discrimination.

Concentration

Concentration of mills at home did not have a significant effect in explaining F.O.B. pricing or price discrimination. However, concentration at home was found to be significantly and positively related to perfect basing point pricing and negatively related to incomplete basing point pricing. Concentration in the "away" market also was found to have a significantly negative effect on incomplete basing point pricing alone.

4.2.3 Cointegration Tests of Market Integration

The results of the Engel - Granger cointegration tests are presented in Table 18 19 and 20 for CNS, PPW and PST, respectively. We summarize these results in Table 8 where we present the number of markets deemed to be cointegrated by the tests and the corresponding market percentages. We also estimated the model for a different time period (1982 to 2004), but the results were the same both qualitatively and quantitatively, thus suggesting that the cointegration relation between these markets has been stable.

Table 8: Summary of Cointegration Results

Product	Total Regions	Cointegrated Markets	Percentage Cointegrated
PST	181	84	46
CNS	155	78	50
PPW	181	130	72

By the bivariate cointegration tests, the whole of the southeast south-central regions of the United States is not one market for any of the three products. However, the results do indicate varying degrees of integration for the various products. Market integration is found to range between 46 and 72 percent of the markets depending on the product considered. Pine Pulpwood markets are more integrated than both Pine Saw Timber and Pine Chip and Saw. The least integrated of the markets, as suggested by cointegration tests, is Pine Saw Timber. These results support results by previous studies of the industry, such as Bingham et al. (2003), for PPW. But do the results suggested by cointegration tests support what is expected from economic theory and our theoretical model?

4.2.4 Comparison of Results: GMM Dynamic Time Series and Cointegration

The results of the cointegration tests suggest that more market regions were integrated than were suggested by the F.O.B. tests imposed on our dynamic time series model for each of the products. Furthermore, we observe that, contrary to a priori expectations, the lower valued product (PPW) has more integrated market regions than the higher valued product (PST). Since most timber market studies use cointegration analysis to test for market integration, it can be concluded that PPW markets are more integrated than PST markets even though theory suggests that the reverse should be the case, especially if arbitrage is deemed to be the error correction mechanism.

The implication of this result is that some basing point price regions that have been stable over a long period probably tested positive for cointegration and thus were assessed wrongly as comprising integrated markets. Table 9 helps investigate this point further. It is clear from the table that a substantial number of the price regions that were deemed to be practicing basing point pricing are also found to be cointegrated. Between 55 and 65 percent of all basing point price regions also were cointegrated. This suggests the possibility that some of the basing point price regions were wrongly considered to be competitively integrated, especially insofar as the cointegrated results contradict theoretical expectations.

Table 9: Comparison: Cointegrated and BPP Markets

PRODUCT	(A)	(B)	(C)	(D)
	F.O.B. % (#)	Cointegrated % (#)	BPP % (#)	Common: Coint & BPP % (#)
PST	33(60)	46 (84)	14 (25)	56 (14)
CNS	21(32)	50 (78)	13 (20)	65 (13)
PPW	6(10)	72 (130)	33 (18)	55 (18)

In conclusion, while cointegration is consistent with price integration, spatial price integration is not the same as spatial market integration. The latter necessarily requires arbitrage (movement of physical quantities of the product between markets). Therefore, testing competitive market integration by relying only on cointegration may be misleading.

4.3 Summary

We tested the theoretical predictions of our model in this chapter. We find that there is not a single market for any of the three products in the southeast southcentral regions considered in this study. However, consistent with our theory, we find more F.O.B. price relations in the higher valued product market (PST) than the lesser valued products markets (PPW and CNS). Testing the validity of our empirical tests, we find that all four pricing behavior tests had the expected sign and magnitude.

We then tested market integration using conventional cointegration analysis. The results from the cointegration analysis also showed that not a single market exist for any of the three products. However, contrary to our theory, there were more cointegration relations for the lesser valued product than the higher valued product. This tended to imply that the lesser valued product markets are more integrated than the higher valued product markets - a puzzle. To solve the puzzle, we inspected the cointegrated markets and compared them with those of basing point markets. This exercise revealed that between 55 to 65 percent of the markets that are deemed to be practicing some form of basing point pricing also are deemed to be cointegrated. This possibly solves the puzzle - some basing point price regions are also cointegrated and thus considered integrated when they are not.

CHAPTER V

CONCLUSION

5.1 Introduction

The economic importance of the forestry industry cannot be underestimated. In many countries it provides income and important job opportunities, especially so in rural areas. The role of the industry means that there is the need for efficient forest product markets so that its societal benefits will be maximized. The degree and extent to which spatial markets are integrated has several implications for public policy. The degree of integration can give an indication as to the competitive nature of the markets. If it is shown that markets are not competitive, then policy measures can be taken to correct the imperfections and ensure optimal resource allocation. On the other hand, if there is significant competitive spatial integration between markets, then any policy intervention will lead only to welfare losses and negatively affect all participating agents in the market. Another important implication is that the lack of integration between markets is not enough evidence to conclude that firms in the industry are violating anti-trust rules. In the presence of spatial market power, we observe that firms may have an incentive to engage in spatial price discrimination. Spatial price discrimination even though not as efficient as F.O.B. pricing is still superior to a single price monopoly or collusion by firms.

5.2 Summary of Findings

In this dissertation, we begun by asking: Are timber markets for three timber products (PST, PPW and CNS) for seven U.S. states in the southeast and south central integrated? What is the market structure and the pricing behavior that characterize these products markets? And, finally, can price cointegrations or correlations be interpreted to be indicative of the degree of competitive market integration for these three products? We sought answers to these questions through a combination of theoretical and empirical models.

We set out by modeling the economic impacts of oligopsony in the procurement of timber products, assuming that there are significant intra-regional transportation costs for timber. We find that

- The extent of spatial market integration will be limited by significant transfer costs and increasing distance between markets.
- The distance between markets provides firms with an economic incentive to price non-competitively. The incentive to price discriminate rises as firms realize that their nearest rival was faraway. Firms also had an incentive to adopt some form of collusive basing point pricing given the significant transportation costs of the product. Basing point pricing could have empirical properties similar to most conventional methods of testing for spatial timber market integration. This thus suggests that price cointegrations may not necessarily imply market integration.
- Finally, given the significance of transportation costs, our model predicted that higher valued products are more likely to be competitively integrated than those for lower valued products because opportunities for arbitrage profits are higher with the former than with the latter.

We next use a combination of statistical methods to test the predictions of our model empirically using data on the three timber products. The empirical analysis showed that

- There was no evidence to support the claim that the southeast south-central states considered in this study constituted a single integrated market for any of the three products. However, bivariate market integration tests provided support for market integration between pairs of regions. There was 33 percent market integration in PST markets, 21 percent in CNS and 6 percent in PPW.
- From the market integration tests, we observed that in support of our theoretical model, the higher valued products have greater degrees of market integration than the lesser valued products.
- Price discrimination as a possible explanation of pricing behaviors in some market pairs could not be rejected. There was evidence of spatial price discrimination in 20 percent of PST markets, 24 percent of CNS markets and 19 percent of PPW markets.
- Between 13 to 18 percent of the price series could not reject the hypothesis that basing point pricing possibly explains the trajectory of observed prices with the most basing point regions occurring in PPW (18 percent).

To validate these the tests of pricing behaviors and market integration, we examined the factors that possibly explain the pricing behavior observed and found that

- distance (transportation costs) had the expected sign and magnitude for all of the pricing behavior tests.
- Market concentration also had the expected sign and magnitude for the pricing behavior tests.
- Timber volume was not significant in explaining most of the tests

To answer the question empirically as to whether price correlations or cointegrations in timber markets imply market integration, we tested for cointegration for all market pairs and examined the results for theoretical consistencies. We find that

- cointegration analysis suggested that more market pairs were integrated than found using the multivariate dynamic time series model with integration running from 46 percent (PST) to 72 percent (PPW) compared to the 6 to 33 percent that we had using the multivariate dynamic time series model.
- However, examining the cointegration results for theoretical correctness revealed that the lesser valued product markets (PPW, in particular) were deemed to be more integrated than the higher valued product markets (PST). This is at variance with our model prediction that higher valued markets should be more integrated than those for lesser valued products.
- Since theory showed that BPP could have empirical properties similar to other conventional methods of market integration tests, such as cointegration, we proceeded to compare the BPP regions with the cointegration regions to see if there were any regions common to the two. We find that between 55 to 65 percent of the regions that were found to exhibit signs of basing point pricing also were cointegrated. Given that the cointegration results are at variance with theory, we lean towards the conclusion that some BPP regions were wrongly considered to be integrated markets by conventional methods using cointegration tests. By this account, we conclude that price correlations or cointegrations do not necessary imply market integration.

5.3 Policy Implications

This dissertation has important implications for industrial policy and anti-trust law, especially with the recent wave of anti-trust violation charges brought against some major players (buyers) in the market. It provides evidence to support the argument that in spatial markets, it is unlikely that firms will price F.O.B. throughout the whole market. Therefore, public policy towards businesses that are informed by the assumption that prices are quoted F.O.B. may be misleading, especially if competitors are located further away. Firms may have an incentive to price discriminate in spatial markets as distance increases between buyers and sellers, yet if care is not taken, this may be misconstrued as collusion; policies based on this conclusion may have unintended consequences. For instance, in an econometric study of an Ohio price-fixing case, the authors inferred that a collusive basing point pricing was in place based on evidence that some sellers of dairy products closer to a school district submitted contract bids for supplying milk that were higher than diaries further away from that school district. They claim that if competition characterized the pricing and bidding behaviors of firms, then bids should have been an increasing function of distance. While it is possible that firms could be colluding and territorially segmenting the markets in which they competed, the pricing behaviors of the firms also are consistent with spatial price discrimination where firms exploit their market power over customers closer to them while they compete for those further away. In this case, prices will be a decreasing function of distance.

