MARKET POWER IN THE U. S. PECAN PROCESSING INDUSTRY

by

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ABSTRACT

Rising industrial concentration is an economic welfare issue that attracts economic analysis directed at measuring market power in the United States. A decreasing number of large companies control a significant share of sales in various industries. As a consequence, consumers may experience higher market prices charged by large firms with market power and consumers, as well as society, may be worse off. The U.S. pecan processing operation is highly concentrated in a limited number of large shelling firms. An econometric model, formerly applied to the beef packing industry, is utilized to estimate oligopoly/oligopsony market power in the pecan processing industry. Although monopoly power is discovered in this research, the alternate bearing nature of pecan trees is not captured in the pecan supply equation of the modeling system thereby limiting the usefulness of the monopsony estimates. Also, the lack of appropriate firm-level data is revealed as a major problem for statistical estimation. These issues challenge future research to accommodate biological information and firm-level data for any market power study, in perennial crops, especially pecans.

CHAPTER ONE: EVOLUTION OF INDUSTRY STRUCTURE

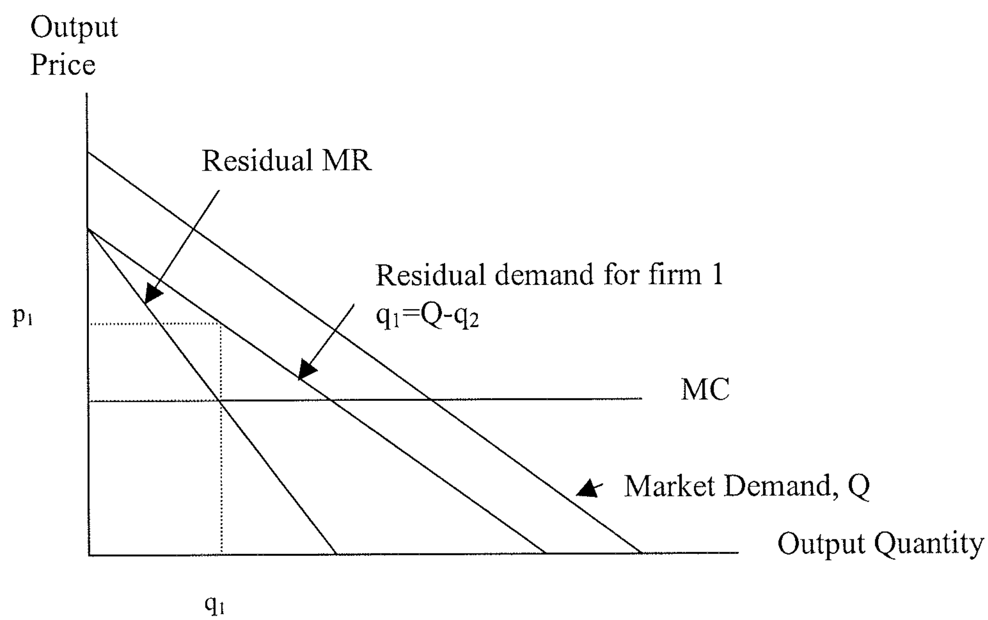
1.1 Motivation

Currently in the United States, numerous industries are dominated by a few large firms that comprise a significant portion of total industry sales. Mergers and acquisitions have changed the structure of many industries. In other cases, industries vertically integrate in order to secure additional resources and distribution channels. Oligopoly, a market controlled by a few large companies, may produce benefits for society by improving products, services, and/or improving industry-wide standards. However, oligopolies may create rents or profits at the expense of consumers and economic progress in general. Oligopoly also can stifle the competition that is critical for efficiency.

1.2 Market Power

Mergers and acquisitions have created fewer and larger firms in the U.S. over the last two decades. This consolidation can be viewed as a process, with an industry increasingly represented by fewer but larger firms, and as a measure of the relative size of the industry's largest firms to the industry as a whole (MacDonald and Denbaly 2000). High concentration in an industry may create conditions where a limited number of large firms possess market power. Firms have market power when they are able to set a price above the competitive or marginal cost levels (Carlton and Perloff 1994). In Figure 1.1, a Cournot duopoly firm produces at level q_1 where the firm's marginal revenue intersects marginal cost, and charges the price p_1 in short run. The firm earns the profit of shaded area.

Figure 1.1 Residual demand facing a Cournot duopoly firm



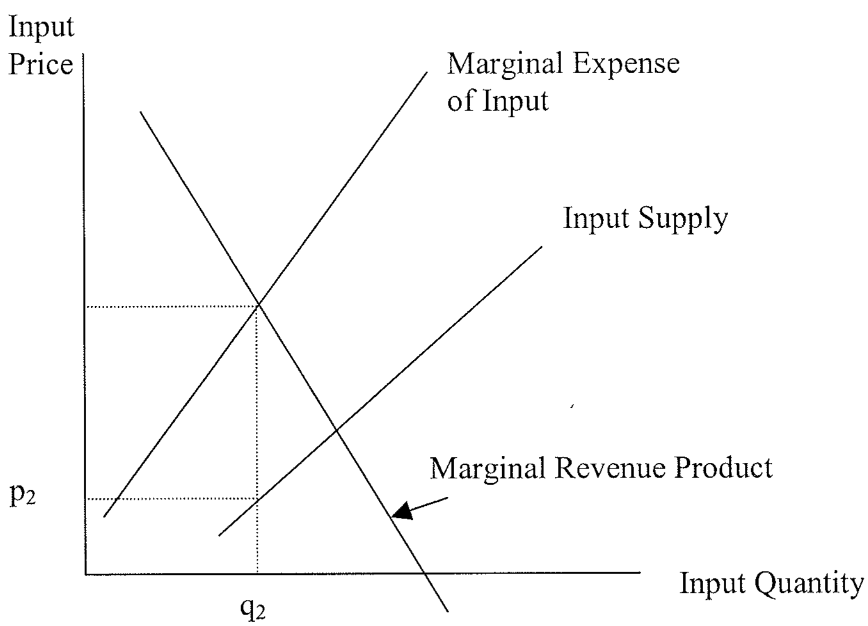
Adapted from Carlton and Perloff 1994

Monopoly is defined as only one firm supplying a market with a product that does not have close substitutes. The firm faces a downward-sloping demand curve and a supply point rather than a supply curve. The company is capable of setting price above its marginal costs and produces less output than what would be expected in a competitive market. Hence, the monopolist generates pure economic profits in long run. In order to maximize its profits, the company sets either the production quantity or the product price. While a monopoly represents one supplier in a market, an oligopoly represents several suppliers. In an oligopoly market a few firms either collude explicitly as a monopolist (e.g. cartel) or act independently but are aware of rivals' decisions (e.g. non-cooperative oligopoly). When firm numbers are few, each seller must be conscious of the actions and potential reaction of rival firms. The equilibrium price in a non-cooperative oligopoly market lies between that of competition and monopoly. An oligopoly market is assumed to sell a homogeneous product and purchase inputs in perfectly competitive markets.

When there is only one buyer in an input market, the firm is referred to as a monopsonist. The monopsonist faces a positive product supply curve (Figure 1.2) (Gould and Ferguson 1980). Therefore, a change in the monopsony firm's purchase affects the price in the factor market. As long as marginal revenue product is higher than marginal expense of input, profits increase by increasing the quantity of input. The firm's profits are maximized when marginal revenue product and marginal expense of input intersect. An oligopsony exists when there are only a few buyers in the input market. When there are a limited number of buyers and they possess market power, input sellers may not have any other option but to accept the prices buyers offer. This situation often occurs regionally. The oligopsonist decides how much to purchase by choosing a price-quantity pair on the industry supply curve.

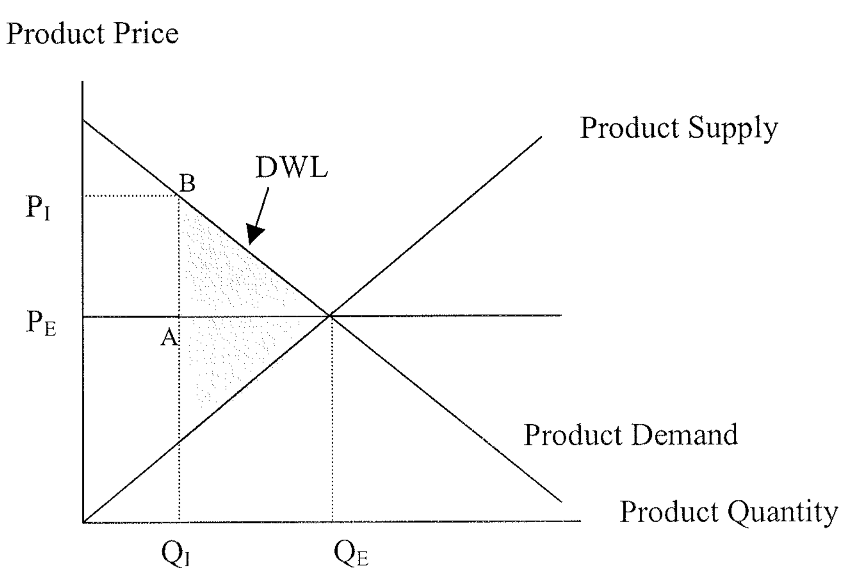
When firms in long run earn profits in an imperfectly competitive market, society is worse off (Carlton and Perloff 1994). In Figure 1.3 consumers attain consumer surplus the area under demand curve and above the equilibrium (combination of the price p_E and the quantity Q_E). Likewise producers attain producer surplus, the area under the equilibrium and above the supply curve. However, firms in an imperfect competition

Figure 1.2 Price and input quantity under monopsony



Adapted from Ferguson and Gould 1980

Figure 1.3 Monopoly profits and dead weight loss



Adapted from Carlton and Perloff 1994

charge the price higher than the competitive level (p_I), and produce less (Q_I). As a result, consumers lose a part of their surplus while producers lose a part of surplus but earn a part of consumer surplus (a rectangle of p_E - p_I - A- B). The shaded area is called dead weight loss (DWL) caused by market power. A perfectly competitive market does not experience these losses.

1.2.1 Causes of Market Power

One of the major economic forces driving industry concentration is scale economies. Production processes exhibit economies of scale if average costs fall as output increases (Carlton and Perloff 1994). As long as marginal costs are below average costs, economies of scale exist. At the production level where average cost equals marginal cost, constant returns to scale are present. Since larger firms produce more than relatively smaller firms, larger firms have advantage in terms of production costs. Since a firm's establishment costs may not vary with the level of output, average cost per unit of output declines as level of production increases. Industries such as telecommunications, cable television, and pharmaceuticals require high establishment costs but face very low marginal costs to serve each additional customer. Serving a large number of customers yields higher profits for these high establishment cost industries.

Establishing formal contracts rather than trading in cash markets is another major factor in industrial concentration. Contracting has led firms to vertically integrate. For example, vertically integrating backward (i.e. acquiring a supplier), a firm reduces transaction costs that occur when using markets, thereby creating the anticipation of higher profits. Transaction costs are the initial costs of negotiating an agreement as well as the ongoing costs of enforcing the agreement. Through vertical integration a company does not need to scrutinize and monitor trading partners in each transaction.

Government involvement such as patents or other restrictions also cause industries to be less competitive. Patent law protects a firm that invents a new product, process, substance, or design with exclusive rights. The law is intended to encourage inventions of new ideas and protects the rights of inventors. The law prevents other individuals from copying the product and suppresses competition for a certain period of time. The copyright law also protects firms. While patents protect function and purpose, copyright laws cover artistic expressions, software, and databases. There are other government restrictions as well. For instance government can set a restriction on the number of businesses in one region. For example, many cities fixes the number of taxicabs. Government interventions can create market power through these types of regulatory activities.

As firms grow larger, their oligopolistic (or oligopsonic) behavior in negotiating prices or terms of trade becomes a potential concern for the public. The U.S. Department of Justice monitors how firms attain and maintain their market power under the regulatory umbrella of antitrust laws. But the Department of Justice does not ban monopolies (Carlton and Perloff 1994). According to common perception, antitrust laws are exercised in order to promote economic efficiency. On the other hand, some analysts argue that laws favor certain groups of society and hurt the rest. Antitrust laws have not yet been enforced on many industries due to the complexity of industrial analysis.

Government agencies attempt to measure industrial concentration but they experience several difficulties in proving market power. First, it is difficult to define a market. How a market is defined often determines the outcome of antitrust cases. Secondly, it is difficult to measure marginal cost in an industry and therefore, difficult to estimate the deviation between price and marginal cost.

1.3 Examples of Market Power

Over the last two decades, the federal government has litigated against several large companies exercising market power. In the early 1980s, AT&T was divested into seven local independent operating companies as a result of the enforcement of antitrust laws. More recently, the Clinton Administration accused Microsoft of using its monopoly power to protect its Windows product (Dreazen, Ip, and Kulish, 2002). The Bush administration's antitrust approach has been more lenient. The recent Economic Report of the President declares that there is little evidence the mergers of the 1980s and 1990s harmed competition (Economic Report of the President 2001). The government's regulatory approach to consolidation influences companies' potential oligopolistic behavior and strategy.

Numerous agribusiness industries, such as meatpacking, grain and oilseed milling, and wholesale and retail food markets, face potentially market power investigations (MacDonald and Denbaly 2000). For example, the beef processing industry's estimated the industry's largest four firm's sales share in percent (CR4) increased from 36 in 1980 to 72 in 1990, with a further increase to 78 in 1997. The leading three companies, IBP, Cargill, and Conagra, dominate beef processing industry sales. No other manufacturing industries have shown as sharp an increase in any period since the U.S. Census Bureau began regularly publishing concentration data in 1947.

Boehlje (1999) points out two major structural transformations occurring in agribusiness. First, consolidation has tightened the control of value chains or supply chains. A value chain is defined as the path of stages (e.g. production, processing, wholesale, and retail). The value chain approach is assumed to improve the chain's efficiency to deliver products to consumers through better product flow, resource utilization, management and quality control, and is expected to reduce risks. The approach is also assumed to improve the ability to respond to changes in consumer demand. In conventional economic theory a "firm" is considered to maximize its profits. According to Boehlje, competition in an industry in the future will not be among firms but among value chains as more industries develop increasingly and tightly aligned paths from input supply to the final customer.

The second transformation, according to Boehlje, is the adoption of process control technology and a manufacturing mentality throughout the entire value chain, particularly at the production level. Agribusiness operations have transformed themselves into more sophisticated, complex industries in order to deliver products for unique end-user products. Process control technology in biological manufacturing has contributed to this movement. This biological manufacturing is characterized by industrialized production using modern business principles and manufacturing approaches. Characteristics of process control technology are (1) information technology to monitor development or deterioration of attributes, (2) biotechnology and nutritional technology to manipulate attributes or development and deterioration of attributes, and (3) technology to intervene with proper adjustments or controls. Successfully implementing the three components of process control technology eliminates the gaps among the steps in the value chain. This transformation eliminates the disconnection that has previously occurred at the farm-gate of the value chain.

These economic forces have raised significant issues in agricultural industries. First, the tightly linked value chains have transformed some agricultural industries into highly concentrated industries. In some food industries, very large firms control the product process from production of raw material through retailing the final product. These companies may exercise market power when buying and selling. They may buy inputs from producers at a lower price than competitive market price and sell products to retailers at a higher price than what would occur in a more competitive market. Boehlje questions, however, whether the concentration in the beef-packing industry is high enough for the government to intervene. What will be the consequences of intervention? Because the beef value chain is across industries, this transformation has changed the definition of "industry." A competitive industry or market has many small firms supplying a homogenous product. However, these chains now deliver products across multiple industries.

The next issue is how firms pass on risks and benefits within the chain. Which level of the value chain bears the risks and which level captures the reward? It is anticipated that vertically integrating reduces risks within the value chain. Is the anticipation correct? What if the chain reallocates the risks externally to producers or consumers? How could a producer in a particular area know the risks he faces are reasonable relative to other producers in the market?

1.4 Potential Market Power in the U.S. Pecan Processing Industry

The U.S. leads the world in the pecan production and trade (USDA ERS 2001). Both production and export volume have increased significantly in the last three decades. However, in the last decade production and prices have been unstable. Pecan production is geographically concentrated in the southern and western regions of the U.S. In addition, a limited number of shellers handle nearly all the processed commodities in the market. Similar to other agricultural industries, the pecan value chain has become more concentrated in recent years.

Although pecan production has increased in recent years, consumer demand has not increased significantly for decades. Season beginning stock levels have risen dramatically. The price of native pecans has not changed considerably since the end of 19th century (McCraw 2002). Native pecans are harvested from trees that have not been grafted or budded. In the southeast U.S., where all native pecans are grown, many small-scale farmers struggle to sustain their pecan orchards. Many native pecan producers are not willing to invest in their trees or production processes due to the part-time nature of these businesses. On the other hand, producers in the western U.S. operate on a more industrialized scale.

What would happen if a limited number of shellers take advantage of small-scale pecan growers and pay less for their pecans than competitive level of market price? What are the effects on pecan price for food companies of having limited a number of pecan processors? The estimate of CR4 for the pecan shelling industry is sixty percent of the shelled pecan market.

1.5 Hypothesis

This paper hypothesizes that there is market power in the pecan processing industry. Shellers may behave as an oligopolist to consumers and oligopsonist to producers. This study will test for this market power using standard econometric tools.

1.6 Organization

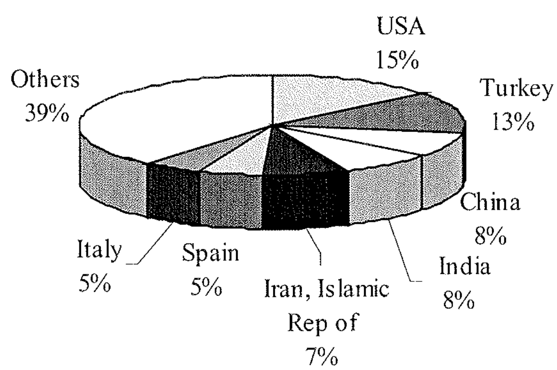
This analysis is organized as follows: Chapter two provides a detailed understanding of pecan industry structure and performance. The third chapter reviews the economic literature on market power and the econometric tools used to estimate market power. The next chapter presents the empirical model and the data used in this analysis and then presents the econometric results. The final chapter summarizes the findings, the limitations of the study, and presents suggestions for further research in the evolving structure of U.S. agribusiness.

CHAPTER TWO: THE U.S. PECAN INDUSTRY

2.1 Tree Nut Markets

World tree nut production reached six million metric tons per year in the late 1990s (Food and Agriculture Organization 2002). As the world's leading tree nut producer, the United States produced approximately 0.86 million metric tons, fifteen percent of world production, followed by Turkey (13%), China (8%), India (8%), Iran (7%), Spain (5%), and Italy (5%) (Figure 2.1). All other nations combined produced less than forty percent of world production. The U.S. accounts for about forty percent of the world's tree nut exports (USDA ERS 2001).

Figure 2.1 World Tree Nut Production by Country in Percentage 5yr Average 1996-2000



Source: Food and Agricultural Organization, FAOSTAT Agriculture Data

The U.S. Department of Agriculture classifies six different kinds of nuts as tree nuts: almonds, hazelnuts, pistachios, walnuts, macadamia nuts, and pecans. Tree nuts classified as "other nuts" are Brazil nuts, pignolias, chestnuts, cashews, and mixed nuts. These later tree nuts are not widely produced in the United States. Peanuts, not a tree nut, are lower priced and do not compete directly on a price basis with tree nuts (Gorman and Herrera 1991). Peanuts are used primarily in salted nut mixtures and candy, while tree nuts are a dominant ingredient in bakery and ice cream products.

Tree nuts are perennial crops. Nut trees mature 3-5 years after planting (Lipe, Stein, and McEachern 1998). Most tree nuts have a significant biological feature known as alternate bearing. Trees produce a large crop one year and significantly less the following year in order to build nutrient reserves. This biological characteristic is a prominent phenomenon in the markets for pecans, walnuts, and pistachios.

Among the six different tree nuts, almonds, pecans, and walnuts represent an annual average of eighty-five percent of U.S. sales over the 1996 to 2000 marketing period. During this period, the U.S. annual domestic tree nut production averaged 1.09 billion pounds and was worth $1.63 billion in farm cash receipts a year. Consumption (domestic consumption + exports) was 1.3 billion pounds per year on average, eighty-two percent of the U.S. total supply (production + imports + beginning stocks). Approximately forty-eight percent of the total supply is consumed domestically. Current per capita consumption of all tree nuts is 2.26 pounds (shelled basis), a slight decrease from 2.27 pounds in the second half of the 1980s. Approximately 684 million pounds, fifty-two percent of U.S. total supply, are exported. This is greater than a sixty percent increase from the late 1980s (USDA ERS 2001). In the 1996-2000 period, sixty-eight percent of U.S. tree nuts exports were almonds, followed by pistachios (4%), and walnuts (3%). Major foreign markets include Canada, Netherlands, Germany, Spain, Mexico, Japan, and the United Kingdom.

Tree nut production is concentrated in several regions in the United States. In 1999, more than seventy-five percent of all tree nuts were produced in the state of California (almonds, walnuts, and pistachios). Nearly all hazelnuts are produced in Oregon, and almost all macadamia nuts are from Hawaii.

United States tree nut imports increased in the 1990s (USDA ERS 2001). The annual average import figure was 253 million pounds in the late 1990s, up from 154 million pounds in the late 1980s. In 1999, fifty percent of U.S. tree nuts imports were cashews, followed by pecans (14%) and Brazil nuts (6%). Sixty-five percent of cashew imports were from India.

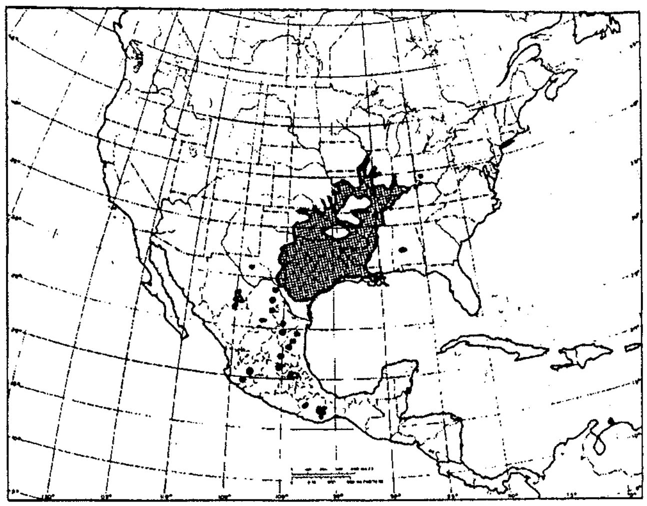
2.2 Pecan Production

Pecans, also called *Carya illinoensis*, are native to Southern North America and grow on alluvial soils of the lower Mississippi River and its tributaries, as well as other river bottoms (Diver and Ames 2000). For thousands of years, both man and wild animals have consumed pecans as an important food source (McEachern, et al. 1997). Commercial production started simply as gathering in native groves and selling the unshelled nuts to the highest bidder. Pecan planting originated in northern Mexico in the late 1600s. Today, most of the world's pecan production is still grown and shelled in North America.

There are two different varieties of pecans: native and improved. As mentioned in Chapter One, native or seedlings nuts are harvested from trees that have not been grafted or budded and do not have a variety name. Native varieties produce smaller nuts, have much lower yields per tree, and produce an inferior kernel percentage than improved varieties. Also, the yield of native nuts is more highly variable from year to year (Diver and Ames 2000). Southern states, such as Georgia, Texas, Oklahoma, Louisiana, and Alabama grow native or seedling varieties (Figure 2.2). However, western Texas and Georgia are shifting to improved varieties that are more resistant to insects. Because of native pecans' extreme alternate bearing nature and the need for income diversification, many pecan farms in the Southern states raise cattle in their pecan groves (Maher 1998).

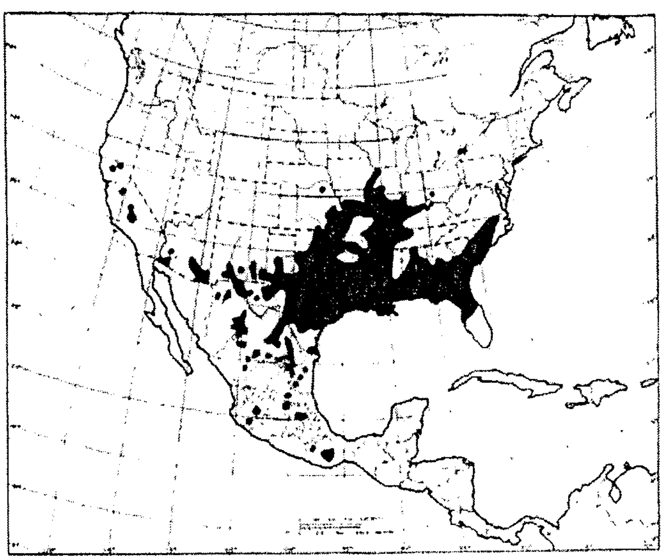
Today, two thirds of all pecan production is from improved varieties or cultivars. The two major objectives of planting improved varieties are nut production and kernel quality (Lipe, Stein, and McEachern 1998). The majority of improved varieties are found in Georgia and Texas as well as in the western U.S. and Mexico (Figure 2.3). Two leading improved varieties in the Southern states are Stuart and Desirable that are well suited to humid regions. These two varieties account for more than one third of U.S. pecan production. Pecans are not considered to be native to the western U.S., where a large proportion of production comes from today. Virtually all pecan trees in the West (i.e. western Texas, New Mexico, and Arizona) are improved varieties planted since the early 1960s. Most of trees found in the western states are Western Schley (also called Western) with Wichita as a pollenizer.

Figure 2.2 Map of native pecan distribution



Source: http://aggie-horticulture.tamu.edu/carya/species/ill/ilnatdis.gif

Figure 2.3 Map of commercial pecan production



Source: http://aggie-horticulture.tamu.edu/carya/species/ill/ilculdis.jpg

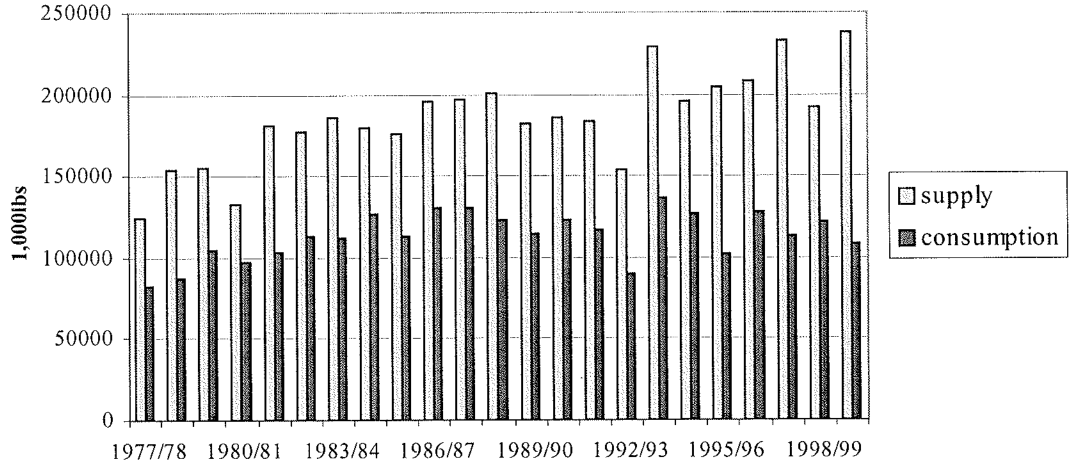
Peña (1993) states that improved variety orchard development is a capital intensive, long-term operation. The establishment of a pecan orchard with improved varieties often requires more than 8 years and it takes 12-13 years to recapture the accumulated expenses. Costs of entry are highly variable and depend on factors such as the size of the orchard, the amount of equipment available, and the management capabilities of the owners.