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LIST OF APPENDICES

APPENDIX A

Omitted Equations

Market Supply functions and price functions for Y and Z

When $i = Y$, then

$$Q_{TY} = \frac{b}{v+1}\left[2\left[\frac{v}{b}\left(P_{TY}+a\right)\right]^{\frac{v+1}{v}} - \left[\frac{v}{b}\left(P_{TY}+a-(D-G)\right)\right]^{\frac{v+1}{v}} - \left[\frac{v}{b}\left(P_{TY}+a-(D-H)\right)\right]^{\frac{v+1}{v}}\right] \quad (17)$$

When $i = Z$

$$Q_{TZ} = \left\{-\frac{b}{v+1}\left[\frac{v}{b}\left(P_{TX}-u+a\right)\right]^{\frac{v+1}{v}}\right\}_0^H \quad (18)$$

Using the following profit function combined with the boundary conditions below

$$\pi_i = (P - P_{Ti})\left\{-\frac{b}{v+1}\left[\frac{v}{b}\left(P_{Ti}-u+a\right)\right]^{\frac{v+1}{v}}\right\}_k^l - Fi \quad (19)$$

$$G = \frac{1}{2}(P_{TX} - P_{TY} + D) \quad (20)$$

$$H = \frac{1}{2}(P_{TZ} - P_{TY} + D) \quad (21)$$

The price reaction functions for Y and Z can thus be specified as

$$P_{TY} = \left(a, b, v, mfc, G, H, \frac{dG}{dP_{TY}}, \frac{dH}{dP_{TY}}\right) \quad (22)$$

$$P_{TZ} = \left(a, b, v, mfc, H, \frac{dH}{dP_{TZ}}\right) \quad (23)$$

Augmented Dickey-Fuller Test

$$\Delta Y_t = \alpha_0 + \alpha_1 T + \delta Y_{t-1} + \sum_{i=1}^{k}\beta_i \Delta Y_{t-i} + e_t$$

APPENDIX B

Price Discrimination Graphical illustration

Discriminatory pricing and F.O.B. pricing (Red dotted lines are the discriminatory price schedules)

Received Price

Received Price

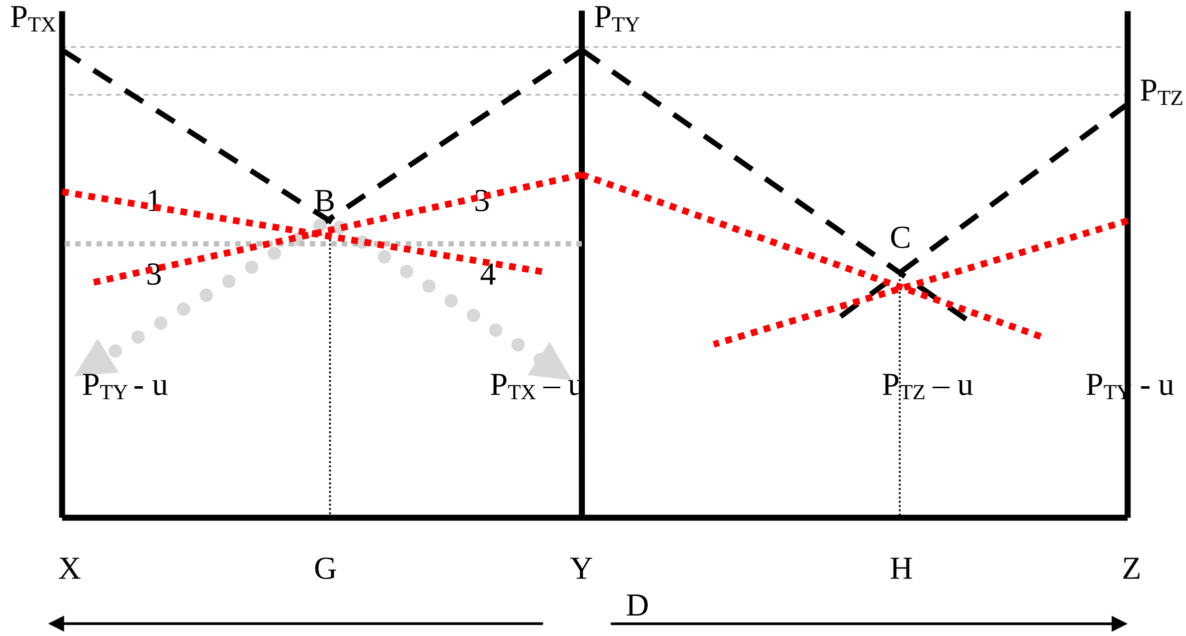

Figure 5: Spatial Price Discrimination

APPENDIX C

Tables and Some Results

Table 10: Timber Imports and Exports Trends by Species and Major Trade Partners

	1990		1995		1996 - 2000		2001 - 2005		2006 - 2007	
PRODUCT	Bd Ft. (Millions)	Percent of total	Bd Ft. (Millions)	Percent of total	Bd Ft. (Millions)	Percent of total	Bd Ft. (Millions)	Percent of total	Bd Ft. (Millions)	Percent of total
IMPORTS										
Lumber, total	13063	100	17524	100	19019	100	23018	100	24422	100
Softwoods	12831	98	17169	98	18474	97	22187	96	23953	98
Hardwoods	232	2	354	2	545	3	824	4	447	2
Total share: Canada	11925	91	17015	97	18049	95	20334	88	21369	88
Logs, total	23	100	80	100	231	100	528	100	502	100
Softwoods	13	57	55	69	190	79	459	87	459	92
Hardwoods	10	44	26	33	41	21	69	13	43	8
Total share: Canada	19	84	56	70	207	89	500	95	441	88
EXPORTS										
Lumber, total	4623	100	2958	100	2654	100	2619	100	2632	100
Softwoods	3753	81	1872	63	1479	55	922	37	1029	39
Hardwoods	813	18	1057	36	1171	45	1635	60	1297	49
To: Canada	647	14	651	22	666	25	637	24	724	28
Japan	1294	28	979	33	545	21	201	8	105	4
Europe	694	15	503	17	547	21	386	15	421	16
Logs, total	4213	100	2820	100	2224	100	2104	100	2154	100
Softwoods	3994	95	2552	91	1880	84	1546	74	1654	77
Hardwoods	219	5	268	10	343	16	558	26	500	23
To: Canada	396	9	716	25	750	34	1065	51	1025	48
Japan	2625	62	1729	61	1199	54	659	31	558	26
China: ainlnd	362	9	20	1	10	1	52	3	127	6

Source: Computed from: U.S. Timber Production, Trade, Consumption, and price Statistics, 1965 – 2005 Research Paper RP-FPL-637

Table 11: Timber Damage Volume (million ft3) and Dollar Impacts of Six U.S. Hurricanes

	Camille 1969	Hugo 1989	Frances 2004	Ivan 2004	Katrina 2005	Rita 2005	TOTAL HURRICANES
Softwood							
South Carolina	0	1008	0	0	0	0	1008
Florida	0	0	87	208	0	0	295
Mississippi	216	0	0	0	619	0	835
Louisiana	0	0	0	0	287	296	583
Alabama	0	0	0	603	126	0	729
Texas	0	0	0	0	0	239	239
Total Softwood							3689
Hardwood							
South Carolina	0	319	0	0	0	0	319
Florida	0	0	58	94	0	0	152
Mississippi	74	0	0	0	426	0	500
Louisiana	0	0	0	0	193	177	370
Alabama	0	0	0	414	91	0	505
Texas	0	0	0	0	0	293	293
							2139
Total Timber (Softwood and Hardwood)							
South Carolina	0	1327	0	0	0	0	1327
Florida	0	0	145	302	0	0	447
Mississippi	290	0	0	0	1044	0	1334
Louisiana	0	0	0	0	480	473	953
Alabama	0	0	0	1017	216	0	1233
Texas	0	0	0	0	0	532	532
	290	1327	145	1319	1740	1005	5826
Softwood portion of damaged volume Percent							
	74	76	60	61	54	53	
Study States: Percent of damage							
Softwood	100	100	100	100	100	55	94
Hardwood	100	100	100	100	100	37.66	86
Total	100	100	100	100	100	47.07	91

Timber value damaged (Price x Quantity) (Millions of 2005 dollars)							
Sawtimber value lost	177	494	153	2094	1600	504	5022
Pulpwood value lost	25	136	9	83	113	32	398
All products	202	630	162	2177	1713	536	5420
Total	404	1260	324	4354	3426	1072	10840

Table 12: ADF Unit Roots Tests

	LEVELS			FIRST DIFFERENCES			MACKINNON CRITICAL VALUES		
REGION	PST	PPW	CNS	PST	PPW	CNS	0.01	0.05	0.1
AL1	-0.857	-2.501	-1.015	-5.55	-6.572	-5.548	-4.032	-3.447	-3.147
AL2	-1.561	-2.565	-0.822	-5.945	-6.004	-6.042	-4.032	-3.447	-3.147
AR1	-1.697	-3.314	-1.927	-5.813	-6.475	-6.184	-4.032	-3.447	-3.147
AR2	-1.292	-3.052		-5.438	-6.054		-4.032	-3.447	-3.147
FL1	-1.422	-2.202	-0.386	-5.874	-4.558	-5.026	-4.032	-3.447	-3.147
FL2	-1.604	-1.862	-0.429	-5.527	-5.122	-5.786	-4.032	-3.447	-3.147
GA1	-0.67	-2.313	-0.433	-5.465	-6.291	-5.717	-4.032	-3.447	-3.147
GA2	-0.055	-2.475	0.212	-5.536	-5.043	-6.033	-4.032	-3.447	-3.147
LA1	-1.695	-3.229	-1.616	-5.159	-5.074	-3.516	-4.032	-3.447	-3.147
LA2	-1.728	-2.606	-1.614	-5.491	-6.004	-4.49	-4.032	-3.447	-3.147
MS1	-1.339	-3.4	-0.715	-5.14	-7.369	-5.514	-4.032	-3.447	-3.147
MS2	-1.83	-3.228	-1.642	-6.43	-5.498	-6.459	-4.032	-3.447	-3.147
SC1	-1.352	-2.571	-1.74	-6.43	-5.258	-5.733	-4.032	-3.447	-3.147
SC2	-0.963	-2.424	-0.985	-5.962	-6.666	-5.784	-4.032	-3.447	-3.147

Table 13: Mean Growth Rates of Prices by Period

	1976q4 to 1982q2			2004q3 to 2009q2			1982q3 to 2004q3		
Region	**PST**	**CNS**	**PPW**	**PST**	**CNS**	**PPW**	**PST**	**CNS**	**PPW**
AL1	0.016	0.024	0.014	-0.015	-0.016	0.005	0.011	0.008	0.003
AL2	0.015	0.011	0.016	-0.014	-0.013	0.01	0.009	0.007	0.001
AR1	0.013	0.005	0.02	-0.019	-0.017	0.012	0.009	0.01	0.002
AR2	0.015	Na	0.016	-0.016	na	0.009	0.009	na	0.002
FL1	0.014	0.014	0.019	-0.013	-0.018	0.005	0.009	0.006	0.002
FL2	0.02	0.02	0.015	-0.006	-0.012	0.007	0.008	0.006	0.001
GA1	0.018	0.022	0.01	-0.016	-0.015	-0.002	0.012	0.007	0.005
GA2	0.013	0.005	0.018	-0.014	-0.016	0.008	0.009	0.007	0.002
LA1	0.012	0.005	0.025	-0.025	-0.019	0.001	0.009	0.009	0.004
LA2	0.016	0.012	0.015	-0.005	-0.005	0.007	0.007	0.006	0.003
MS1	0.017	0.011	0.014	-0.01	-0.012	0.009	0.01	0.008	0.004
MS2	0.019	0.011	0.014	-0.009	-0.004	0.008	0.008	0.006	0.002
SC1	0.014	0.03	0.009	-0.007	-0.002	0.007	0.011	0.006	0.004
SC2	0.012	0.006	0.016	-0.009	-0.005	0.008	0.008	0.005	0.003
AVERAGE	**0.015**	**0.014**	**0.016**	**-0.013**	**-0.012**	**0.007**	**0.009**	**0.007**	**0.003**