Southeastern and western states have different orchard management issues (Diver and Ames 2000). Pecan scab disease is a serious problem in the humid southeastern states, so growers plant scab-resistant varieties. Irrigation water is the single largest input for nearly all pecan growers in the western states (Payne 2001). It is also one of the few production inputs over which the grower can exercise nearly complete control. Proper management of irrigation water is critical to the economic productivity of pecan operations since water influences both the crop yield and nut quality.

2.2.1 Pecan Producing States

As noted in Chapter One, the United States is the world's largest producer of pecans. The U.S. and Mexico produce ninety to ninety-five percent of world's pecans depending on the year (Johnson 1997). The major pecan production states are Georgia, Texas, New Mexico, Oklahoma, Arizona, and Louisiana (Table 2.1). U.S. pecan supply significantly increased over the last two decades. During the 1990s, supply exceeded demand causing higher stock levels countrywide (Figure 2.4).

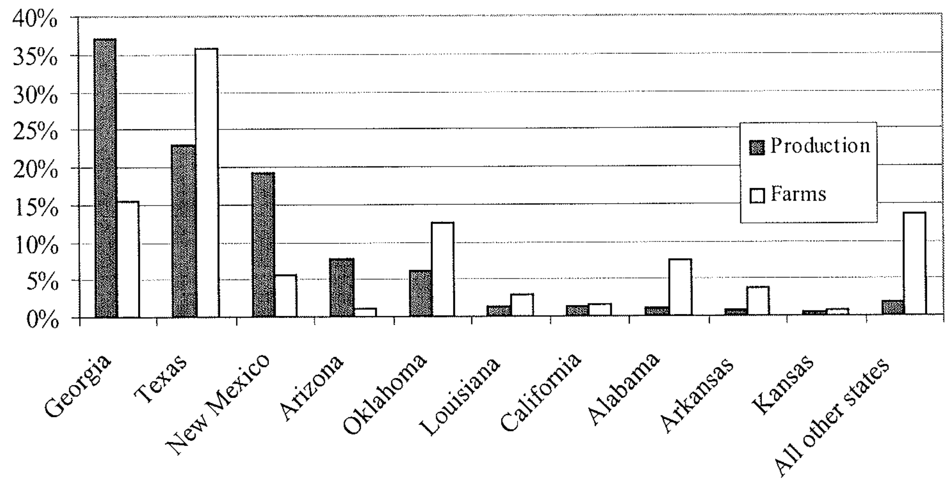
Figure 2.4 U.S. Pecan Supply and Consumption



Source: U.S. Department of Agriculture, Economic Research Service

The 1997 Census of Agriculture (USDA NASS 1999) defines a farm to be any place from which $1,000 or more of agricultural products are produced and sold, or normally would have been sold, during the census year. There were 19,923 U.S. farms producing pecans in 1997, down from 21,206 in 1992. For income and risk diversification, many pecan farms also grow crops other than pecans, such as cotton, peaches, and peanuts. There were 519,000 acres of pecan orchards in the nation in 1997, a ten percent increase from 1992. The census results (harvested pounds, number of farms, and production acres) are presented by percentage by state in Figure 2.5. The top seven producing states have ninety percent of acreage nationwide. Between 1997 and 2001, the U.S. produced an annual average of 283 million pounds of pecans (USDA NASS 2002).

Table 2.5 U.S. Pecan Production and Number of Farms by Percentage by State



Source: U.S. Department of Agriculture, National Agricultural Statistic Service

The largest pecan producing state is Georgia, particularly the southwest region of the state. The state produced an annual average of 88 million pounds of pecans during the 1997 – 2001 marketing period accounting for approximately one third of national pecan production. In Georgia, improved varieties consist of seventy-eight percent of the state's production – the remaining production coming from native varieties. The state is still in transition from native to improved varieties. The number of pecan farms and pecan acreage in the state is 3,000 and 132,000, respectively.

The second largest producing state is Texas with 62 million pounds, which represents twenty-two percent of national production. These top two states, Georgia and Texas, comprise over one half of all U.S. pecan production. Approximately one half of the Texas state production is from native varieties representing nearly one third of national native pecan production. However, pecan production in Texas is gradually shifting toward improved varieties. For example, in western Texas, most pecan orchards are large operations with improved varieties. The state of Texas has the most pecan farms (7,102) and acreage (168,000) in the nation. The number of Texas farms is more than twice the number of Georgia's, indicating that overall, average Texas farms are smaller in scale than those in Georgia. In the southern states, where native pecans originated, trees are often randomly spaced in pastures or along riverbanks, as opposed to the mass commercial plantings in the West.

The third largest producing state, New Mexico, accounts for approximately one sixth of national production with 52 million pounds. Unlike many southeastern states, western states such as New Mexico, Arizona and California have planted improved varieties over the last three decades. New Mexico has 1,105 pecan farms and approximately 30,000 acres of orchards, ranking it fifth and fourth in the country, respectively. According to the 1992 and 1997 Agricultural Censuses, New Mexico's pecan acreage increased twelve percent from 1987 to 1992, and seventeen percent by 1997.

Oklahoma is the fourth largest producing state with 24 million pounds, while ninety-two percent of state production is from native and seedling varieties. The state is the second largest producing state of native pecans after Georgia. The state has approximately 2,500 farms and 84,000 acres of pecans.

The state of Arizona ranks fifth, accounting for 18 million pounds of production, and six percent of U.S. production. The state has only 226 farms (14th), but 14,502 acres of orchards (7th). Similar to New Mexico, Arizona has several large pecan farms. Most of the state's production comes from these large-scale orchards.

Finally, Louisiana, the six largest producing state, produced nearly as many pecans as Arizona did (17 million pounds). However, eighty percent of Louisiana's production comes from native varieties. The state has 579 pecan farms and 14,502 acres. In the area adjacent to the lower Mississippi River in Louisiana, pecans are indigenous and native pecan groves are still productive.

Mexico is the second largest pecan producing country, following the United States, and its production has increased in recent years. In the 2001/2002 marketing year, Mexico's production rose to nearly 59,000 tons (118 million pounds), forty percent of U.S. production) (USDA FAS 2000). Nearly all Mexican pecan production is from improved varieties. All new Mexican plantings of improved varieties were completed in the 1990s and production is expected to increase dramatically as these young trees mature.

U.S. pecan growers are in direct competition with Mexican growers in the state of Chihuahua (Paterson, 1999). The state retains more acreage than New Mexico, Arizona, and California combined. Mexican pecan production is expected to grow significantly with U.S. domestic demand remaining unchanged. Small U.S. producers will face competition, not only with large U.S. producers, but also with pecan producers in Mexico exporting to the U.S. market.

A survey of Georgia growers revealed that very small growers also called "backyard operators" are more likely to have native or seedling varieties (Hubbard, Purcell, and Ott 1987). Small farmers are relatively more dependent on non-farm income sources than large pecan farms. Operators of smaller farms lack market power to negotiate prices with buyers. Smaller farms are concerned that a few large-volume buyers may take advantage of them. These growers experience difficulties in determining the strength of demand among buyers, market price level, and believe that buyers have greater access to market information. Smaller farm operators feel that the limited number of buyers reduces competition, thereby reducing the prices they offer for pecans in the shell.

2.2.2 Demand Dimensions

Consumption for tree nuts, other than almonds and pistachios, has not increased dramatically over the last two decades. The U.S. per capita pecan consumption moderately increased from the late 1970s to 0.506 pounds in the late 1980s, but has shown no significant change since then. It was down to 0.432 pounds in 2000. Relative to other tree nut consumption, pecans rank second, behind almonds, and are followed by walnuts. Pecans represent ten percent of all tree nut consumption in the 1990s (USDA-NASS 2000).

Thirty-nine percent of all tree nuts are consumed as nuts, while twenty-five percent of all tree nuts are eaten as morning cereal (Lin, Frazao, and Allshouse 2001). One pecan grower suggested that pecans should be marketed as a snack food, like pistachios, rather than as a baking or ice cream ingredient (Eastman 2001). This producer noted that customers complain when plain-shelled pecan prices rise in his retail store.

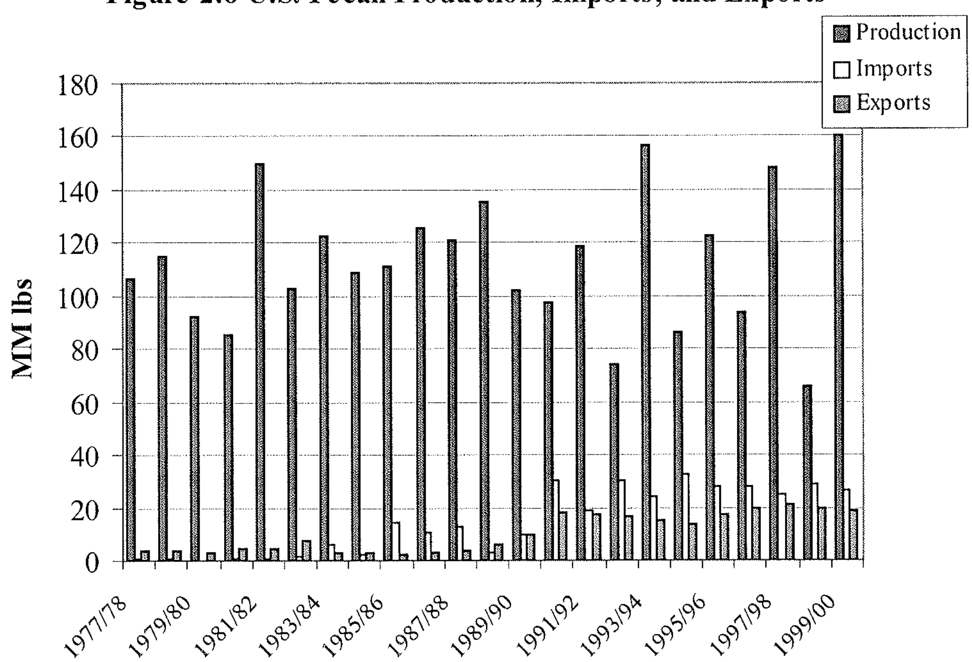
However, customers are more indifferent to price increases on value-added snack-type foods, such as chocolate-coated pecans. Demand for plain pecans is more elastic than ready-to-eat snack food. Customers also prefer to buy pecans in a steady price range, and dislike price fluctuations, according to this producer.

Since pecan demand has been constant, producers and manufacturers claim that the industry needs to promote its consumption. Recently, the pecan industry has promoted the health benefits of pecans through sponsored research (Rajaram, et al. 2001). This recent study shows that the consumption of monounsaturated fat found in pecans helps to reduce coronary risk factors. As another opportunity for increased pecan sales, Storey (1997) analyzed the possibility that pecan oil can be marketed competitively with olive oil. A good quality pecan kernel consists of 73-75 percent oil. According to the author, pecan oil could be a satisfactory salad oil substitute if its price were competitive.

2.2.3 Trade Patterns

Although pecans are consumed primarily within the United States, pecan exports by the United States in 1999 nearly doubled from the volume of exports in 1989. The U.S. exports as a ratio of domestic production grew from a 5-year average of four percent in the late 1980s, to eighteen percent in the late 1990s. Fifty-seven percent of U.S. pecan exports in volume were exported to Canada and Mexico during the 1996 to 2000 period. Under North American Free Trade Agreement (NAFTA), pecans are now traded in a free market zone between Canada, the U.S., and Mexico (U.S. International Trade Commission 2002). Otherwise, an import customs duty is imposed on pecans: 8.8¢/kg on in-shell pecans and 17.6¢/kg on shelled pecans. Mexico has removed tariffs on nuts imported from the United States that had varied from fifteen to twenty percent. A large share of the exports to Mexico is in-shell pecans to be shelled out by Mexican shellers and re-exported to the United States. The U.S. exported an annual average of almost 20 million pounds, shelled basis (U.S. Department of Commerce 2000) (Figure 2.6). The value of exports was approximately $55 million. Other major foreign markets are England and the Netherlands.

Figure 2.6 U.S. Pecan Production, Imports, and Exports



Source: U.S. Department of Agriculture, Economic Research Service

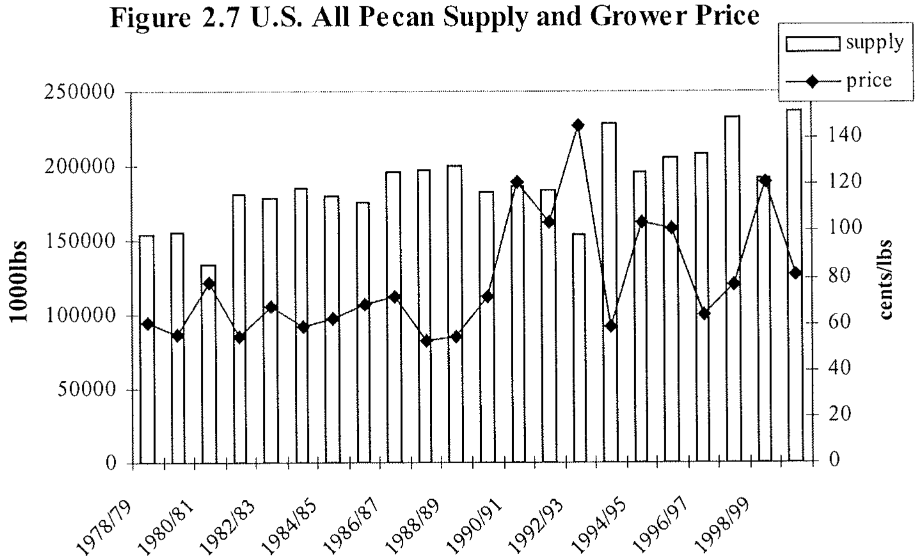
Although pecan exports have increased, the traded amount is still not substantial compared to total supply. Because pecans have been produced and consumed in a limited geographic area, pecans are not a well-known food outside North America. The industry has not been aggressive about expanding domestic consumption and developing foreign markets.

The United States is a major importer of pecans, as noted earlier, primarily shelled pecans from Mexico (USDA ERS 2001). Until the mid-1980s, pecan imports were trivial, but grew throughout the 1990s. In the late 1990s, the United States imported an average of 26 million pounds a year. In a five-year average, pecan imports represented twenty-six percent of U.S. domestic production in the late 1990s, an increase from nine percent in the late 1980s. Although domestic production levels vary, U.S. pecan imports have increased steadily in the past two decades as Mexico's production increased and labor advantages were exploited by large U.S. pecan producers. Ninety-eight percent of pecan imports come from Mexico followed by Australia (1.2%), and Peru (0.6%) (U.S. Department of Commerce 2000). Mexico principally exports to the U.S. and Canada.

2.2.4 Price Analysis

In the past decade, pecan prices have trended slightly upward and have become increasingly difficult to predict. Pecan prices prior to the late 1980s were significantly lower than current prices, but also more stable. Since the late 1980s, there have been more variable supply and price conditions, due in part to the alternate bearing characteristics of pecan trees (Figure 2.7).

Figure 2.7 U.S. All Pecan Supply and Grower Price



Source: U.S. Department of Agriculture, Economic Research Service

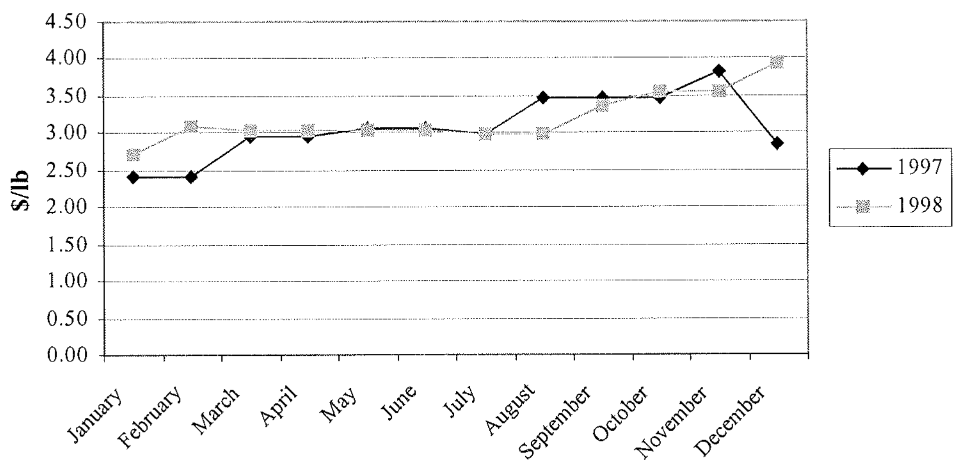
Pecan buyers such as processors take into account various factors to determine the price they are willing to offer the product. First, buyers consider nut quality. The criteria for nut quality are: nut size, meat size, color of the meat, and shell-out percentage of the nut. Shell-out percentage refers to the amount of nutmeat yield relative to the weight of the whole pecan. For instance, Western Schley variety, fifty-five to sixty percent of nutmeat is expected (Herrera 1995).

Other factors that affect market prices are the current forecast of domestic pecan crop size and the volume of Mexican production (Hall et al.1998). In 2001, Mexican pecan prices averaged approximately $1.10 per pound for good quality improved varieties – a price comparable to the U.S. price (Pecan Newsletter 2002). Other factors, such as late season weather, crop size of other nuts, the quality of their crops, and volume of pecans in cold storage, have limited influence.

Johnson (1998) claims that the recent price fluctuations are principally due to economic factors. He points out the possibility of shellers' "oligopsonistic" behavior against producers. Since there are few pecan buyers they, according to Johnson, are capable of exploiting producers. Johnson argues that shellers take into account their stocks from the previous season using their proprietary storage information. If they have enough carryover, they may not purchase extra amounts or may offer less than the price producers expect. Since there are few buyers in the market, producers have to take the offer if no other alternative is available.

Producers are also constrained in terms of the optimal time to market their crops. Prices do not only differ every year, but also within a season. Typical monthly prices are presented in Figure 2.8. The data are reported by Food Institute, not by the government, so only data for two years is available. When the price data are reported as a range, the midpoint is calculated and reported. Since the pecan demand increases before the Thanksgiving-Christmas holiday season, pecan prices generally increase approaching December. After the holiday season, pecan prices usually decline due to a significant drop in demand. If growers expect favorable prices, they sell their crops in a relatively short time after harvesting in the fall. According to a survey (Hall et al. 1998), most shellers in Texas prefer to purchase pecans in October and pay cash on delivery after grading. Shellers prefer to prepare their stock at this time for the November-December holiday season. Based on Hall et al.'s survey, no other form of transaction, such as forward contracting, was exercised in these exchanges.

Figure 2.8 FOB Monthly Pecan Prices 1997-98



Source: U.S. Department of Agriculture, Economic Research Service 1999

2.2.5 Pecan Value Chain

The pecan value chain is presented in Figure 2.9. Pecans are marketed either shelled or in-shell. Pecan growers buy resources such as fuel, labor, pesticides, herbicides, and fertilizers from suppliers. Most of these inputs are not unique to pecan production, except for harvest equipment designed specifically for nut orchards (Gorman and Herrera 1991). Because investment on pecan orchard equipment is costly, growers with a small orchard custom contract larger growers or harvesters for tree nut harvesting services.

Growers sell crops to middlemen after harvesting. One type of middleman is an accumulator (Hall et al. 1998). Accumulators purchase pecans from growers in small lots until they have enough volume to sell to shellers or wholesalers at favorable prices.

Small-scale pecan producers prefer to trade with accumulators since these middlemen deal comfortably with small quantities. When a single grower brings his crop to a buyer the buyer offers a "door price." If several growers offer their crops combined to a buyer it is called "pooling." Since pooling represents a larger crop, the buyer will quote a better price than the "door price". Producers with slightly larger crops choose brokers to trade their pecans. Brokers do not own pecans during the trade, but earn a sales commission for negotiating the transaction between growers and buyers. Since accumulators and brokers are associated with relatively small-scale growers, these middlemen are most common in the South and Southeast states. Accumulators and brokers sell in-shell pecans to shellers, wholesalers, or directly to retailers.

In the Western states, where large-scale growers are more common, shellers play an important role in the pecan value chain – many of the largest shellers wholesale and retail shelled pecans, and are producers as well. Shellers obtain in-shell nuts from local pecan growers, then split the pecan shell and the nutmeat (Hall et al. 1998). Next, the sheller evaluates and sorts the nut by size, and grades. Finally, they package the nut and market when appropriate or store the final product. Shellers typically sell commodities to wholesalers and pecan processors (e.g. bakers, confectioners, salters, and ice cream manufacturers), retailers, and exporters (Gorman and Herrera 1991). Processors are the largest end-users of shelled pecans. Hershey's, Keebler, and Mars are major customers for shelled pecans. Processed products are then resold to retail, industrial, and other wholesale outlets.

Retailers market pecans shelled or in-shell as well. Supermarkets and grocery stores are the largest retail outlets for pecans and food products containing pecans. On a much smaller scale, consumers also buy pecans at roadside stands. Direct retail selling, such as roadside markets, provide the highest gross revenues to growers but require significant amounts of their time and labor.

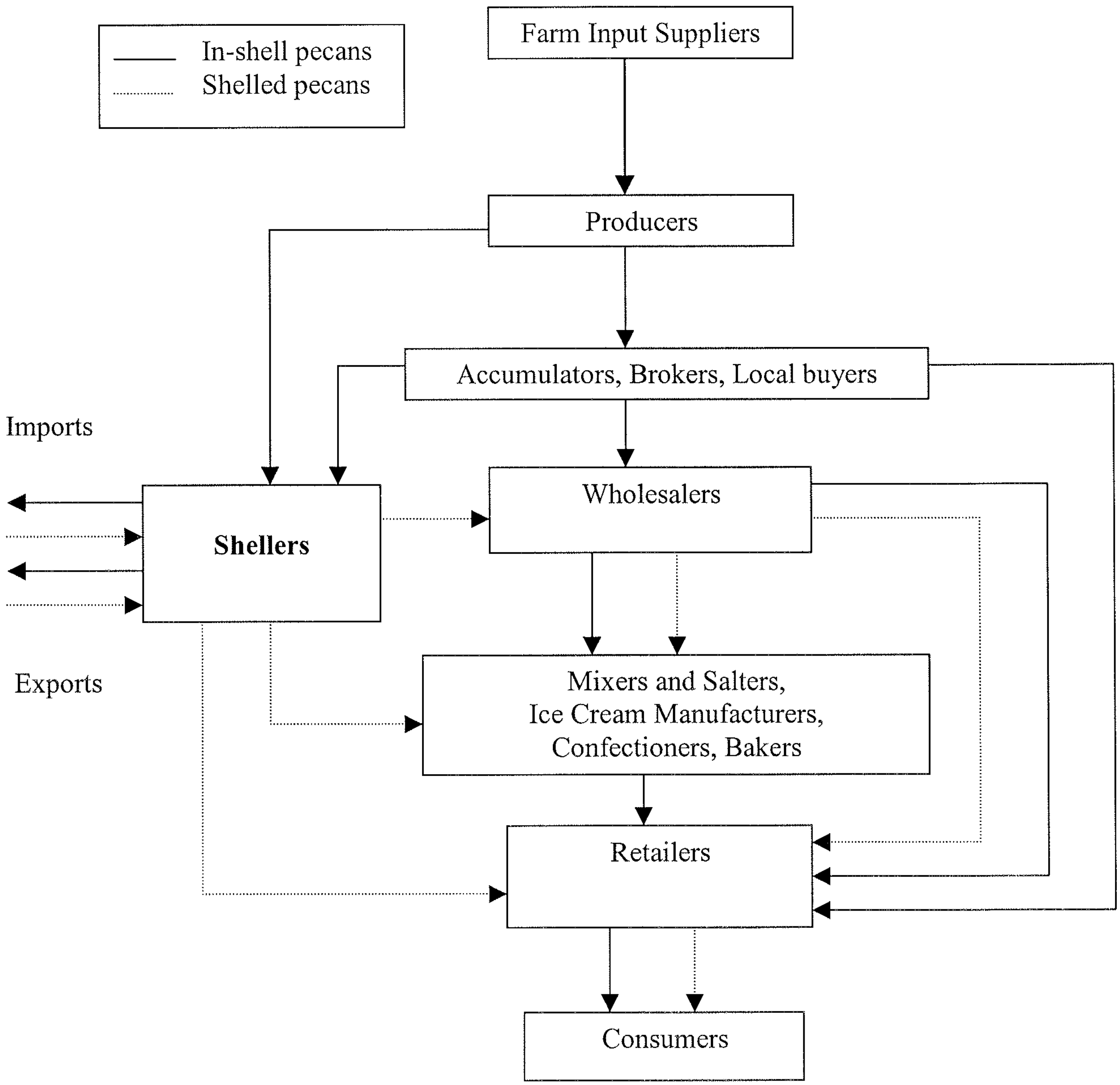


Figure 2.9 Pecan Value Chain (Adapted from Gorman and Herrera 1991)

CHAPTER THREE: MEASURING MARKET POWER: A SELECTED LITERATURE REVIEW

Industrial organization (IO) economists have attempted to measure the market power of numerous industries over the years. Two theories, the Structure-Conduct-Performance (SCP) paradigm and New Empirical Industrial Organization (NEIO) have received the most attention in the IO literature. NEIO was developed to improve upon the earlier contributions of SCP theory to utilize econometric analysis to evaluate market structure. In recent years, many economists have analyzed the market structure of processing and retail industries, including beef packing in the United States. This chapter reviews the methodology and results of recent market structure evaluations.

3.1 The Structure-Conduct-Performance (SCP) Paradigm

Historically, the SCP paradigm has been one of the principal approaches to the study of industrial organization (Carlton and Perloff 1994). Edward Mason and his colleagues at Harvard first introduced the concept of SCP in 1937 with case studies of single industries. Since then many economists have applied SCP to examine what major factors determine market power and how much market power individual firms exercise in their industries. SCP studies have more recently been conducted to compare market power across multiple industries.