Growth rates (Percentage changes in prices) are in decimals and not percentages

Table 14: Summary Statistics of Determinants of Market Integration and Others

Variable	Obs	Mean	Std. Dev.	Min	Max
CHI-SQUARE					
FOB Pricing	520	11.05519	10.98307	0	67.57
Complete BPP	520	90.53215	104.3358	0.02	700.04
Incomplete BPP	520	26.41923	24.2891	0.18	141.73
Price Discrimination	520	6.875135	5.200201	0	32.1
P-VALUES					
FOB Pricing	520	0.1092502	0.2120612	0	0.9829
Complete BPP	520	0.0044438	0.0281078	0	0.3521
Incomplete BPP	520	0.0403577	0.1235822	0	0.9134
Price Discrimination	520	0.2698231	0.2672421	0	0.9985
CONCENTRATION					
Concentration: 1983	520	3758.953	2517.813	1083.577	10000
Concentration: 2004	520	4154.435	2735.666	1142.39	10000
All Period Concentration	520	3956.694	2493.503	1112.984	10000
VOLUME					
Total Timber	520	83600000	52100000	8477010	200000000
Total Softwood Timber	520	59500000	39200000	4752927	160000000
Volume Total Wood	520	83600000	52100000	8477010	0
Volume Softwood	520	59500000	39200000	4752927	60000000
Distance: Home and Away	520	427.8173	209.2253	63	892
PRICING BHVR ACCEPTED					
FOB Pricing	520	34		10	60
Complete Basing Point Pricing	520	4		0	9
Incomplete BPP	520	26		20	33
Price Discrimination	520	36		35	37

Table 15: CNS Pricing Behavior Tests

REGION HOME(Y)	REGION AWAY(X)	FOB		Price Discrim		Incomplete BPP		Complete BPP	
		Wald Stat	P-Value	Wald Stat	P-Value	Wald Stat	P-Value	Wald Stat	P-Value
AL1	AL2	8.85	0.0029	5.89	0.2072	16.61	0.0002	66.92	0
AL1	AR1	10.38	0.0013	10.67	0.0305	36.42	0	57.25	0
AL1	FL1	0.96	0.3273	11.86	0.0184	1.54	0.4627	19.4	0.007
AL1	FL2	18.9	0	8.01	0.0912	44.39	0	74.72	0
AL1	GA1	3.95	0.0468	6.33	0.1755	10.12	0.0063	78.62	0
AL1	GA2	4.83	0.028	2.53	0.6389	14.85	0.0006	48.37	0
AL1	LA1	9.22	0.0024	1.44	0.8378	35.3	0	128.84	0
AL1	LA2	10.87	0.001	5.57	0.2334	19.11	0.0001	98.26	0
AL1	MS1	5.66	0.0173	9.17	0.0569	10.19	0.0061	46.79	0
AL1	MS2	9.71	0.0018	4.21	0.3785	21.9	0	35.33	0
AL1	SC1	5.58	0.0182	4.75	0.314	12.02	0.0025	34.92	0
AL1	SC2	7.05	0.0079	4.04	0.4002	17.22	0.0002	56.06	0
AL2	AL1	0.94	0.333	20.75	0.0004	5.47	0.0649	120.13	0
AL2	AR1	37.08	0	5.5	0.2396	73.37	0	136.22	0
AL2	FL1	2.85	0.0912	3.62	0.46	4.06	0.1311	54.82	0
AL2	FL2	25.05	0	10.4	0.0341	25.05	0	84.26	0
AL2	GA1	12.09	0.0005	0.48	0.9755	26.34	0	102.34	0
AL2	GA2	25.18	0	11.63	0.0203	25.39	0	82.69	0
AL2	LA1	11.6	0.0007	6.95	0.1386	28.45	0	179.64	0
AL2	LA2	44.12	0	7.85	0.0974	75.4	0	206.59	0
AL2	MS1	23.39	0	2.13	0.711	24.54	0	67.03	0
AL2	MS2	14.33	0.0002	6.89	0.1419	14.46	0.0007	86.34	0
AL2	SC1	12.09	0.0005	3.16	0.5316	17.83	0.0001	168.88	0
AL2	SC2	14.66	0.0001	12.31	0.0152	24.56	0	52.49	0
AR1	AL1	0	0.979	6.49	0.1654	3.01	0.2224	24.09	0.0011
AR1	AL2	6.22	0.0126	4.3	0.3667	17.57	0.0002	52.52	0
AR1	FL1	7.88	0.005	10.36	0.0348	30.74	0	43.89	0
AR1	FL2	0.4	0.5279	15.28	0.0042	0.57	0.7513	16.93	0.0179
AR1	GA1	0.36	0.5472	1.43	0.8386	11.75	0.0028	45.18	0
AR1	GA2	1	0.3169	2.82	0.5886	2.69	0.26	15.2	0.0335
AR1	LA1	0.69	0.4059	9.11	0.0583	11.51	0.0032	73.98	0
AR1	LA2	10.65	0.0011	12.82	0.0122	19.48	0.0001	36.69	0
AR1	MS1	9.43	0.0021	3.4	0.4926	16.2	0.0003	33.92	0
AR1	MS2	0.01	0.9286	30.49	0	5.81	0.0548	57.71	0

AR1	SC1	0.74	0.3884	2.19	0.7012	11.18	0.0037	25.95	0.0005
AR1	SC2	9.55	0.002	7.65	0.1054	11.75	0.0028	15.44	0.0086
FL1	AL1	2.12	0.1451	6.78	0.1481	5.87	0.0531	27.11	0.0003
FL1	AL2	10.11	0.0015	6.37	0.1733	24.91	0	95.92	0
FL1	AR1	67.57	0	7.19	0.1262	141.73	0	166.63	0
FL1	FL2	3.02	0.0822	18.23	0.0011	5.37	0.0683	23.24	0.0015
FL1	GA1	3.57	0.0589	2.02	0.7319	33.65	0	107	0
FL1	GA2	5.63	0.0176	0.42	0.9808	9.79	0.0075	45.37	0
FL1	LA1	17.85	0	3.02	0.5546	69.04	0	256.98	0
FL1	LA2	16.9	0	6.37	0.173	23.62	0	44.27	0
FL1	MS1	21.07	0	5.97	0.2013	26.85	0	88.87	0
FL1	MS2	5.38	0.0203	3.66	0.4543	18.48	0.0001	78.48	0
FL1	SC1	10.9	0.001	3.12	0.5381	41.03	0	85.04	0
FL1	SC2	18.16	0	5.33	0.2555	18.64	0.0001	16.47	0.0056
FL2	AL1	30.96	0	11.68	0.0199	45.5	0	161.19	0
FL2	AL2	8.14	0.0043	5.9	0.2069	70.93	0	163.09	0
FL2	AR1	7.99	0.0047	16.82	0.0021	68.16	0	97.22	0
FL2	FL1	5.25	0.022	15.17	0.0044	5.35	0.069	25.23	0.0007
FL2	GA1	6.31	0.012	2.51	0.6422	17.93	0.0001	83.2	0
FL2	GA2	0.03	0.8682	7.09	0.1313	13.2	0.0014	57.07	0
FL2	LA1	25.3	0	6.22	0.1831	75.99	0	269.12	0
FL2	LA2	2.94	0.0867	3.48	0.4811	36.61	0	101.03	0
FL2	MS1	0.08	0.7748	10.62	0.0311	12.73	0.0017	59.89	0
FL2	MS2	23.65	0	3.57	0.467	32.04	0	79.01	0
FL2	SC1	16.11	0.0001	4.52	0.3405	25.24	0	58.01	0
FL2	SC2	0.41	0.5215	6.09	0.1925	3.59	0.166	17.91	0.0031
GA1	AL1	22.12	0	6.32	0.1765	24.58	0	106.3	0
GA1	AL2	25.71	0	2.18	0.702	37.51	0	114.24	0
GA1	AR1	43.09	0	7.57	0.1085	69.15	0	155.93	0
GA1	FL1	19.82	0	0.3	0.9901	19.85	0	106.55	0
GA1	FL2	23.82	0	6.32	0.1763	24.55	0	81.08	0
GA1	GA2	0.03	0.8645	2.38	0.6666	1.3	0.5215	68.75	0
GA1	LA1	34.3	0	16.09	0.0029	51.69	0	493.41	0
GA1	LA2	26.87	0	3.07	0.5459	27.82	0	116.86	0
GA1	MS1	24.42	0	4.51	0.3414	30.99	0	103.44	0
GA1	MS2	30.89	0	12.58	0.0135	60.35	0	113.72	0
GA1	SC1	28.07	0	8.22	0.0837	41.23	0	104.49	0
GA1	SC2	14.06	0.0002	30.99	0	14.33	0.0008	96.65	0
GA2	AL1	28.8	0	13.3	0.0099	78.43	0	109.63	0
GA2	AL2	18.04	0	5.04	0.2833	32.23	0	229.55	0
GA2	AR1	36.78	0	7.52	0.1107	100.52	0	145.26	0
GA2	FL1	9.69	0.0019	5.27	0.2602	11.21	0.0037	76.2	0