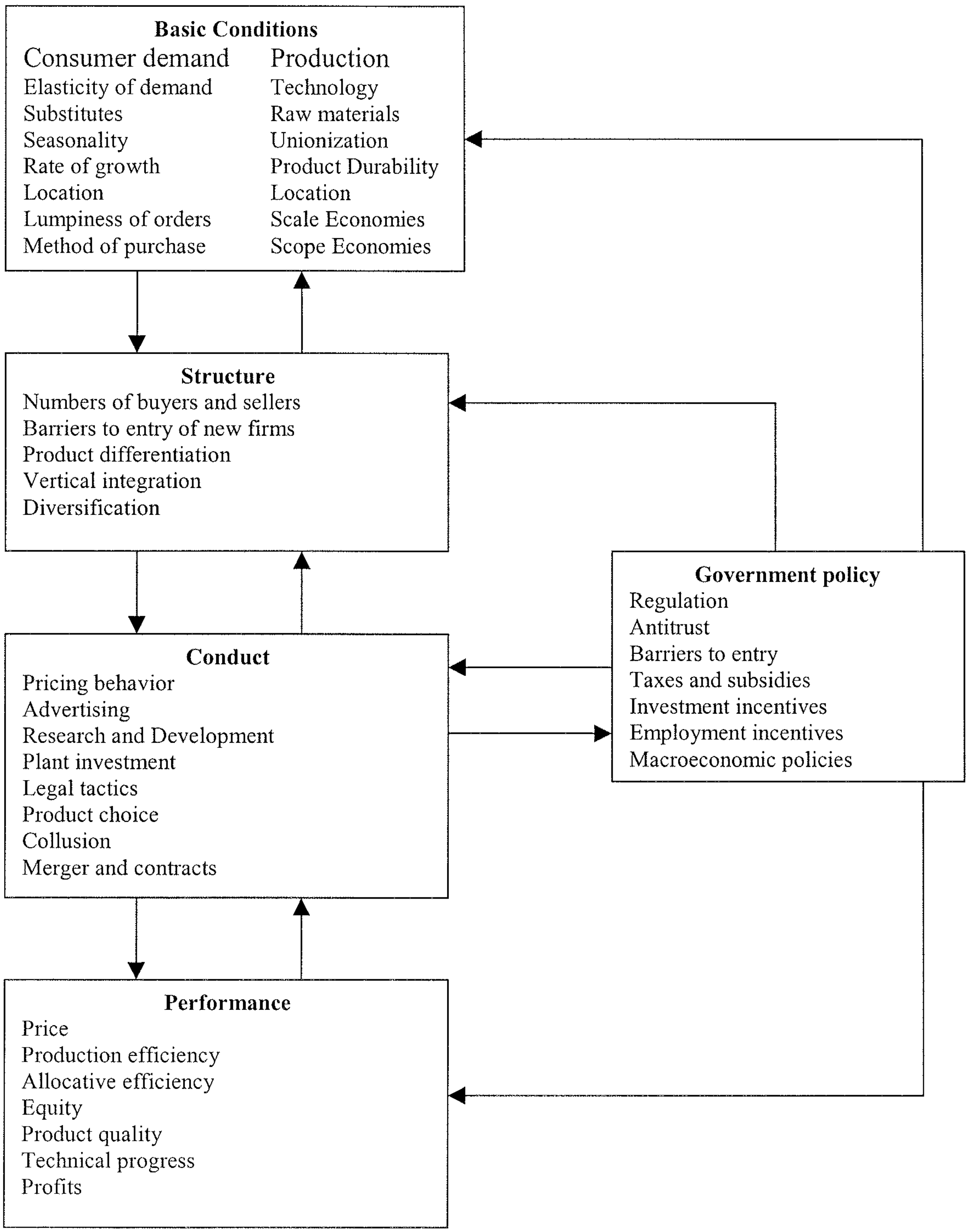
In the SCP framework, market performance is the success of the firm or industry in producing benefits for consumers. Market structure is developed based on the basic conditions for consumer demand and production. Conduct or activities such as R&D, advertising, and pricing behavior, depend on the structure of market. A firm's market power (or performance), frequently measured by profits or price-cost margin (PCM), depends on the conduct or behavior of sellers or buyers. The interdependent factors in SCP theory are illustrated in Figure 3.1.

3.1.1 Market Power Measures

In SCP theory, market power is measured in several ways including PCM. One of the methods is the four firm concentration ratio (CR4) issued by Bureau of Census. It refers to the percentage of industry sales accounted for the four largest firms within the industry. The value of CR4 lies between 0 and 100 (Carlton and Perloff 1994). The Census Bureau also publishes CR8, the share of sales accounted for by the eight largest firms. An alternative measure of market power is the Herfindahl-Hirschman Index (HHI). This index is the sum of the squared market share of each individual firm in an industry, and the value of HHI lies between zero and one. These measures require individual firm's market share information. Unfortunately, firm-level information is not accessible in many industries.

A third measure is the Gini coefficient derived from the Lorenz Curve (Yotopoulos and Nugent 1976). The Lorenz Curve generally is used to illustrate the unequal income distribution within and between nations. This relationship can also show the inequality of revenue distribution within an industry. The Lorenz Curve is illustrated in Figure 3.2 in which the cumulated sales (expressed as a percentage) are on the vertical

Figure 3.1 Structure, Conduct, and Performance Paradigm

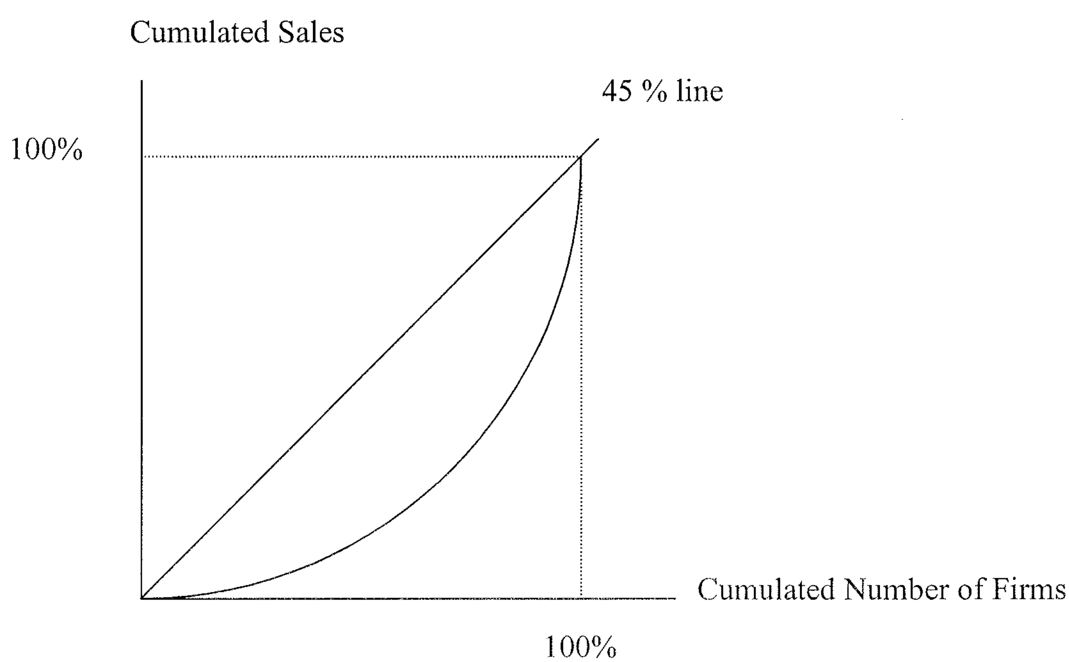


Source: Adopted from Carlton and Perloff 1994 axis and the cumulated number of firms (expressed as a percentage) is on the horizontal axis. Firms are placed from the lowest to the highest amount of sales in the figure. A forty-five degree line represents an even distribution of sales in a perfectly competitive market. The closer the Lorenz Curve of an industry is to this line, the more equal the distribution of revenues is across firms. The Gini Coefficient is the ratio between the area under the forty-five degree line and the area under the actual line. It is mathematically defined as

$$G = \frac{I}{T} = \frac{T-U}{T} = 1 - \frac{U}{T} \tag{3.1}$$

where G is the Gini coefficient, I is the area between the actual line (curved line) and the 45-degree line, T is the size of triangle (the triangle ABC), and U is the is the

Figure 3.2 Lorenz Curve



complement of I in the right triangle. The closer the Gini Coefficient is to one, the greater the inequality of the distribution. The Gini Coefficient also requires firm-level financial data to estimate market power of an industry.

Finally, numerous economists have attempted to estimate industry concentration with the price-cost margin (PCM) or Lerner Index (Lerner 1934). Profit maximizing firms choose a production level where marginal revenue equals marginal cost. PCM is the ratio of the difference between the output price and the marginal cost to the output price. That is,

$$PCM = \frac{p - MC}{p} = -\frac{\lambda}{\varepsilon} \qquad (3.2)$$

where p is the price of output, MC is the firm's marginal cost, and ε is the price elasticity of demand for output. λ represents the industry concentration measure. Its value lies between zero and one, zero being perfect competition and one for monopoly. Price elasticity of demand is the percentage change in quantity demanded in response to an infinitesimally small percentage change in price. It is defined mathematically,

$\varepsilon = (\frac{\partial Q}{\partial P})\frac{P}{Q}$. In a perfectly competitive market, price is identical to marginal cost, so the value in equation 3.2 will be zero. At the other extreme, a monopoly will have a significant divergence between price and marginal cost. A monopolistic market is characterized by a high price-marginal cost differential and inelastic demand. As industry concentration increases, the differential increases and the PCM ratio increases. As the differential between price and cost increases, the absolute value of price elasticity of demand decreases, thereby increasing the ratio value.

PCM is a major analytical concept in SCP research. Typical SCP studies regress accounting rate of return on the industry concentration index, CR4 or CR8. The rate of return from accounting records is used as a proxy for the MC of a firm or industry. Empirical studies generally have multiple industry data (Sheldon and Sperling 2001). The following is an example of a typical SCP model,

$$\Pi_i = \alpha_i + \beta S_i \tag{3.3}$$

where Π is a measure of average accounting rate of return in the i^{th} industry, S_i is industry concentration and α is a constant and represents all other factors affecting industry profitability. The coefficient, β, is usually a positive value indicating a positive relationship between firm-level profits and industry concentration.

SCP analysis typically examines only a single time period. It is known that models produce biased policy results when data are utilized from only one particular year. Utilizing time series data can avoid this problem, however, most SCP studies have data from multiple industries, which make it difficult to observe inter-industry differences within a single model.

3.2 New Empirical Industrial Organization Theory (NEIO)

Industrial organization economists extended the SCP methods to develop a new theory called New Empirical Industrial Organization (NEIO). NEIO research focuses on a single industry with panel data. NEIO analyses hypothesize that an industry is imperfectly competitive and assume that firms maximize profits. Empirical researchers utilizing NEO theory typically use industry-level data because firm-level data are not generally available.

An NEIO oligopoly model is a structural model containing demand and supply equations. In imperfectly competitive markets firms do not posses a supply curve but rather "general supply relations", the locus of points that result from equating marginal revenue and marginal cost (Sheldon and Sperling 2001). Mathematically general supply relation represents the equality of "perceived" marginal revenue and marginal cost.

The following equation is a general form of i^{th} firm's supply relation model. The model assumes n-firms, homogenous products, and a quantity-setting oligopoly. In an oligopoly market, firms maximize their profits by meeting the following condition,

$$P(Q,z) = \frac{\partial C(q_i, w)}{\partial q_i} - \lambda_i \frac{\partial P(Q,z)}{\partial Q} q_i, \tag{3.4}$$

where $P(Q,z)$ is inverse industry demand, $Q = \sum_{i=1}^{n} q_i$ is industry output, z is a vector of exogenous demand-shift variables (e.g. price of other products), $\partial C / \partial q_i$ is a firm specific marginal cost, q_i is the firm's output, w is a vector of exogenous cost-shift variables (e.g. price of other inputs). λ_i indicates the competitiveness of an industry, and is the parameter to be determined. $\partial P / \partial Q$ is the slope of inverse industry demand. If the product is inelastic, the industry tends to have high profitability. In contrast, if the industry has elastic demand and is less profitable — the difference between the price and the cost is less significant. Supply relations indicate that perceived marginal revenue equals marginal cost. Unlike accounting rate of return in the SCP model, NEIO theory does not assume economic cost is directly observed in accounting data but instead estimates marginal cost as a part of an econometric structural model derived from a cost function. Sheldon and Sperling (2001) interpret equation 3.4 as an industry average supply relation.

The variable λ, defined as $\lambda = dQ/dq_i$, is important in this model because it indicates the competitiveness of the market. In a perfect competitive market λ is zero, so perceived marginal revenue equals the marginal cost. On the other hand, λ is equal to one in a monopoly or a cartel. In most industries, λ is between zero and one depending on the number of participants in the market. The value of λ will be 1/n for n-firm Cournot oligopoly. In a Cournot equilibrium, it is assumed that each firm acts independently and attempts to maximize its profits by choosing an output level in a non-cooperative oligopoly (Carlton and Perloff 1994).

Sheldon and Sperling introduce an interpretation of λ in an industry average supply relation. They subtract $\partial C / \partial Q$ from the values of both sides in equation 3.4 (with the values of industry-level supply Q, not q_i), then divide the resulting expression by P. The calculation gives an industrial supply relation in a different form,

$$\lambda = -L\varepsilon . \qquad (3.5)$$

where $\varepsilon < 0$ is the industry price elasticity of demand, and L is the PCM (or Lerner Index). Since the value of the parameter λ is between zero and one, the L will be $0 \leq L \leq -1/\epsilon$. λ can be interpreted as the elasticity adjusted PCM in equation 3.5. According to Sheldon and Sperling, λ accounts for either a market that has high margins because demand is inelastic or a market that has high margins due to market power. In addition, PCM ($L = -\lambda / \varepsilon$ where ε is inverse demand elasticity) is derived from the equation 3.5.

The following section discusses three NEIO studies. Bresnahan's review of the NEIO literature, Appelbaum's application of the analytical techniques to industrial-level data, and finally, Schroeter's attempt to measure oligopoly/oligopsony market power simultaneously.

3.2.1 Bresnahan's Review of NEIO

Bresnahan summarizes past studies of NEIO theory in his "Empirical Studies of Industries with Market Power" (1989). Bresnahan uses Porter's (1984) study of strategic interaction in the nineteenth-century railroad industry as an introduction to NEIO theory. The stylized model contains three sets of unknown parameters to be estimated: costs, demand, and firm conduct (or profitability). The endogenous time-series variables include industry price and each firm's production levels. The exogenous variables include those that shift cost and demand functions such as prices of other products and inputs.

The NEIO method first defines industry demand as

$$P_t = D(Q_t, Y_t, \delta, \mu_{dt}) \tag{3.6}$$

where P_t are market prices (the dependent variable), Q_{it} are each firm's quantities, Y_t are all variables shifting demand, δ represents other exogenous variables of the demand function, and μ_{dt} are econometric error term. d indexes the demand function. In a single product market, $Q_t = \Sigma_i Q_{it}$. i indexes firms, and t indexes time-series observations. A firm's total cost function is,

$$C_{it} = C(Q_{it}, W_{it}, Z_{it}, \Gamma, \mu_{cit}) \tag{3.7}$$

where W_{it} is the vector of factor prices paid by firm i at observation t, Z_{it} are other variables that shift cost, Γ are unknown parameters, and ε_{it} are econometric error term. c indexes the cost function. The firm's marginal cost function is obtained by differentiating the total cost function, so

$$MC = C_1(Q_{it}, W_{it}, Z_{it}, \Gamma, \mu_{cit}). \tag{3.8}$$

As noted before, except in a perfectly competitive market, firms do not have supply curves. Instead, price- or quantity-setting conduct follows the general supply relations:

$$P_t = C_1(Q_{it}, W_{it}, Z_{it}, \Gamma, \mu_{cit}) - D_1(Q_t, Y_t, \delta, \mu_{dt})Q_{it}\theta_{it}. \tag{3.9}$$

Equation 3.9 can be interpreted as the marginal cost equals perceived marginal revenue for oligopoly models. The parameter θ, defined as conjectural variations, indexes the competitiveness of oligopoly activities (equivalent to λ by Sheldon and Sperling). θ is a change in industry supply with respect to an individual firm's supply. As θ_{it}, a positive parameter, increases the conduct of firm i moves away from a perfect competitor's.

With firm-level or industry-level data, these relationships are estimated econometrically using simultaneous equation estimation techniques. If equations 3.6 and 3.9 are solved simultaneously for all firms, the model yields the reduced forms for price and each firm's quantity:

$$P_t = P^*(W_t, Z_t, Y_t, \Omega, \mu_t), \tag{3.10}$$

$$Q_{it} = Q^*_{i_t}(W_t, Z_t, Y_t, \Omega, \mu_t), \tag{3.10'}$$

where $\Omega = (\delta, \Gamma, \theta)$ is the vector of all parameters, μ_t is the vector of all structural error terms, W_t is the superset of all the W_{it}, and Z_t and Y_t are similarly defined. Also, we have the reduced form equation for industry quantity, $Q^*(\cdot)$.

Bresnahan discusses three advantages of estimating the above stylized models. First, the econometric approach is structural, meaning each parameter has an economic interpretation. The demand model specifies a behavioral response of consumers in the market, and the supply model specifies a behavioral response of firms. Second, conjectural elasticity, θ, will reveal the distortion within the industry if the estimation is correct. The third advantage is that given the structural nature of the econometric models, the data will identify the conduct parameters such as pricing behavior.

3.2.2 Use of Industrial Aggregate Data

Appelbaum (1982) uses the production theoretic approach to exploit the duality between cost and production functions in order to derive industry measures of conduct and the PCM (Sheldon and Sperling 2001). Since only industry-wide aggregate data are available for many industries, Appelbaum replaces firm-specific data with industry aggregate data. t indexes time-series, and j indexes firms throughout the model. The general supply relation (3.9) for industry-level data without the firm index j, is defined,

$$P_t = C_1(Q_t, W_t, Z_t, \Gamma, \mu_{ct}) - D_1(Q_t, Y_t, \delta, \mu_{dt})Q_t\theta_t. \qquad (3.11)$$

Appelbaum (1982) applied this estimation procedure to four U.S. industries: rubber, textiles, electrical machinery, and tobacco. Appelbaum measured the degree of industry oligopolistic power by utilizing the Lerner index, L. An important contribution by

Appelbaum is the estimate of a conjectural elasticity, θ, defined as $(\partial y / \partial y^j)(y^j / y)$, where y is industry supply and y^j is a firm's supply. Conjectural elasticity includes both its conjectural variation, $\partial y / \partial y^j$, and the firm's output share. It estimates the effect of each firm's production change on the whole industry. Conjectural elasticity would be one in a monopoly market and is zero in a perfectly competitive market. In many industries, θ is estimated to be between these two values. In conjectural variation models, each firm chooses its price or output to maximize its profit based on its conjecture (hypothesis or expectation) about how each rival firm will respond to their actions (variations) (Carlton and Perloff 1994). Each firm's conjecture is that no matter how it behaves, other firms will continue to sell their current quantity of output.

Appelbaum defines market demand as a function of price and exogenous variables such as prices or quantities of other inputs. He then derives input demand functions from the cost function by applying Shephard's Lemma. Appelbaum defines the j^{th} firm's profit maximization problem as,

$$\max[py^j - C^j(y^j, w) : y = J(p,z)] \tag{3.12}$$

where $y = \sum_{j=1}^{s} y^j$ is industry supply, p is the price of output, C^j is j^{th} firm's cost function. J is the market demand, w is the price vector of the inputs, and z is the vector of exogenous variables. The optimality condition corresponding to this profit maximization problem is

$$p(1 - \theta^j \varepsilon) = \partial C^j(y^j, w) / \partial y^j \tag{3.13}$$

where θ^j is conjectural elasticity for j^{th} firm, and ϵ is the inverse market demand elasticity, $\varepsilon = -(\partial p / \partial y)(p / y)$. The optimality condition describes that the j^{th} firm equates its marginal cost with its perceived marginal revenue. With the profit maximization condition, Appelbaum defines the degree of oligopoly power of the j^{th} firm, α^j, as

$$\alpha_j = [p - \partial C^j(y^j, w) / \partial y^j] / p = \theta^j \varepsilon . \tag{3.14}$$

This measure of oligopoly power contains the conjectural elasticity and the inverse demand elasticity. The value for the degree of oligopoly power for a firm is between zero and one. Given a firm's degree of oligopoly power, α_j, Appelbaum defined the degree of oligopoly power in an industry, L, as:

$$L = \sum_j [(p - MC^j) / p] S_j = \sum_j \alpha_j S_j = \sum_j \theta^j S_j \varepsilon \tag{3.15}$$

where $S_j = y^j / y$ and the MC^j is the marginal cost of j^{th} firm. Therefore, the industry measure is a weighted average of the firm-level measures of oligopoly power. Equation 3.15 can be rewritten by substituting the definition of θ_j to produce

$$L = \sum_j \frac{\partial y}{\partial y^j} S_j^2 \varepsilon . \tag{3.16}$$

The measure of oligopoly power, is a weighted sum of the squared shares of the firms in the industry multiplied by the inverse demand elasticity. The measure of oligopoly can be obtained as

$$L = \theta \varepsilon . \tag{3.17}$$

Appelbaum then shifts to aggregate industry-level measures. He assumes that all firms face the same prices in input industries. The aggregate demand function for the i^{th} input is

$$x_i = \sum_j x_i^j = \sum_j \partial C^j(y^j, w) / \partial w_i, \qquad i=1,\ldots,n, \qquad (3.18)$$

where x_i^j is the j^{th} firm's input demand for i^{th} input and $\partial C^j / \partial w$ is the column vector of partial derivatives of C^j with respect to w. Appelbaum assumes that the cost function of the firms satisfy the following condition,

$$C^j(y^j, w) = y^j C(w) + G^j(w), \qquad i=1,\ldots,s, \qquad (3.19)$$

where C^j is the cost function, G^j is fixed cost for the j^{th} firm. In this model marginal costs are constant and identical across firms. The aggregate input demand functions are obtained by differentiating the cost function, 3.18 to find

$$x = y[\partial C(w) / \partial w] + \sum_j \partial G^j(w) / \partial w. \qquad (3.20)$$

This function is expressed with only aggregate industry variables. From the profit maximizing condition 3.13 we see that at equilibrium firms have the same conjectural elasticities if marginal costs are identical for all firms.

Appelbaum concludes that as long as equilibrium exists, θ is at the "equilibrium value" for all companies and is a function of all exogenous variables. The aggregate optimality condition is

$$p(1 - \theta\varepsilon) = C(w). \qquad (3.21)$$

Thus, as long as equilibrium exists, all firms have equal perceived marginal revenues and equal conjectural elasticities. The estimate of the model will yield the value of θ between zero and one. θ indicates the deviation of the market structure from two extreme conditions, monopoly and perfect competition. Appelbaum states that the conjectural elasticity provides a measure of concentration of an industry.

Appelbaum assumed that three inputs - capital (K), labor (L) and an intermediate input (M) - are competitively priced. Initially, he estimated an industry demand function in Cobb-Douglas form,

$$\ln y = a - \eta \ln(p / S) + \rho \ln(q / S), \tag{3.22}$$

where q is the GNP in current dollars and S is the implicit GNP deflator. α is constant and η, ρ are coefficients. The demand elasticity is a constant value, $\eta = 1/\varepsilon$. Appelbaum also assumed the industry cost function as a generalized Leontief of the Gorman-polar form,

$$c = \sum_i \sum_j b_{ij} (w_i w_j)^{1/2} y + \sum_i b_i w_i, \qquad i,j\text{=}K,L,M, \tag{3.23}$$

where $b_{ij} = b_{ji}$ and $\sum b_i w_i = \sum_j G^j(w)$, b's are coefficients.

The full model for each of the industries is estimated simultaneously,

$$x_K / y = b_{KK} + b_{KL} (w_L / w_K)^{1/2} + b_{KM} (w_M / w_K)^{1/2} + b_K / y,$$

$$x_L / y = b_{LL} + b_{KL} (w_K / w_L)^{1/2} + b_{LM} (w_M / w_L)^{1/2} + b_L / y,$$

$$x_M / y = b_{MM} + b_{KM} (w_K / w_M)^{1/2} + b_{LM} (w_L / w_M)^{1/2} + b_M / y,$$

$$\ln y = a + \eta \ln(p / S) + \rho \ln(q / S),$$

$$\begin{aligned} p = [&b_{KK} w_K + b_{LL} w_L + b_{MM} w_M + 2b_{KL} (w_K w_L)^{1/2} \\ &+ 2b_{KM} (w_K w_M)^{1/2} + 2b_{LM} (w_L w_M)^{1/2}]/[1 - \theta / \eta]. \end{aligned} \tag{3.24}$$

θ is plugged into the last equation of 3.24,

$$\theta = A_0 + A_K w_K + A_L w_L + A_M w_M . \quad (3.25)$$

Conjectural elasticity (θ) is estimated as a function of input prices. A's are parameters. This form allows for θ varying over time to indicate changes in market structure. The model is estimated using full information maximum likelihood method with y, p, x_K, x_L, and x_M as endogenous variables.

Appelbaum's model (3.24) consists of three input demand equations for the material input and the non-material inputs (labor and capital), an industry demand equation, and the profit equation. By estimating the five equations in 3.24 simultaneously the system determines the magnitude of each variable, and the conjectural elasticity, and the demand elasticity at the equilibrium points for each industry.

Appelbaum applies this aggregate approach to four U.S. manufacturing industries: rubber, textiles, electrical machinery, and tobacco. Results are presented in Table 3.1. The data were collected for 25 years from 1947 to 1971. He calculated the conjectural elasticities, θ, and degree of oligopoly power, L, for these industries. He then, tested the obtained values to the null hypothesis, $A_0 = A_L = A_M = A_K = 0$, and hence θ is zero, against the alternative hypothesis that not all A's are zero.

Table 3.1 Appelbaum's Empirical Results

Industry	θ, Estimated conjectural elasticity	Demand elasticity	L, Degree of oligopoly power	χ^2 Statistics ($\chi^2_{(4)0.01}$=13.3)
Rubber	0.0186	0.2159	0.0559	16.455
Textile	0.0368	0.5487	0.0671	29.001
Electrical machinery	0.2001	1.0165	0.1960	49.773
Tobacco	0.4019	0.6175	0.6508	98.074

After applying the data to four industries, the null hypothesis was tested and rejected for all four industries with χ^2 tests. Next, to test if θ is zero, Appelbaum calculates the values for θ at the sample mean. Subsequently, he concludes that conjectural elasticity is insignificant in the rubber and textile industries, but significant in the electrical machinery and tobacco industries. Demand elasticity for each industry is calculated and reported as inelastic except for the electrical machinery industry (Table 3.1). The monopoly index, $L = \theta / \eta$, the estimates produces low for rubber and textile industries but relatively high values for the electrical machinery and tobacco industries.

Finally, Appelbaum calculated the monopoly index. Rubber, textile, and tobacco industries' L values are higher than the θ values. This is due to inelastic demand in these industries. In contrast, electrical machinery industry's elasticity is 1.0165, a value close to the unity. The author notes that conjectural elasticity and monopoly indexes yield similar values. Appelbaum then concludes by stating that the monopoly index values are not high in rubber and textile industries but these measures are high in electrical machinery and tobacco industries.

3.2.3 Estimating Oligopoly/Oligopsony Market Power

While a monopoly refers a single seller in an output market, monopsony refers a single buyer in an input industry. In industries, processors can play this monopolist/monopsonist or oligopolist/oligopsonist role simultaneously. Schroeter (1988) applied Appelbaum's oligopoly theory in a two-sided market analysis of the U.S. beef-packing industry.

Schroeter's analytical framework starts with a non-material factor demand for input i. By non-material input, he means inputs other than a material (or primary) input. Schroeter employs capital and labor as two major non-material inputs. He defines demand as a function of j^{th} firm's output and input prices. Schroeter assumes that firms are not necessarily price-takers in the material input and output markets. Each firm expects that a change in its own output will affect market quantity and price to some degree. Schroeter defines the industry demand, H, and supply, F, functions as follows,

$$Q = H(p, Z_1) \tag{3.26}$$

$$Q = F(w_M, Z_2) \tag{3.27}$$

where p is the price of the output, w_M is the price of the material input, and Z_1 and Z_2 are the vectors of exogenous variables. The j^{th} firm's profit maximization equation is

$$pQ^j - w_M Q^j - C^j(Q^j, w) \tag{3.28}$$

where p is the price of the product, Q^j is j^{th} firm's output, C^j is the cost function of jth firm, and w is the vector of input prices. The condition is subject to equations 3.26 and 3.27. The profit maximization equation is defined,

$$p(1 + \theta^j / \eta) = w_M(1 + \theta^j / \varepsilon) + \partial C^j / \partial Q^j \tag{3.29}$$

where $\eta = (\partial H / \partial p) p / Q$, the elasticity of market demand,

$\varepsilon = (\partial F / \partial w_M) w_M / Q$, the elasticity of material input supply, and

$\theta^j = (\partial Q / \partial Q^j) Q^j / Q$, the j^{th} firm's conjectural elasticity.