GA2	FL2	32.1	0	11.72	0.0196	40.23	0	104.8	0
GA2	GA1	7.6	0.0058	23.05	0.0001	10.22	0.006	116.35	0
GA2	LA1	49.56	0	4.06	0.3975	133.35	0	347.16	0
GA2	LA2	21.84	0	1.75	0.7818	75.48	0	117.02	0
GA2	MS1	28.13	0	4.5	0.3431	38.71	0	68.21	0
GA2	MS2	35.37	0	8.02	0.0909	38.86	0	112.77	0
GA2	SC1	24.82	0	9.7	0.0457	34.31	0	93.48	0
GA2	SC2	33.35	0	12.51	0.014	95.59	0	131.51	0
LA1	AL1	8.45	0.0037	3.62	0.4606	10.66	0.0049	90.14	0
LA1	AL2	11.24	0.0008	6.93	0.1398	12.39	0.002	127.35	0
LA1	AR1	22.09	0	10.73	0.0298	36.29	0	78.07	0
LA1	FL1	7.23	0.0072	0.11	0.9985	8.24	0.0162	95.81	0
LA1	FL2	18.98	0	0.13	0.998	20.68	0	98.92	0
LA1	GA1	7.05	0.0079	0.65	0.9579	9.05	0.0108	129.25	0
LA1	LA1	8.01	0.0046	7.77	0.1002	28.37	0	115.31	0
LA1	LA2	7.06	0.0079	12.95	0.0115	7.74	0.0209	52.65	0
LA1	MS1	9.08	0.0026	1.77	0.7778	9.52	0.0086	114.35	0
LA1	MS2	6.65	0.0099	5.95	0.2026	7.05	0.0294	52.36	0
LA1	SC1	7.3	0.0069	3.28	0.5122	27.86	0	100.46	0
LA1	SC2	10.5	0.0012	4.6	0.3305	11.45	0.0033	52.8	0
LA2	AL1	16.94	0	7.46	0.1134	40.15	0	145.77	0
LA2	AL2	19.34	0	2.49	0.6473	53.49	0	114.39	0
LA2	AR1	30.2	0	6.83	0.1451	131.1	0	183.87	0
LA2	FL1	3.69	0.0547	3.23	0.5202	5.44	0.0659	38.38	0
LA2	FL2	20.86	0	2.05	0.7269	31.91	0	55.4	0
LA2	GA1	1.99	0.1579	5.52	0.238	17.08	0.0002	71	0
LA2	GA2	3.93	0.0475	8.15	0.0862	4.63	0.0989	29.69	0.0001
LA2	LA1	7.54	0.006	11.16	0.0249	51.69	0	195.32	0
LA2	MS1	4.99	0.0254	8.29	0.0816	32.02	0	54.44	0
LA2	MS2	16.71	0	2.18	0.7029	18.47	0.0001	54.29	0
LA2	SC1	15.12	0.0001	4.65	0.3253	32.66	0	65.69	0
LA2	SC2	15.26	0.0001	13.88	0.0077	48.99	0	86.23	0
MS1	AL1	6.28	0.0122	6.45	0.1678	10.44	0.0054	84.01	0
MS1	AL2	26.65	0	1.43	0.8392	75.77	0	123.4	0
MS1	AR1	27.11	0	2.94	0.5683	88.3	0	224.68	0
MS1	FL1	15.9	0.0001	7.15	0.1284	37	0	95.31	0
MS1	FL2	25.56	0	1.65	0.7995	28.02	0	100.9	0
MS1	GA1	5.31	0.0212	3.22	0.5218	37.15	0	146.54	0
MS1	GA2	10.29	0.0013	4.98	0.289	30.91	0	74.64	0
MS1	LA1	27.43	0	4.78	0.3104	73.5	0	276.78	0
MS1	LA2	32.74	0	8.79	0.0666	65.2	0	103.02	0
MS1	MS2	1.19	0.2753	24.54	0.0001	3.27	0.1946	54.72	0

MS1	SC1	11.58	0.0007	14.06	0.0071	40.1	0	101.25	0
MS1	SC2	23.66	0	5.46	0.2432	31.31	0	66.37	0
MS2	AL1	19.33	0	6.2	0.1845	29.29	0	57.32	0
MS2	AL2	16.82	0	1.42	0.8407	37.82	0	123.53	0
MS2	AR1	42.38	0	4.18	0.3822	71.79	0	257.21	0
MS2	FL1	10.84	0.001	12.27	0.0155	11.32	0.0035	71.28	0
MS2	FL2	14.75	0.0001	3.35	0.5004	26.8	0	63.47	0
MS2	GA1	29.79	0	11.47	0.0218	43.83	0	94.55	0
MS2	GA2	0.94	0.3332	5.48	0.2416	9.81	0.0074	69.44	0
MS2	LA1	44.23	0	22.08	0.0002	68.76	0	262.48	0
MS2	LA2	7.33	0.0068	21.17	0.0003	22.2	0	139.18	0
MS2	MS1	0.94	0.3314	24.66	0.0001	2.58	0.2754	38.85	0
MS2	SC1	28.37	0	10.15	0.038	53.84	0	94.7	0
MS2	SC2	1.06	0.3022	26.78	0	4.01	0.1348	96.59	0
SC1	AL1	2.94	0.0866	2.71	0.608	6.12	0.0469	29.23	0.0001
SC1	AL2	7.62	0.0058	7.61	0.1069	13.65	0.0011	80.84	0
SC1	AR1	32.76	0	2.77	0.5972	77.88	0	129.83	0
SC1	FL1	15.4	0.0001	3.81	0.4316	25.52	0	41.98	0
SC1	FL2	2.28	0.1311	9.15	0.0575	3.79	0.1504	21.28	0.0034
SC1	GA1	6.71	0.0096	4.29	0.3679	28.36	0	48.19	0
SC1	GA2	0.99	0.3201	4.65	0.3254	2.97	0.227	26.25	0.0005
SC1	LA1	25.06	0	6.28	0.1794	54.36	0	172.91	0
SC1	LA2	17.52	0	10.02	0.04	23.04	0	78.29	0
SC1	MS1	7.14	0.0076	4.8	0.3088	12.46	0.002	49.29	0
SC1	MS2	9.42	0.0022	2.95	0.567	18.92	0.0001	33.74	0
SC1	SC2	1.13	0.2884	27.01	0	1.22	0.5421	17.59	0.0139
SC2	AL1	0.69	0.4048	6.01	0.1987	17.21	0.0002	63.98	0
SC2	AL2	18.65	0	6.95	0.1385	56.95	0	265.56	0
SC2	AR1	21.03	0	5.79	0.2155	139.83	0	236.89	0
SC2	FL1	0.06	0.8123	11.57	0.0209	20.39	0	53.56	0
SC2	FL2	15.88	0.0001	8.03	0.0904	27.96	0	92.28	0
SC2	GA1	2.79	0.0946	3.97	0.41	28.85	0	86.31	0
SC2	GA2	41	0	32.1	0	55.64	0	73.14	0
SC2	LA1	11.03	0.0009	10.35	0.0349	85.03	0	280.8	0
SC2	LA2	38.95	0	7.9	0.0953	90.7	0	140.9	0
SC2	MS1	22.51	0	4.89	0.2988	53.75	0	73.19	0
SC2	MS2	5.01	0.0252	10.09	0.0389	18.84	0.0001	94.72	0
SC2	SC1	0.03	0.8658	27.81	0	16.75	0.0002	51.17	0

Table 16: PPW Pricing Behavior Tests

REGION HOME (Y)	REGION AWAY (X)	FOB		Price Discrim		Incomplete BPP		Complete BPP	
		Wald-Stat	P-Value	Wald-Stat	P-Value	Wald-Stat	P-Value	Wald-Stat	P-Value
AL1	AL2	0.01	0.9032	10.29	0.0357	7.77	0.0205	46.48	0
AL1	AR1	12.12	0.0005	2.91	0.5738	36.3	0	209.29	0
AL1	AR2	9.75	0.0018	1.06	0.9003	16.58	0.0003	60.42	0
AL1	FL1	17.11	0	8.95	0.0622	20.15	0	68.56	0
AL1	FL2	3.49	0.0617	1.87	0.7601	5.03	0.0808	37.04	0
AL1	GA1	0.44	0.5082	2.49	0.6466	7.7	0.0213	89.87	0
AL1	GA2	7.49	0.0062	4.65	0.3248	18.52	0.0001	99.64	0
AL1	LA1	12.69	0.0004	4.16	0.3845	22.28	0	77.55	0
AL1	LA2	28.57	0	7.86	0.0968	30.36	0	334.66	0
AL1	MS1	7.73	0.0054	3.66	0.4542	31.74	0	96.06	0
AL1	MS2	8.09	0.0044	4.34	0.3625	22.62	0	59.58	0
AL1	SC1	4.85	0.0277	10.23	0.0368	10.77	0.0046	52.19	0
AL1	SC2	1.75	0.186	6.44	0.1688	12.07	0.0024	73.79	0
AL2	AL1	8.65	0.0033	9.49	0.05	26.66	0	126.58	0
AL2	AR1	3.3	0.0692	4.01	0.4053	39.07	0	178.69	0
AL2	AR2	14.12	0.0002	3.28	0.5124	38.17	0	75.43	0
AL2	FL1	3	0.083	13.14	0.0106	4.43	0.1089	32.9	0
AL2	FL2	41.73	0	4.94	0.293	46.66	0	90.58	0
AL2	GA1	2.43	0.1194	7.13	0.1294	19.61	0.0001	92.54	0
AL2	GA2	6.22	0.0126	5.65	0.227	17.7	0.0001	80.73	0
AL2	LA1	4.93	0.0264	16.22	0.0027	17.47	0.0002	36.82	0
AL2	LA2	17.03	0	10.44	0.0336	22.71	0	523.06	0
AL2	MS1	3.81	0.0508	1.03	0.9054	41.88	0	59.54	0
AL2	MS2	13.51	0.0002	4.29	0.3685	50.5	0	141.7	0
AL2	SC1	6.06	0.0138	11.74	0.0194	20.48	0	33.77	0
AL2	SC2	11.74	0.0006	8.03	0.0905	0.4	0	12.33	0.0305
AR1	AL1	2.25	0.1336	7.44	0.1142	4.54	0.1032	60.04	0
AR1	AL2	3.27	0.0704	8.41	0.0777	6.77	0.0339	26.06	0.0005
AR1	AR2	1.91	0.1667	15.47	0.0038	2.18	0.3363	18.77	0.0089
AR1	FL1	0.26	0.6106	13.31	0.0098	22.72	0	48.65	0
AR1	FL2	0.27	0.6	2.15	0.7089	5.69	0.0581	22.91	0.0018
AR1	GA1	3.89	0.0487	7.53	0.1106	19.17	0.0001	77.37	0
AR1	GA2	1.22	0.2686	6.72	0.1517	1.3	0.5218	38.25	0
AR1	LA1	0.25	0.617	22.62	0.0002	1.52	0.4676	11.65	0.1127

AR1	LA2	14.88	0.0001	4.95	0.2928	17.14	0.0002	104.16	0
AR1	MS1	0.25	0.6157	2.54	0.637	9.67	0.008	19.69	0.0063
AR1	MS2	3.9	0.0482	4.12	0.3898	9.87	0.0072	44.34	0
AR1	SC1	2.31	0.1285	4.15	0.3855	6.72	0.0348	14.41	0.0444
AR1	SC2	4.9	0.0269	8.65	0.0704	5.88	0.0528	8.11	0.15
AR2	AL1	5.35	0.0207	7.67	0.1043	7.86	0.0196	28.29	0.0002
AR2	AL2	0.01	0.9243	11.99	0.0174	0.65	0.7243	15.75	0.0275
AR2	AR1	0.42	0.5185	18.58	0.0009	7.99	0.0184	38.24	0
AR2	FL1	0.2	0.6587	7.81	0.0988	0.39	0.8242	10.06	0.1852
AR2	FL2	1.67	0.1967	2.43	0.6563	1.68	0.4315	11.74	0.1094
AR2	GA1	0.43	0.5126	3.22	0.5213	4.66	0.0972	28.31	0.0002
AR2	GA2	8.79	0.003	12.39	0.0147	21.34	0	49.34	0
AR2	LA1	7.71	0.0055	10.29	0.0358	13.95	0.0009	54.56	0
AR2	LA2	9.47	0.0021	9.74	0.045	16.13	0.0003	178.28	0
AR2	MS1	2.3	0.129	5.08	0.2796	6.96	0.0307	25.46	0.0006
AR2	MS2	1.21	0.271	6.41	0.1709	17.03	0.0002	52.66	0
AR2	SC1	4.11	0.0427	5.58	0.2327	5.01	0.0816	32.08	0
AR2	SC2	4.84	0.0278	9.53	0.0491	16.44	0.0003	17.36	0.0039
FL1	AL1	3.29	0.0696	1.94	0.7461	28.42	0	72.8	0
FL1	AL2	10.44	0.0012	13.73	0.0082	10.46	0.0054	29.47	0.0001
FL1	AR1	36.15	0	12.45	0.0143	21.51	0	178.07	0
FL1	AR2	11.6	0.0007	6.93	0.1394	44.42	0	104.08	0
FL1	FL2	0.06	0.8103	24.37	0.0001	4.65	0.0978	27.72	0.0002
FL1	GA1	16.95	0	4.03	0.4015	32.39	0	164.84	0
FL1	GA2	2.21	0.1367	15.78	0.0033	8.03	0.018	112.41	0
FL1	LA1	6.79	0.0092	3.25	0.517	23.74	0	70.69	0
FL1	LA2	20.79	0	16.38	0.0026	25.8	0	567.84	0
FL1	MS1	16.92	0	2.51	0.6426	36.55	0	125.87	0
FL1	MS2	6.31	0.012	0.32	0.9883	48.82	0	127.79	0
FL1	SC1	14.08	0.0002	12.78	0.0124	35.93	0	82.78	0
FL1	SC2	6.65	0.0099	7.51	0.1113	20.87	0	31.63	0
FL2	AL1	8.76	0.0031	3.78	0.4372	29.69	0	87.99	0
FL2	AL2	19.75	0	14.88	0.0049	87.23	0	189.63	0
FL2	AR1	17.94	0	7.2	0.1255	89.93	0	150.17	0
FL2	AR2	20.3	0	0.85	0.9312	48.07	0	115.26	0
FL2	FL1	10.5	0.0012	18.9	0.0008	16.23	0.0003	69.09	0
FL2	GA1	18.67	0	8.99	0.0613	18.67	0.0001	142.13	0
FL2	GA2	2.18	0.1402	16	0.003	18.37	0.0001	121.95	0
FL2	LA1	4.1	0.0428	20.76	0.0004	24.04	0	75.05	0
FL2	LA2	29.88	0	12.14	0.0164	80.98	0	633.54	0
FL2	MS1	6.75	0.0094	1.94	0.7464	30.23	0	58.98	0
FL2	MS2	24.12	0	6.96	0.1383	62.23	0	205	0
FL2	SC1	7.87	0.005	7.06	0.133	22.52	0	45.54	0

FL2	SC2	15.46	0.0001	12.41	0.0145	73.89	0	24.82	0.0002
GA1	AL1	9.1	0.0026	10.23	0.0367	11.06	0.004	138.14	0
GA1	AL2	35.75	0	9.48	0.0502	38.69	0	88.53	0
GA1	AR1	50.72	0	6.39	0.1718	23.4	0	251.48	0
GA1	AR2	30.48	0	6.32	0.1762	34.61	0	97.64	0
GA1	FL1	9.79	0.0018	6.31	0.1772	23.99	0	106.66	0
GA1	FL2	1.71	0.1908	5.79	0.2153	2.9	0.2345	60.98	0
GA1	GA2	6.84	0.0089	14.91	0.0049	7.19	0.0275	82.23	0
GA1	LA1	11.22	0.0008	24.82	0.0001	12.89	0.0016	58.17	0
GA1	LA2	48.48	0	16.61	0.0023	48.49	0	397.87	0
GA1	MS1	13.25	0.0003	10.79	0.0291	37	0	100.05	0
GA1	MS2	9.43	0.0021	8.1	0.0881	25.86	0	99.4	0
GA1	SC1	14.63	0.0001	14.84	0.005	16.06	0.0003	61.04	0
GA1	SC2	24.99	0	1.86	0.762	25.9	0	58.27	0
GA2	AL1	12.26	0.0005	3.44	0.4877	22.42	0	139.49	0
GA2	AL2	0.64	0.4247	5.53	0.2369	13.5	0.0012	59.75	0
GA2	AR1	8.42	0.0037	10.13	0.0383	66.92	0	301.61	0
GA2	AR2	14.44	0.0001	10.73	0.0297	80.47	0	135.69	0
GA2	FL1	2.47	0.1163	7.27	0.1225	4.63	0.0986	95.26	0
GA2	FL2	15.15	0.0001	14.19	0.0067	15.18	0.0005	66.35	0
GA2	GA1	0.13	0.7211	11.41	0.0223	5.13	0.0768	84.5	0
GA2	LA1	20.14	0	6.76	0.1489	65.21	0	132.92	0
GA2	LA2	24.46	0	12.34	0.015	24.55	0	476	0
GA2	MS1	13.61	0.0002	12.86	0.012	40.73	0	117.74	0
GA2	MS2	8.04	0.0046	10.87	0.028	41.99	0	135.75	0
GA2	SC1	11.64	0.0006	4.74	0.3151	18.86	0.0001	68.9	0
GA2	SC2	18.29	0	0.43	0.9801	36.65	0	68.21	0
LA1	AL1	6.04	0.014	6.94	0.1392	12.34	0.0021	26.46	0.0004
LA1	AL2	1.47	0.2258	7.7	0.1034	4.31	0.1161	10.49	0.1623
LA1	AR1	0.68	0.4096	3.73	0.4431	13.53	0.0012	34.02	0
LA1	AR2	5.25	0.022	8.94	0.0626	14.72	0.0006	38.38	0
LA1	FL1	1.41	0.2358	7.9	0.0953	2.07	0.3546	9.85	0.1973
LA1	FL2	2.83	0.0922	3.85	0.427	4.79	0.0911	10.51	0.1617
LA1	GA1	3.61	0.0576	12.6	0.0134	4.21	0.1221	22.84	0.0018
LA1	LA1	6.92	0.0085	9.44	0.051	20.48	0	53.69	0
LA1	LA2	7.58	0.0059	8.87	0.0644	10.56	0.0051	96.97	0
LA1	MS1	0.58	0.4444	8.27	0.0823	4.55	0.1026	21.15	0.0036
LA1	MS2	3.43	0.0641	7.62	0.1064	10.34	0.0057	33.66	0
LA1	SC1	4.23	0.0397	8.37	0.0788	4.85	0.0884	23	0.0017
LA1	SC2	2.44	0.1181	2.35	0.6708	6.16	0.046	13.17	0.0681
LA2	AL1	0.39	0.5347	4.51	0.3419	86.6	0	587.69	0
LA2	AL2	1.68	0.1953	4.18	0.3824	67.4	0	676.56	0
LA2	AR1	0.08	0.7765	5.62	0.2293	3.83	0	670.3	0

LA2	AR2	0.39	0.5341	2.64	0.6201	36.56	0	700.04	0
LA2	FL1	1.24	0.2653	12.11	0.0166	31.16	0	283	0
LA2	FL2	1.52	0.2179	12.86	0.012	31.08	0	422.24	0
LA2	GA1	1.78	0.1826	6.31	0.1773	72.33	0	503.62	0
LA2	GA2	2.21	0.1371	5.1	0.277	10.91	0	645.63	0
LA2	LA1	5.36	0.0206	13.78	0.008	58.53	0	47.2	0
LA2	MS1	1.14	0.2852	4.41	0.3531	51.54	0	597.2	0
LA2	MS2	0.1	0.7488	10.55	0.0322	98.7	0	614.54	0
LA2	SC1	0.56	0.4549	3.03	0.5526	10.65	0	346.16	0
LA2	SC2	0	0.9829	4.36	0.3593	2.01	0	586.09	0
MS1	AL1	0.17	0.6812	13.3	0.0099	21.62	0	150.8	0
MS1	AL2	11.73	0.0006	6.03	0.1967	16.43	0.0003	58.75	0
MS1	AR1	20.24	0	3.17	0.5301	1.38	0	222.78	0
MS1	AR2	19.35	0	17.17	0.0018	43.64	0	116.83	0
MS1	FL1	0.85	0.3557	13.86	0.0078	36.66	0	126.4	0
MS1	FL2	1.15	0.2831	3.08	0.5449	3.28	0.1942	32.51	0
MS1	GA1	9.94	0.0016	6.01	0.1983	19.78	0.0001	86.84	0
MS1	GA2	7.25	0.0071	7.26	0.1227	17.87	0.0001	105.56	0
MS1	LA1	3.78	0.0518	13.46	0.0093	15.24	0.0005	101.65	0
MS1	LA2	17.86	0	20.02	0.0005	19.26	0.0001	379.19	0
MS1	MS2	0.05	0.8242	16.34	0.0026	16.22	0.0003	57.65	0
MS1	SC1	8.21	0.0042	10.41	0.034	34.19	0	96.05	0
MS1	SC2	7.65	0.0057	7.78	0.1001	25.12	0	85.62	0
MS2	AL1	16.85	0	20.07	0.0005	16.89	0.0002	79.21	0
MS2	AL2	1.97	0.1602	7.05	0.1334	15.07	0.0005	77.69	0
MS2	AR1	23.24	0	3.78	0.4367	48.65	0	138.86	0
MS2	AR2	10.81	0.001	6.17	0.187	36.98	0	144.35	0
MS2	FL1	6.56	0.0104	7.86	0.0968	7.2	0.0273	70.33	0
MS2	FL2	6.56	0.0104	5.56	0.2346	21.98	0	79.15	0
MS2	GA1	4.5	0.0339	5.78	0.2159	4.79	0.0911	138.06	0
MS2	GA2	5.18	0.0228	9.2	0.0562	5.72	0.0573	56.06	0
MS2	LA1	20.48	0	5.35	0.2535	22.51	0	145.39	0
MS2	LA2	41.51	0	3.39	0.494	42.73	0	327.51	0
MS2	MS1	10.25	0.0014	31.44	0	13.15	0.0014	69.84	0
MS2	SC1	21.04	0	0.86	0.9304	25.11	0	79.51	0
MS2	SC2	21.95	0	8.8	0.0662	68.91	0	109.25	0
SC1	AL1	3.9	0.0482	9.06	0.0597	12.25	0.0022	96.66	0
SC1	AL2	1.01	0.3155	4.48	0.3444	1.76	0.4151	20.24	0.0051
SC1	AR1	16.33	0.0001	6.1	0.1915	78.8	0	143.63	0
SC1	AR2	5.86	0.0155	0.53	0.971	26.54	0	76.83	0
SC1	FL1	0.3	0.5865	3.44	0.4866	10.74	0.0047	26.21	0.0005
SC1	FL2	0.4	0.5249	1.25	0.8699	3.66	0.1607	26.34	0.0004
SC1	GA1	1.13	0.2871	3.34	0.5033	13.65	0.0011	98.97	0