θ_j is the j^{th} firm's perceived rate of change of market output (material input) with respect to own output (material input) change, expressed as an elasticity. θ_j is zero in a perfectly competitive market since one firm's production does not affect the market supply. On the other hand, θ_j is one in a monopoly since $Q \equiv Q^j$. As noted earlier, the empirical value of θ_j is expected to fall between zero and one.

Schroeter derives two indices to demonstrate market concentration: a monopoly price distortion index (PCM) and a monopsony price distortion index from the preceding equations. The monopoly price distortion index is defined as,

$$L^j = -\theta^j / \eta . \tag{3.30}$$

The monopsony price distortion index is defined as

$$M^j = \theta^j / \varepsilon . \tag{3.31}$$

With the last two equations 3.30 and 3.31, Schroeter rearranges the optimality equation 3.29 to arrive at

$$w_M(1+\theta^j / \varepsilon) = p(1+\theta^j / \eta) - \partial C^j / \partial Q_j . \tag{3.32}$$

This equation expresses the equality between the marginal factor cost (MFC) of the material input and its marginal net revenue product (MNRP) — the marginal revenue product net of the marginal cost of non-material inputs. If the market is competitive, MNRP and MFC will be equal. Therefore, relative monopsony distortion is defined as the difference between MNRP and w_M as a proportion of the latter, $\frac{MNRP - w_M}{w_M}$. Both of the indexes measure oligopoly/oligopsony power directly in terms of profit rates or concentration.

Schroeter's empirical model consists of four equations to estimate beef packing industry concentration using annual data for the years 1951 through 1983. The first two equations represent optimality conditions for the industry labor demand and profit maximization.

$$x_L = (b_{LL} + b_{LK}(w_K / w_L)^{1/2})Q + b_L \tag{3.33}$$

$$p(1+\theta/\eta) = w_M(1+\theta/\varepsilon) + (b_{LL}w_L + 2b_{LK}(w_L w_K)^{1/2} + b_{KK}w_K) \tag{3.34}$$

Schroeter states that appropriate input quantity data for capital was not available, so no estimate for this input is provided. Schroeter estimates the following industry demand and supply functions:

$$\begin{aligned}\ln Q &= \alpha + \eta \ln(p/S_1) + \gamma_1 \ln(p_h/S_1) + \gamma_2 \ln(p_c/S_1) \\ &+ \gamma_3 \ln(Y/S_1) + \gamma_4 \ln(POP)\end{aligned} \tag{3.35}$$

$$\ln Q = b + \varepsilon \ln(w_M / S_2) + \delta_1 \ln(p_f / S_2) + \delta_2 \ln C_s, \tag{3.36}$$

where

S_1 = consumer price index

p_h = wholesale price of pork

p_c = wholesale price of chicken

Y = per capita nominal income

POP = population

S_2 = farm output price index

p_f = price of feed corn

C_s = stock of cattle on farms.

Schroeter follows Appelbaum's estimate of conjectural elasticity, θ, as,

$$\theta_t = \theta_1 + \theta_2 w_L + \theta_3 w_K + \theta_4 t, \tag{3.37}$$

where t is a time trend variable. The estimated θ is utilized in equation 3.34. In a log linear function, demand elasticity η and supply elasticity ϵ are simply the coefficient of the product price in each equation.

The four simultaneous equations from 3.33 through 3.36 estimate the magnitude of each variable, the conjectural elasticity, and the demand and supply elasticities. By adding demand and supply estimations, the system examines the bilateral relationships of the industry to both consumers and suppliers.

Schroeter applied the model to the U.S. beef packing industry (Table 3.2). The beef packing industry CR4 has increased in the last two decades. Multiple economists have attempted to measure its degree of competitiveness. Schroeter's focus was on beef processors' bilateral market power in the beef industry value chain. He obtained data from beef packing or meatpacking industries including the number of industry production workers, production worker average hourly earnings, and feed corn price.

Table 3.2 Schroeter's Empirical Results

Industry	θ, Estimated Conjectural elasticity	L, Monopoly Price Distortion	M, Monoposony Price Distortion
Beef packing	0.0504	0.0426	0.0133

Schroeter found no significant indication of price-taking behavior in the beef processing industry. He learned that beef is elastic in retail market and inelastic in wholesale market. The conjectural elasticity and price distortion indices are presented in 12 selected years from 33 observation years. He estimated conjectural elasticity and found that the estimates are significantly greater than zero at one percent and five percent confidence levels in many years of the observation period. Schroeter concludes that the assumption of price-taking behavior in the beef packing industry is inappropriate (Table 3.2). However, the price distortion indices turned out to be modest. Furthermore, all three measures (conjectural elasticity, monopoly and monopsony price distortions) had tendencies to decrease overtime as opposed to the increased CR4 measure. Schroeter deduces that the recent increase in the beef packing industry CR4 has not increased any price distortion associated with increasing market power.

CHAPTER FOUR: ESTIMATION METHOD AND EMPIRICAL RESULTS

This chapter presents on a simultaneous equation model to estimate market power in the U.S. pecan processing industry. The model was adapted from John Schroeter's analysis of the meat packing industry presented in the previous chapter. The data, the pecan shelling industry model, the estimation, and the empirical results are presented in an integrated fashion.

4.1 The Pecan Shelling Industry Model

This study derives measures of oligopoly/oligopsony market power in the U.S. pecan industry by estimating four equations simultaneously. The input demand equation and the profit equation estimate the optimum production level for the pecan shelling industry. The aggregate industry demand and supply equations estimate industry equilibrium.

Schroeter utilized selected data from the beef packing industry report. Unfortunately, industry specific data were not available from the pecan shellers themselves. This study utilized annual data to estimate the pecan industry model. Monthly or quarterly production level data were not available for this industry. Therefore, this study tests the feasibility of estimating reliable measures of market power with proxy variables given an incomplete set of industry-level data or firm-level data. Schroeter's model used a time series of thirty-three years from 1951 to 1983 and Appelbaum utilized twenty-five years from 1947 to 1971. This pecan industry model utilizes twenty-seven years from 1970 through 1996. Data used in the study are collected from U.S. government agencies. Data sources are presented in Table 4.1.

Schroeter derived but did not estimate the capital demand model presented in the study for beef-packing model due to lack of reliable industry capital quantity data. This analysis attempted to derive dependable capital quantity data. However, the present study also could not develop reliable capital investment data for the pecan shelling industry. Thus, this study does not estimate the capital demand equation.

Table 4.1 Parameters and Data Sources

Symbol	Parameters	Unit	Data Source
Q	Shelled Pecan Consumption Levels	Million lbs	USDA ERS
p	Shelled Pecan Prices	\$/cwt.	USDA ERS
p_A	Almond Prices	\$/cwt.	USDA ERS
p_W	Walnut Prices	\$/cwt.	USDA ERS
Y	Per Capita Income	\$	Department of Commerce, Bureau of Economic Analysis
POP	Population	Million persons	US Census Bureau Population Division
	Consumer Price Index		Bureau of Labor Statistics
w_M	In-shell Pecan Wholesale Prices	\$/cwt.	USDA ERS
p_C	Index Prices Paid by Farmers for Interest		USDA NASS
P_S	Pecan Beginning Stocks	Million lbs	USDA
	Index Prices Received by Farmers		USDA NASS
w_L	Hourly Earnings	\$/hr	Bureau of Labor Statistics
w_K	Prime Rate	%	Federal Reserve
x_L	Number of production workers		NBER-CES, Manufacturing Industry Database
t	Time Variable		
	Producer Price Index		Bureau of Labor Statistics

4.1.1 Aggregate Demand Model

The endogenous variable for the aggregate demand model is annual shelled pecan consumption level (Q). The exogenous variables are shelled pecan price (p), price of almonds (p_A), price of walnuts (p_W), per capita income (Y), and U.S. population (POP). The endogenous variable in Schroeter's model was commercial beef production levels, but the pecan industry model utilizes consumption levels. Pecans are storable commodities up to two years while beef is perishable. Shelled pecans deteriorate faster than in-shell nuts so shellers store surplus in-shell pecans until next season. Annual shelled pecan production levels will not necessarily reflect the market equilibrium of each year if a large portion of production is stored and does not reach the retail market until next season. Furthermore, the beef production depends primarily on human behavior that reacts to the market. However, the pecan production is determined by largely biological factors rather than producers' conduct. Therefore, this model utilizes consumption levels from USDA data as "pecan shellers' production levels."

Tree nuts prices and quantity levels were collected from the "Fruit and Tree Nuts: Situation and Outlook Yearbook" U.S. Department of Agriculture (USDA ERS various years). Pecan processors purchase in-shell pecans from producers and sell shelled pecans to retailers and confectioners. In-shell pecans are the material input in the supply equation and the profit equation. Shelled pecans are the final product for consumers and are included in the demand and the profit equations. Pecan price, almond price, and walnut price are reported in U.S. dollars per cwt. and shelled pecan production levels are reported in million pounds.

Per capita disposable income data are published by Department of Commerce, Bureau of Economic Analysis. The numbers are reported at the national level and in U.S. dollars. The above four exogenous variables (three tree nut prices and per capita income) in the demand model are deflated by dividing by the Consumer Price Index (CPI) with 1970 as the base year. CPI is used for deflate variables in the demand equation. Annual CPI data are reported by the Bureau of Labor Statistics of the U.S. Department of Labor.

The last exogenous variable in the demand model is national population, reported by the U.S. Census Bureau. The numbers were reported as Historical National Population Estimate, Resident Population in million persons.

One of the four models to be estimated for the U.S. pecan industry is the demand model. Annual shelled pecan consumption levels are regressed in a log linear form to estimate the equation.

$$\ln Q = a + \eta \ln(p) + \gamma_1 \ln(p_A) + \gamma_2 \ln(p_W) + \gamma_3 \ln(Y) + \gamma_4 \ln(POP) \qquad (4.1)$$

where Q is the annual shelled pecan consumption, p is the price of shelled pecans, p_A is price of shelled almonds, and p_W is shelled walnuts, Y is per capita income, and POP is population. a is a constant, and η, γ_1, γ_2, γ_3, and γ_4, are coefficients. η represents demand elasticity in a log linear form. As stated in Chapter 2, the level of consumption of almonds, walnuts, and pecans are higher than other tree nuts. Therefore, these two alternative tree nuts are included as hypothesized substitutes for pecans. Per capita income also is considered to be one of the factors influencing aggregate demand. Assuming pecans is a normal good, the consumption level is expected to increase as income increases.

4.1.2 Product Supply Model

The national shelled pecan supply model has the same endogenous variable as the demand model, annual shelled pecan consumption (Q). The exogenous variables are in-shell pecan price (w_M), price index paid by farmers on interest (p_C), season beginning stock levels of pecans (P_S).

In-shell pecan prices are incorporated in the model as a material input price. Shellers take into account wholesale-price to determine the amount to purchase. The pecan in-shell price is reported in "Fruit and Tree Nuts: Situation and Outlook Yearbook" by the Department of Agriculture (ERS, various years). These prices are reported in U.S. dollars per cwt. The prices are deflated with Index of Price Received by Farmers for Fruit published in "Agricultural Statistics" by the Department of Agriculture (NASS, various years).

The Index of Price Received by Farmers for interest is included as an exogenous variable. Peña (1993) states that pecan orchard development is a capital intensive operation. Not only the establishment stage of the orchard for several years, but producers invest throughout the annual production periods. Producers have risks that they may not receive enough returns in off-years for insufficient production and in on-years due to low-priced commodities. Thus, capital is a critical resource in pecan production in order to maintain the productivity of orchards.

Pecan beginning stock levels are reported in "Fruit and Tree Nuts: Situation and Outlook Yearbook" by the Department of Agriculture. Due to alternate bearing characteristics, product carry-over from previous season should have a negative relationship with current year production. However, this analysis utilizes annual shelled pecan consumption levels as "market equilibrium" in the endogenous variable. The numbers are reported in million pounds.

The supply model is defined as,

$$\ln Q = b + \varepsilon \ln(w_M) + \delta_1 \ln(p_C) + \delta_2 \ln(P_S) \quad (4.2)$$

where Q is shelled pecan production level, w_M is price of material input, in-shell pecan wholesale price, and p_C is interest index. b is a constant, and ϵ, δ_1, and δ_2, are coefficients. ϵ represents supply elasticity.

4.1.3 Input Demand and the Profit Maximization Models

The other two equations in the model represent the pecan shellers' perspective. This analysis initially assumed that the pecan processing industry minimizes the cost of two non-material inputs (capital and labor) by solving the first order condition of the indirect cost function obtained using Shephard's Lemma. The profit equation equates marginal revenue and marginal cost to maximize shellers' profits. As noted earlier in this chapter, the capital demand model is omitted from the system, due to unavailable industry-specific data.