SC1	GA2	3.44	0.0636	2.95	0.5657	6.02	0.0494	31.67	0
SC1	LA1	6.81	0.0091	4.17	0.3831	13.04	0.0015	100.23	0
SC1	LA2	14.84	0.0001	3.63	0.4591	17.06	0.0002	269.03	0
SC1	MS1	11.79	0.0006	14.86	0.005	51.77	0	107.47	0
SC1	MS2	0.17	0.6812	16.46	0.0025	12.27	0.0022	48.23	0
SC1	SC2	5.83	0.0158	12.5	0.014	6.15	0.0463	14.27	0.0465
SC2	AL1	2.1	0.1471	2.43	0.6565	8.96	0.0113	35.5	0
SC2	AL2	1.4	0.2371	2.53	0.6395	12.86	0.0016	29.59	0.0001
SC2	AR1	1.64	0.2001	3.35	0.5017	19.26	0.0001	51.5	0
SC2	AR2	6.89	0.0087	3.3	0.5083	43.55	0	78.02	0
SC2	FL1	2.26	0.1329	3.15	0.5323	2.26	0.3232	23.26	0.0015
SC2	FL2	1.3	0.2551	5.22	0.2651	2.86	0.2388	28.11	0.0002
SC2	GA1	1.04	0.3088	5.84	0.2115	4.58	0.1013	33.7	0
SC2	GA2	3.64	0.0565	2.55	0.6362	16.3	0.0003	31.91	0
SC2	LA1	2.68	0.1014	12.14	0.0163	14.43	0.0007	45.26	0
SC2	LA2	13.95	0.0002	4.03	0.4025	15.82	0.0004	210.13	0
SC2	MS1	2.1	0.1468	5.91	0.2058	13.47	0.0012	37.91	0
SC2	MS2	19.63	0	6.15	0.1881	47.34	0	88.57	0
SC2	SC1	0.01	0.9394	11.03	0.0262	1.18	0.5543	7.78	0.3521

Table 17: PST Pricing Behavior Tests

REGION HOME (Y)	REGION AWAY (X)	FOB		Price Discrimination		Incomplete BPP		Complete BPP	
		Wald Stat	P-value	Wald Stat	P-value	Wald Stat	P-value	Wald Stat	P-value
AL1	AL2	3.51	0.0611	5.93	0.2041	6.15	0.0461	54.88	0
AL1	AR1	2.3	0.1295	9.24	0.0554	4.67	0.097	56.18	0
AL1	AR2	23.38	0	7.78	0.1002	65.86	0	11.67	0
AL1	FL1	12.27	0.0005	2.87	0.012	53.71	0	66.15	0
AL1	FL2	0.12	0.7305	0.31	0.0356	1.2	0.5492	58.41	0
AL1	GA1	5.14	0.0234	5.7	0.2231	14.11	0.0009	65.84	0
AL1	GA2	7.62	0.0058	4.18	0.3821	21.59	0	52.86	0
AL1	LA1	16.81	0	7.93	0.0941	48.71	0	80.58	0
AL1	LA2	4.35	0.037	6.5	0.165	24.14	0	44.58	0
AL1	MS1	11.08	0.0009	3.02	0.5553	11.96	0.0025	62.58	0
AL1	MS2	18.94	0	7.04	0.1339	49.79	0	12.56	0
AL1	SC1	17.25	0	4.67	0.0054	27.19	0	89.2	0
AL1	SC2	9.58	0.002	1.8	0.0189	16.01	0.0003	24.05	0
AL2	AL1	3.46	0.0627	2.63	0.6217	4.15	0.1255	48.76	0
AL2	AR1	7.78	0.0053	7.61	0.107	21.33	0	64.01	0
AL2	AR2	16.66	0	2.98	0.5616	94.32	0	82.39	0
AL2	FL1	10.87	0.001	6.97	0.1375	16.74	0.0002	54.91	0
AL2	FL2	9.14	0.0025	2.02	0.7315	10.98	0.0041	43.17	0
AL2	GA1	4	0.0455	1.44	0.8369	16.6	0.0002	37.52	0
AL2	GA2	6.12	0.0134	1.27	0.8673	31.44	0	63.19	0
AL2	LA1	3.63	0.0568	4.64	0.3261	12.69	0.0018	73.54	0
AL2	LA2	8.35	0.0039	4	0.4055	36.06	0	89.19	0
AL2	MS1	1.76	0.1848	6.3	0.1779	10.69	0.0048	63.95	0
AL2	MS2	1.63	0.2021	8.99	0.0613	11.62	0.003	95.1	0
AL2	SC1	9.3	0.0023	5.03	0.2839	28.06	0	70	0
AL2	SC2	1.38	0.2404	7.8	0.0991	18.86	0.0001	22.32	0.0005
AR1	AL1	0.34	0.5571	6.36	0.1738	1.14	0.5642	113.1	0
AR1	AL2	3.01	0.0829	3.56	0.4692	3.11	0.2113	59.85	0
AR1	AR2	10.43	0.0012	0.65	0.9574	31.02	0	83.47	0
AR1	FL1	5.81	0.016	9.59	0.0478	6.85	0.0326	1.49	0
AR1	FL2	16.53	0	7.09	0.1311	21.17	0	84.24	0
AR1	GA1	7.31	0.0069	2.94	0.0116	9.1	0.0106	74.62	0
AR1	GA2	11.3	0.0008	7.32	0.12	24.22	0	86.18	0
AR1	LA1	3.33	0.0679	5.34	0	3.54	0.1705	0.23	0

AR1	LA2	16.28	0.0001	4.18	0.3825	18.35	0.0001	5.85	0
AR1	MS1	10.55	0.0012	4.32	0.3642	19.75	0.0001	80.92	0
AR1	MS2	2.39	0.1221	4.05	0.0071	2.74	0.2544	97.5	0
AR1	SC1	17.25	0	0.94	0.9193	29.79	0	29.11	0
AR1	SC2	9.3	0.0023	3.47	0.4821	23.6	0	64.14	0
AR2	AL1	2.42	0.1196	1.25	0.8698	6.39	0.0409	19.72	0.0062
AR2	AL2	1.48	0.2231	5.02	0.2857	1.52	0.4675	24.03	0.0011
AR2	AR1	4.82	0.0281	8.84	0.0008	5.75	0.0564	63.43	0
AR2	FL1	5.23	0.0222	4.57	0.3344	6.23	0.0445	20	0.0056
AR2	FL2	0.12	0.7274	2.54	0.6375	0.18	0.9134	16	0.0251
AR2	GA1	7.85	0.0051	3.12	0.5372	12.36	0.0021	27.47	0.0003
AR2	GA2	17.14	0	3.76	0.439	18.75	0.0001	27.82	0.0002
AR2	LA1	3.75	0.0529	2.86	0.5817	10.28	0.0059	24.94	0.0008
AR2	LA2	1.47	0.2254	7.29	0.1216	12.57	0.0019	27.86	0.0002
AR2	MS1	0.1	0.7521	5.85	0.211	0.54	0.7636	17.26	0.0158
AR2	MS2	5.11	0.0238	1.15	0.887	9.67	0.008	30.83	0.0001
AR2	SC1	0.03	0.8529	9.06	0.0596	2.28	0.3195	30.5	0.0001
AR2	SC2	0.02	0.8979	3.47	0.4824	5.3	0.0705	8.72	0.1208
FL1	AL1	7.68	0.0056	6.12	0.1906	15.54	0.0004	60.64	0
FL1	AL2	1.74	0.1876	3.88	0.4221	4.33	0.115	16.81	0.0186
FL1	AR1	0.05	0.8209	1.07	0.0258	7.01	0.0301	82.96	0
FL1	AR2	7.15	0.0075	0.72	0.0299	28.5	0	61.95	0
FL1	FL2	3.75	0.0527	5.58	0	3.92	0.1411	19.07	0.008
FL1	GA1	8.09	0.0045	7.11	0.0018	8.5	0.0142	44.77	0
FL1	GA2	2.45	0.1174	5.32	0.256	7.51	0.0234	20.4	0.0048
FL1	LA1	15.34	0.0001	1.98	0.0175	47.31	0	90	0
FL1	LA2	4.18	0.0409	3.73	0.4443	27.99	0	69.32	0
FL1	MS1	0.77	0.3789	7.16	0.1276	1.78	0.4097	49.46	0
FL1	MS2	8.74	0.0031	2.71	0.0128	32.76	0	60.58	0
FL1	SC1	2.93	0.0869	0.36	0.0348	12.96	0.0015	58.62	0
FL1	SC2	0.4	0.5271	4.89	0.2992	6.6	0.0368	5.98	0.3081
FL2	AL1	8.07	0.0045	2.99	0.56	8.59	0.0136	82.22	0
FL2	AL2	6.81	0.0091	3.04	0.5505	17.28	0.0002	74.66	0
FL2	AR1	14.92	0.0001	5.95	0.2029	50.93	0	70.34	0
FL2	AR2	30.19	0	0.34	0.035	86.22	0	15.32	0
FL2	FL1	25.72	0	3.86	0.0077	37.13	0	55.32	0
FL2	GA1	6.16	0.0131	4.55	0.0057	45.08	0	45.45	0
FL2	GA2	10.37	0.0013	6.16	0.1875	15.58	0.0004	55.02	0
FL2	LA1	3.04	0.0814	1.15	0.0249	10.54	0.0051	37.12	0
FL2	LA2	13.94	0.0002	9.44	0.0509	28.5	0	57.47	0
FL2	MS1	9.65	0.0019	6.69	0.0022	43.65	0	1.01	0
FL2	MS2	6.47	0.011	4.16	0.3845	9.29	0.0096	67.15	0

FL2	SC1	33.66	0	7.27	0.0017	49.15	0	43.08	0
FL2	SC2	13.87	0.0002	7.1	0.1308	27.61	0	15.33	0.0091
GA1	AL1	5.77	0.0163	4.12	0.3896	14.64	0.0007	42.98	0
GA1	AL2	3.21	0.0732	3.19	0.5268	12.75	0.0017	42.45	0
GA1	AR1	8.4	0.0038	9.84	0.0432	30.97	0	39.12	0
GA1	AR2	18.65	0	6.53	0.1631	77.95	0	71.96	0
GA1	FL1	4.92	0.0266	8.29	0.0815	60.66	0	0.35	0
GA1	FL2	9.58	0.002	2.25	0.6892	12.05	0.0024	96.12	0
GA1	GA2	5.46	0.0195	7.82	0.0985	17.1	0.0002	36.65	0
GA1	LA1	2.38	0.1225	2.01	0.0172	45.58	0	28.98	0
GA1	LA2	6.85	0.0089	5.55	0.235	47.12	0	75.78	0
GA1	MS1	10.09	0.0015	2.86	0.5807	19.59	0.0001	66.34	0
GA1	MS2	0.82	0.3642	8.71	0.0688	21.96	0	48.52	0
GA1	SC1	5.14	0.0234	7.71	0.1027	23.74	0	97.4	0
GA1	SC2	0.81	0.3676	4.21	0.3782	10.36	0.0056	65.98	0
GA2	AL1	12.97	0.0003	6.19	0.1853	20.38	0	12.45	0
GA2	AL2	0.65	0.4193	1.58	0.8122	12.78	0.0017	53.23	0
GA2	AR1	6.65	0.0099	4.15	0.3863	79.88	0	0.44	0
GA2	AR2	15.27	0.0001	3	0.5579	138.93	0	7.38	0
GA2	FL1	9.48	0.0021	1.86	0.7607	31.53	0	81.87	0
GA2	FL2	0.95	0.3287	6.07	0.1942	14.19	0.0008	61.07	0
GA2	GA1	0.32	0.5739	6.16	0.0028	7.36	0.0252	26.49	0.0004
GA2	LA1	8.12	0.0044	5.58	0.2329	41.17	0	10.36	0
GA2	LA2	0.49	0.4852	9.67	0.0464	24.05	0	63.89	0
GA2	MS1	4.35	0.0371	1.5	0.8264	30.94	0	0.76	0
GA2	MS2	3.35	0.0673	4.42	0.3519	20.41	0	37.63	0
GA2	SC1	4.58	0.0324	3.59	0.4645	62.93	0	15.98	0
GA2	SC2	17.96	0	9.01	0.0609	43.28	0	0.03	0
LA1	AL1	14.96	0.0001	3.94	0.4145	23.55	0	86.81	0
LA1	AL2	8.77	0.0031	1.48	0.8305	11.02	0.004	30	0.0001
LA1	AR1	1.04	0.3088	2.9	0.0118	6.61	0.0368	79.77	0
LA1	AR2	20.29	0	6.08	0.1932	22.7	0	54.62	0
LA1	FL1	39.65	0	8.69	0.0692	61.11	0	8.34	0
LA1	FL2	0.17	0.6813	0.04	0.0005	0.87	0.646	44.13	0
LA1	GA1	11.88	0.0006	9.27	0.0547	16.52	0.0003	63.2	0
LA1	LA1	11.87	0.0006	4.5	0.3426	20.31	0	48.56	0
LA1	LA2	8.27	0.004	5.02	0.2854	12.49	0.0019	53.53	0
LA1	MS1	3.14	0.0763	5.78	0.2165	3.91	0.1414	28.97	0.0001
LA1	MS2	21.21	0	4.63	0.3269	25.22	0	66.57	0
LA1	SC1	17.07	0	0.77	0.0293	20.39	0	79.36	0
LA1	SC2	2.73	0.0987	4.63	0.3268	12.3	0.0021	51.61	0
LA2	AL1	21.76	0	4.77	0.3112	27.16	0	30.52	0

LA2	AL2	14.81	0.0001	1.8	0.7717	19.82	0	77.26	0
LA2	AR1	3.71	0.0542	6.55	0.1614	28.08	0	29.51	0
LA2	AR2	32.25	0	3.28	0.5126	79.3	0	80.94	0
LA2	FL1	62.27	0	8.07	0.0891	94.43	0	91.92	0
LA2	FL2	1.67	0.1957	6.28	0.179	3.19	0.2027	33.52	0
LA2	GA1	20.23	0	7.13	0.129	25.02	0	73.13	0
LA2	GA2	12.28	0.0005	4.12	0.3895	16.11	0.0003	64.49	0
LA2	LA1	8.27	0.004	4.71	0.3182	12.03	0.0024	22.43	0
LA2	MS1	6.28	0.0122	6.13	0.1894	6.6	0.0368	71.08	0
LA2	MS2	10.8	0.001	6.23	0.1824	11.94	0.0026	61.22	0
LA2	SC1	15.06	0.0001	6.17	0.1868	19.73	0.0001	56.42	0
LA2	SC2	0.5	0.4798	5.85	0.2102	8.8	0.0123	0.02	0
MS1	AL1	1.42	0.234	7.16	0.1279	5.7	0.0579	63.98	0
MS1	AL2	4.43	0.0354	4.07	0.3972	9.87	0.0072	10.24	0
MS1	AR1	48.33	0	3.37	0.0096	74.3	0	63.04	0
MS1	AR2	29.87	0	6.83	0.1452	106.99	0	43.61	0
MS1	FL1	8.52	0.0035	5.24	0.2632	12.57	0.0019	5.64	0
MS1	FL2	55.64	0	1.84	0.0186	56.32	0	2.97	0
MS1	GA1	2.61	0.1065	3.96	0.0074	21.78	0	21.09	0
MS1	GA2	21.47	0	7.66	0.1048	29.72	0	68.83	0
MS1	LA1	2.13	0.1444	8.96	0.0621	11.96	0.0025	43.88	0
MS1	LA2	6.99	0.0082	2.25	0.6907	14.66	0.0007	72.93	0
MS1	MS2	1.41	0.2359	3.23	0.0001	5.03	0.0809	52.56	0
MS1	SC1	18.59	0	7.62	0.1067	54.82	0	7.44	0
MS1	SC2	12.74	0.0004	3.85	0.4272	31.54	0	19.34	0
MS2	AL1	19.18	0	3.79	0.4352	25.35	0	64.32	0
MS2	AL2	5.25	0.0219	5.86	0.2097	6.91	0.0316	47.31	0
MS2	AR1	2.25	0.134	6.83	0.1453	12.83	0.0016	90.73	0
MS2	AR2	28.86	0	7.42	0.1152	54.49	0	39.61	0
MS2	FL1	43.17	0	0	0.0404	69.42	0	10.19	0
MS2	FL2	0.46	0.4996	8.66	0.0703	0.57	0.7526	30.78	0.0001
MS2	GA1	22.7	0	9.07	0.0594	28.09	0	77.22	0
MS2	GA2	6.78	0.0092	3.59	0.4637	8.94	0.0114	48.13	0
MS2	LA1	19.48	0	7.64	0.1056	54.02	0	12.47	0
MS2	LA2	11.68	0.0006	0.84	0.9333	17.17	0.0002	65.58	0
MS2	MS1	1.49	0.2223	8.4	0.001	1.84	0.3993	44.49	0
MS2	SC1	19.6	0	2.84	0.5848	35.96	0	78.51	0
MS2	SC2	1.24	0.2663	6.07	0.1941	7.17	0.0277	46.06	0
SC1	AL1	2.15	0.1428	1.23	0.873	6.95	0.0309	33.18	0
SC1	AL2	0.98	0.321	4.91	0.2968	5.47	0.0648	34.71	0
SC1	AR1	3.78	0.0517	5.17	0.27	11.26	0.0036	93.48	0
SC1	AR2	25.1	0	5.86	0.2098	60.22	0	79.7	0

SC1	FL1	5.78	0.0162	1.22	0.8754	11.29	0.0035	78.93	0
SC1	FL2	2.72	0.099	1.24	0.024	15.98	0.0003	61.8	0
SC1	GA1	0.29	0.593	5.94	0.2034	19.68	0.0001	87.45	0
SC1	GA2	9.25	0.0024	2.75	0.6007	11.49	0.0032	27.47	0.0003
SC1	LA1	4.09	0.0432	4.58	0.3329	22.82	0	71.47	0
SC1	LA2	2.96	0.0854	9.8	0.0439	5.05	0.0802	36.9	0
SC1	MS1	11.39	0.0007	3.1	0.5412	14.8	0.0006	38.55	0
SC1	MS2	0.74	0.3905	2.34	0.674	6.23	0.0443	41.65	0
SC1	SC2	11.07	0.0009	7.63	0.1061	19.2	0.0001	38.65	0
SC2	AL1	12.06	0.0005	4.67	0.3228	19.46	0.0001	1.6	0
SC2	AL2	10.67	0.0011	3.83	0.4292	12.88	0.0016	56.98	0
SC2	AR1	14.85	0.0001	2.49	0.6461	31.98	0	69.14	0
SC2	AR2	21.9	0	2.18	0.7019	84.65	0	99.79	0
SC2	FL1	21.28	0	0.67	0.9546	28.72	0	84.25	0
SC2	FL2	6.02	0.0141	6.36	0.1738	6.21	0.0448	26.49	0.0004
SC2	GA1	13.77	0.0002	5.46	0.2431	13.81	0.001	92.12	0
SC2	GA2	7.44	0.0064	4.4	0.3549	8.5	0.0142	26.89	0.0003
SC2	LA1	23.58	0	1.85	0.7633	33.79	0	26.4	0
SC2	LA2	16.51	0	5.42	0.2464	26.2	0	18.25	0
SC2	MS1	14.7	0.0001	4.7	0.3193	15.78	0.0004	80.41	0
SC2	MS2	17.23	0	0.76	0.9439	17.79	0.0001	12.9	0
SC2	SC1	31.92	0	4.33	0.3634	53.43	0	78.92	0

Table 18: Pine Chip and Saw Bivariate Cointegration Tests

REGION	AL1	AL2	AR1	AR2	FL1	FL2	GA1	GA2	LA1	LA2	MS1	MS2	SC1	SC2
AL1	NA	0.01	0.02	NA		0	0.01	0.04	0.13	0.16	0.1	0.02	0.18	0
AL2	0.02	NA	0.02	NA	0	0	0	0.06	0.09	0.17	0.13	0.04	0.13	0.02
AR1	0.03	0.02	NA	NA	0.01	0.01	0.01	0.06	0	0.01	0	0	0.01	0.01
AR2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FL1	0.02	0.01	0.01	NA	NA	0	0.1	0.13	0.15	0.21	0.17	0.02	0.33	0.01
FL2	0	0	0.01	NA	0	NA	0.02	0.02	0.11	0.25	0.09	0.01	0.11	0
GA1	0.02	0	0.02	NA	0.07	0.02	NA	0.41	0.15	0.09	0.06	0	0.1	0.01
GA2	0.1	0.11	0.1	NA	0.13	0.04	0.31	NA	0.38	0.35	0.44	0.05	0.66	0.01
LA1	0.18	0.11	0	NA	0.14	0.11	0.18	0.34	NA	0	0.03	0.02	0.22	0.28
LA2	0.23	0.2	0.01	NA	0.2	0.27	0.09	0.31	0	NA	0.04	0.02	0.1	0.09
MS1	0.23	0.26	0	NA	0.26	0.16	0.14	0.53	0.08	0.09	NA	0	0.2	0.18
MS2	0.02	0.04	0	NA	0.01	0.01	0	0.03	0.02	0.02	0	NA	0.02	0.02
SC1	0.22	0.12	0	NA	0.29	0.07	0.09	0.63	0.17	0.08	0.08	0.02	NA	0.13
SC2	0.01	0.04	0.02	NA	0.01	0	0.01	0.01	0.28	0.1	0.11	0.02	0.14	NA
Total	7	6	10		5	9	6	4	3	3	3	12	2	8

Table 19: Pine Pulpwood Bivariate Cointegration Tests

REGION	AL1	AL2	AR1	AR2	FL1	FL2	GA1	GA2	LA1	LA2	MS1	MS2	SC1	SC2
AL1	NA	0	0	0	0.01	0.11	0.01	0.03	0	0	0.01	0.01	0.01	0
AL2	0	NA	0.02	0.01	0	0.03	0.03	0.02	0.02	0	0.02	0.01	0.01	0
AR1	0	0.03	NA	0.01	0.22	0.52	0.04	0.29	0.02	0.07	0.01	0	0.02	0.05
AR2	0	0.02	0.01	NA	0.07	0.4	0	0.15	0.01	0.01	0	0	0.02	0.02
FL1	0.01	0.01	0.17	0.06	NA	0.1	0.04	0.14	0.02	0	0.02	0.01	0.02	0.07
FL2	0.1	0.04	0.39	0.32	0.1	NA	0.35	0.11	0.27	0.11	0.22	0.13	0.09	0.03
GA1	0.01	0.07	0.07	0.01	0.07	0.48	NA	0.3	0.01	0	0.03	0.03	0.01	0.02
GA2	0.01	0.01	0.13	0.07	0.07	0.06	0.12	NA	0.05	0.06	0.11	0.02	0.03	0.04
LA1	0	0.02	0.01	0.01	0.01	0.23	0	0.06	NA	0.01	0	0	0	0.01
LA2	0	0.01	0.07	0.01	0	0.12	0	0.12	0.01	NA	0.01	0	0.01	0.03
MS1	0.01	0.03	0.01	0	0.01	0.23	0.01	0.19	0.01	0	NA	0.01	0.01	0.07
MS2	0	0.01	0	0	0	0.1	0.01	0.02	0	0	0.01	NA	0.01	0.01
SC1	0.02	0.02	0.04	0.04	0.05	0.17	0.02	0.1	0.01	0.03	0.02	0.05	NA	0.05
SC2	0	0	0.04	0.01	0.06	0.01	0.01	0.06	0.01	0.02	0.06	0.01	0.01	NA
Total	12	12	8	10	6	2	11	3	12	10	10	11	12	11

Table 20: Pine Saw Timber Pricing Behavior Tests

REGION	AL1	AL2	AR1	AR2	FL1	FL2	GA1	GA2	LA1	LA2	MS1	MS2	SC1	SC2
AL1	NA	0.01	0.13	0.08	0.01	0.03	0.04	0.21	0.23	0.19	0.43	0.22	0.01	0.03
AL2	0.01	NA	0.08	0.02	0	0	0	0	0.08	0.13	0.22	0.23	0.03	0
AR1	0.12	0.14	NA	0	0.01	0.03	0.15	0.14	0	0	0	0	0.26	0.16
AR2	0.12	0.08	0	NA	0.06	0.16	0.19	0.12	0.07	0.03	0.01	0	0.27	0.11
FL1	0	0	0.01	0.04	NA	0.01	0.01	0.01	0.12	0.07	0.13	0.04	0.01	0
FL2	0.01	0	0.02	0.06	0	NA	0.02	0.01	0.17	0.11	0.16	0.06	0.01	0
GA1	0.05	0	0.16	0.13	0.01	0.04	NA	0.02	0.34	0.23	0.49	0.14	0.02	0
GA2	0.21	0	0.14	0.07	0.02	0.05	0.02	NA	0.34	0.18	0.47	0.11	0.21	0
LA1	0.23	0.13	0	0.05	0.12	0.26	0.31	0.34	NA	0.04	0.01	0	0.27	0.35
LA2	0.2	0.23	0	0.02	0.07	0.18	0.24	0.18	0.02	NA	0.01	0.02	0.2	0.24
MS1	0.52	0.41	0	0.01	0.19	0.32	0.56	0.56	0.02	0.02	NA	0	0.3	0.39
MS2	0.22	0.32	0	0	0.03	0.08	0.12	0.1	0	0.01	0	NA	0.1	0.07
SC1	0.01	0.07	0.32	0.24	0.01	0.03	0.04	0.26	0.32	0.24	0.28	0.14	NA	0.04
SC2	0.04	0	0.18	0.08	0	0	0	0	0.36	0.24	0.33	0.09	0.03	NA
	6	6	7	5	9	7	7	5	4	5	5	6	6	7

GLOSSARY OF TIMBER TERMS

1. **Consumption.** The quantity of a commodity, such as pulpwood, utilized by a particular mill or group of mills.
2. **Domestic fuelwood.** The volume of roundwood harvested to produce heat for residential settings.
3. **Exports.** The volume of domestic roundwood utilized by mills outside the state wherein timber was cut.
4. **Growing-stock removals.** The growing-stock volume removed from poletimber and sawtimber trees in the timberland inventory. (Note: Includes volume removed for roundwood products, logging residues, and other removals.)
5. **Growing-stock trees.** Living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings. Growing-stock trees must contain at least one 12-foot or two 8-foot logs in the saw-log portion, currently or potentially (if too small at present to qualify). The log(s) must meet dimension and merchantability standards and have, currently or potentially, one-third of the gross board-foot volume in sound wood.
6. **Growing-stock volume.** The cubic-foot volume of sound wood in growing-stock trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.
7. **Hardwoods.** Dicotyledonous trees, usually broadleaf and deciduous.

Soft hardwoods. Hardwood species with an average specific gravity of 0.50 or less, such as gums, yellow poplar, cottonwoods, red maple, basswoods, and willows.

Hard hardwoods. Hardwood species with an average specific gravity > 0.50, such as oaks, hard maples, hickories, and beech.

8. **Imports.** The volume of domestic roundwood delivered to a mill or group of mills in a specific state but harvested outside that State.
9. **Industrial fuelwood.** A roundwood product, with or without bark, used to generate energy at a manufacturing facility such as a wood-using mill.
10. **Industrial roundwood products.** Any primary use of the main stem of a tree, such as saw logs, pulpwood, and veneer logs, intended to be processed into primary wood products such as lumber, wood pulp, sheathing, at primary wood-using mills
11. **Log.** A primary forest product harvested in long, primarily 8-, 12-, and 16-foot lengths.
12. **Nonforest land.** Land that has never supported forests and land formerly forested where timber production is precluded by development for other uses.
13. **Primary wood-using plants.** Industries that convert roundwood products (saw logs, veneer logs, pulpwood, etc.) into primary wood products, such as lumber, veneer or sheathing, and wood pulp.
14. **Production.** The total volume of known roundwood harvested from land within a state, regardless of where it is consumed. Production is the sum of timber harvested and used within a state, and all roundwood exported to other states.
15. **Pulpwood.** A roundwood product that will be reduced to individual wood fibers by chemical or mechanical means. The fibers are used to make a broad generic group of pulp

products, which includes paper products, as well as fiberboard, insulating board, and paperboard.

16. **Receipts.** The quantity or volume of industrial roundwood received at a mill or by a group of mills in a state, regardless of the geographic source. The volume of roundwood receipts is equal to the volume of roundwood retained in a State plus roundwood imported from other states.
17. **Retained.** Roundwood volume harvested from and processed by mills within the same state.
18. **Roundwood (roundwood logs).** Logs, bolts, or other round sections cut from trees for industrial manufacture or consumer uses.
19. **Roundwood chipped.** Any timber cut primarily for industrial manufacture, delivered to nonpulpmills, chipped, and then sold to pulpmills for use as fiber. Includes tops, jump sections, whole trees, and pulpwood sticks.
20. **Roundwood product drain.** That portion of total drain used for a product.
21. **Roundwood products.** Any primary product, such as lumber, veneer, composite panels, poles, pilings, pulp, or fuelwood, that is produced from roundwood.
22. **Salvable dead trees.** Standing or downed dead trees that were formerly growing stock and considered merchantable. Trees must be at least 5.0 inches d.b.h. to qualify
23. **Saw log.** A roundwood product, usually 8 feet in length or longer, processed into a variety of sawn products such as lumber, cants, pallets, railroad ties, and timbers.
24. **Saw-log portion.** The part of the bole of sawtimber trees between a 1-foot stump and the saw-log top.

25. **Saw-log top.** The point on the bole of sawtimber trees above which a conventional saw log cannot be produced. The minimum saw-log top is 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods for FIA standards.
26. **Sawtimber-size trees.** Softwoods 9.0 inches d.b.h. and larger and hardwoods 11.0 inches d.b.h. and larger.
27. **Sawtimber volume.** Growing-stock volume in the saw-log portion of sawtimber-sized trees in board feet (International ¼-inch rule).
28. **Softwoods.** Coniferous trees, usually evergreen, having leaves that are needles or scale like.
29. **Timberland.** Forest land capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.
30. **Timber product output.** The total volume of roundwood products from all sources plus the volume of byproducts recovered from mill residues (equals roundwood product drain).
31. **Timber products.** Roundwood products and byproducts.
32. **Timber removals.** The total volume of trees removed from the timberland inventory by harvesting, cultural operations such as stand improvement, land clearing, or changes in land use. (Note: Includes roundwood products, logging residues, and other removals.)
33. **Tree.** Woody plants having one erect perennial stem or trunk at least 3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet (at maturity)
34. **Production** = Retained + Exports
35. **Receipts** = Retained + Imports

VITA

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