Schroeter's labor demand model utilizes numbers of production workers in meat-packing plants (derived from American Meat Institute's Annual Financial Review report) as an endogenous variable and production worker average hourly earnings in the meat-packing industry as an exogenous variable. Both data were either collected for or derived from the meat-packing industry. The pecan industry model derives labor quantity (x_L)

data using the number of production workers for "salted and roasted nuts and seeds" (Standard Industrial Classification, SIC 2068) from Manufacturing Industry Database by National Bureau of Economic Research and U.S. Census Bureau's Center for Economic Studies (NBER-CES) (various years). This industry is defined as establishments primarily engaged in manufacturing nuts and seeds for snack purposes by SIC. "Nut shelling and hulling" establishments are categorized into agricultural sectors by SIC (0723). No government agency reports capital expenditure of this category. Some pecan shellers operate roasting facilities. Shellers also transform raw pecans into retail products such as pralines, pecan turtles, and pecan pies, and sell these finished products themselves. Therefore, the border between pecan shellers and pecan processors is vague. This study applies the closest available data from the industry SIC 2068 as a proxy for pecan shellers'. This study makes the assumption that the pecan manufacturing and other manufacturing industries have the same labor productivity.

The number of production workers is obtained by multiplying the industry total production workers by the proportion of the pecan production to the total tree nut production. The proportion of the pecan production is obtained from "Fruit and Tree Nuts: Situation and Outlook Yearbook (USDA ERS, various years)." This proportion is thirteen-percent on average during the observation period. SIC 2068 is assumed to include processors for seed crops such as peanuts, sunflower seeds, and flaxseeds. Nevertheless, "Oil crops Situation and Outlook" by ERS does not separate crop production volume by usage (i.e. oil and non-oil use such as snack). A large portion of seed crops is consumed as oil, not as a snack. It is inappropriate to include oil crop production into the estimation of the labor quantity data for this study. Consequently, it is excluded from the estimation.

The exogenous variable of the labor demand equation, hourly wage (w_L) is reported in the Bureau of Labor Statistics. This measures the average hourly earnings of production workers for the food and kindred products within the manufacturing industry. It is reported in U.S. dollars.

The pecan industry capital expenditure cannot be derived using the method used to derive labor quantity. NBER-CES database also incorporates total capital expenditure for the industry. However, the share of total production does not reflect the share of capital expenditure due to the different capital expenses among the industry, SIC 2068. Therefore, the author omitted the equation from the system. However, the prime interest rate is applied as a price of capital (w_K).

All prices including the prime interest rate are adjusted for inflation using the Producer Price Index (PPI) that measures the average change over time in the selling prices received by domestic producers for their output. In addition to wage rate and prime interest rate, a time trend variable (t) is used in the conjectural elasticity model. The variable from one to twenty seven for twenty-seven years is used to represent the observation period of 1970 to 1996.

The non-material input demand function is obtained using Shephard's Lemma. It is the first-order condition derived from the industry cost function. j^{th} firm's non-material cost function, C^j is defined as

$$C^j(Q^j, w) = Q^j C(w) + G(w) \qquad \text{for } j=1,2,\cdots,N \qquad (4.3)$$

where *C(w)* is the marginal cost function, and *G(w)* is the fixed cost function, respectively. The Gorman polar form cost function allows different firms to have different cost curves but the curves are linear and parallel to each other (Gorman 1959). By taking its first derivative with respect to i^{th} non-material input, we can derive input demand for the j^{th} firm,

$$x_i \equiv \sum_{j=1}^{N} x_i^j = Q\partial C(w)/\partial w_i + \sum_{j=1}^{N} \partial G^j(w)/\partial w_i \qquad \text{for all } i. \qquad (4.4)$$

A generalized Leontief form is selected to represent the industry non-material input cost. Equation 4.4 becomes,

$$C(Q,w) \equiv \sum_{j=1}^{N} C^j(Q^j, w) = Q\sum_i \sum_k b_{ik}(w_i w_k)^{1/2} + \sum_i b_i w_i \qquad (4.5)$$

where $b_{ik} = b_{ki}$ for all i and k, $C(w) = \sum_i \sum_k b_{ik}(w_i w_k)^{1/2}$, and $\sum_{j=1}^{N} G^j(w) = \sum_i b_i w_i$. bi's are coefficients and i represents input.

A major input in pecan production is labor. The non-material input demand model is,

$$x_L = (b_{LL} + b_{LK}(w_K / w_L)^{1/2})Q + b_L, \qquad (4.6)$$

where x_L is the number of labor, w_L is cost of labor, w_K is cost of capital, and Q is pecan consumption levels. b_{LL}, b_{LK}, and b_L are parameters.

The optimality condition is derived from the profit function of processing firms. Firms are assumed to not necessarily be price takers in the material input and output markets, but can affect the market price and quantity if their production levels change. j^{th} firm's profit function is defined as

$$pQ^j - w_M Q^j - C^j(Q^j, w) \tag{4.7}$$

where Q^j is the j^{th} firm's production level, C_j is non-material input cost function for the j^{th} firm, w is a vector of w_i, the prices of i^{th} non-material input. The firm maximizes profits by equating marginal revenue and marginal cost. The first order condition of the profit function is

$$p(1 + \theta^j / \eta) = w_M(1 + \theta^j / \varepsilon) + \partial C^j / \partial Q_j \tag{4.8}$$

where η is the market demand elasticity, $(\partial H / \partial p) p / H$; ϵ is the material input supply elasticity, $(\partial F / \partial w_M) w_M / Q$; and θ is j^{th} firm's conjectural elasticity, $(\partial Q / \partial Q^j) Q^j / Q$. H is the demand function and F is the supply function in the system. Note, η and ϵ are the price elasticities estimated in demand and supply models 4.1, 4.2, respectively. Since all firms will operate at the same value of θ^j at the intersection of market demand and supply, the market optimal condition is rewritten,

$$p(1 + \theta / \eta) = w_M(1 + \theta / \varepsilon) + C(w) . \tag{4.9}$$

This equation sets the industrial marginal revenue equal to marginal cost and estimates demand, supply, and conjectural elasticities at the same time. Applying a generalized Leontief form for industry non-material input cost-function with two inputs, capital and labor, 4.9 becomes the last equation of the model,

$$p(1 + \theta / \eta) = w_M(1 + \theta / \varepsilon) + (b_{LL} w_L + 2b_{LK}(w_L w_K)^{1/2} + b_{KK} w_K). \tag{4.10}$$

A Leontief form is selected because capital and labor are both necessary inputs and they have low substitutability to each other in the pecan shelling industry.

Finally, the conjectural elasticity is estimated as a linear function of exogenous variables (input prices, time trend variable) to allow equilibrium conjectures to vary with market conditions.

$$\theta_t = \theta_1 + \theta_2 w_L + \theta_3 w_K + \theta_4 t \tag{4.11}$$

Equation 4.11 is plugged into equation 4.10 to estimate the optimality condition.

Conjectural elasticity is defined as $(\partial Q / \partial Q^j) Q^j / Q$, the percent change in industry production with respect to one-percent change in j^{th} firm's production. The value is expected to be one in a monopoly since only one firm supplies the entire product. The value is zero in a perfect competition because there are many suppliers in the market and one supplier has no influence. Conjectural elasticity represents industry concentration.

4.1.4 Monopoly and Monopsony Price Distortion Indexes

Monopoly and monopsony price distortion indexes are obtained by dividing conjectural elasticity by industry's demand and supply elasticities, respectively. The indexes are described mathematically as,

$$L = -\theta / \eta \tag{4.12}$$

$$M = \theta / \varepsilon \tag{4.13}$$

where L is monopoly price distortion and M is monopsony price distortion. The value of both indexes lies also between zero and one. L has negative sign on right hand side, so the value becomes positive with a negative demand elasticity. Market price distortion is determined by both conjectural elasticity and the elasticity of input/output side of the industry. If product demand is inelastic, the price distortion index increases and vice versa.

Table 4.2 Results of Full Information Maximum Likelihood Estimation Annual Data, 1970-1996

Coefficients	Associated Variable	Expected Sign	Estimate	Standard Error	t-value	Approx Pr>|t|
Product Demand Equation						
a	intercept		3.684892	8.2187	0.45	0.6585
η	shelled pecan price (p)	-	-0.6154	0.4082	-1.51	0.1465
r_1	almond price (p_A)	-/+	0.012904	0.1507	0.09	0.9326
r_2	walnut price (p_W)	-/+	-0.05515	0.2803	-0.2	0.8459
r_3	per capita income (Y)	+	-0.01829	0.6943	-0.03	0.9792
r_4	population (POP)	+	0.705082	1.6365	0.43	0.671
Product Supply Equation						
b	intercept		22.69469	127.5	0.18	0.8603
ε	in-shell pecan price (w_M)	+	-6.63686	44.4599	-0.15	0.8827
d_1	interest index (p_C)	-	1.674315	9.4591	0.18	0.8611
d_2	pecan beginning stock level (P_S)	-	-0.81154	4.8878	-0.17	0.8696
Input Demand Equations/Profit Max Equation						
b_{KK}	pecan production level (Q)	+	-2.08004	2.6207	-0.79	0.4367
b_{LK}	sqareroot of input price ratios	+	0.307456	0.9962	0.31	0.7605
b_{LL}	pecan production level (Q)	+	-0.21299	1.0593	-0.2	0.8425
b_K	intercept	+	945.6958	222.4	4.25*	0.0003
Conjectural Variation						
t_1	intercept		0.378269	0.282	1.34	0.1948
t_2	hourly earnings (w_L)		0.002746	0.0565	0.05	0.9617
t_3	prime rate (w_K)		-0.01666	0.0202	-0.82	0.4198
t_4	time variable (t)		-0.00078	0.00132	-0.59	0.5621

4.2 Parameter Estimation Results

This section explains the empirical results by estimated equation. The parameters are summarized in Table 4.2 along with the expected signs, standard deviations, t-values and p-values.

4.2.1 Aggregate Demand Model

The demand model has five different parameters. None of the parameters yielded statistically significant results. The principle focus of this model is the coefficient estimate for shelled pecan retail price representing the demand elasticity for pecans. The estimated elasticity has the expected negative sign. The result shows that a one-percent increase in shelled pecan price causes 0.615 percent decrease in aggregate consumption. Pecans are inelastic in the retail market.

The estimated coefficient for almond prices is positive and the coefficient for walnut prices is negative, indicating almonds are compliments of pecans but walnuts are not. The pecan consumption levels are expected to increase as almond price increases and walnut price decreases. Pecans and walnuts are used primarily in baking while a significant share of almonds is also consumed in other forms such as snacks. However, neither of these estimated parameters is statistically significant. These results illustrate that neither alternative tree nut price has a significant impact on pecan consumption.

The estimated coefficient of per capita income has a negative value, indicating that as per capita income increases aggregated pecan consumption decreases – pecans are not a normal good. As noted in Chapter Two, per capita pecan consumption has not changed significantly, but has slightly decreased over the study period. The negative coefficient indicates this change. The coefficient estimate on the U.S. population is positive. As stated in Chapter Two, pecan consumption levels have increased gradually in the past several decades, paralleling population growth.

4.2.2 Product Supply Model

The supply elasticity coefficient, along with the intercept of the supply model does not have statistically significant results either. The endogenous variable is the consumption level in the retail market. The selected exogenous variables in the model may have limited effects on consumption levels.

The coefficient of the in-shell pecan price is the supply elasticity in this model. The negative value on this estimated coefficient is unexpected. The value indicates that as the price of in-shell pecan increases by one-percent, the production levels decrease by 6.64 percent. Because the model includes pecan consumption levels as the endogenous variable, the wholesale price may have an influence on consumption levels. Nevertheless, pecan production levels depend greatly on one biological factor – the alternate bearing characteristic of pecan trees. There is a negative relationship between production levels and prices in the market. Buyers quote low prices when commodities are abundant and vice versa. The negative elasticity reflects this relationship.

The previous season's interest index has a positive intercept, implying that equilibrium levels increase despite high interest levels. The parameter was expected to be negative because high interest rate can hinder investment in the next year's production. This also indicates that pecan yields are dependent on biological factors rather than market factors. The season beginning stock level parameter resulted in a negative value as expected. The sign was hypothesized to be negative due to pecans' alternate bearing characteristics. High carry-over levels from the previous season are expected to initiate lower levels of supply in the following year.

4.2.3 Input Demand and Profit Maximization Models

The input cost functions' coefficients are associated with two input variables, labor and capital. The first derivative of the industry cost function with respect to input cost, b_L, is also the intercept of the labor demand model. This estimate is the only statistically significant variable in the estimated system.

The coefficients, b_{LL} and b_{KK}, have unexpected negative values. Because they are associated with product quantity levels, they are coefficients of the marginal costs. As product levels increase, input demand levels are expected to increase as well. However, the negative coefficients indicate that the industry requires less inputs as the production level increases. It is a matter of fact that labor demanded has decreased overtime. This may be attributed to the industrialization of pecan shellers over the observation period as they have substituted capital for labor. An alternative explanation is that the proxy production worker numbers for pecan shellers may not reflect the actual industry labor demand.

The coefficient b_{LK} has a positive estimate. This parameter is associated with the square root of input price ratio in equation 4.6 and the square root of the product of input prices in equation 4.10. The estimate of b_{LK} is between zero and one as expected. This indicates that cost function is concave.

The conjectural elasticities for each year are calculated by substituting the costs of labor and capital back into the equation 4.11 (Table 4.3). As noted earlier, conjectural elasticity is the percent change in the industry production with respect to one firm's production change. The hourly earning variable has a positive parameter, and the other two variables have negative estimates. Real wage rate has not changed significantly over time, but the real interest rate has decreased during the observation period considerably. As a result, conjectural elasticity increased moderately with its lowest value of 0.236 in 1981 and highest at 0.337 in 1993. This is attributed to the highest real interest rate in 1981 and the lowest interest rate in 1993. Appelbaum (1982) estimated four U.S. industries' price distortion measures. In his empirical results, one of the industries, the tobacco industry had slightly lower values than the pecan shelling industry. He concluded that tobacco industry yielded high conjectural elasticity. Therefore, pecan industry is considered to have high conjectural elasticity as well. This indicates that the pecan industry production level is affected by a simple firm's production.

4.2.4 Monopoly and Monopsony Price Distortion Estimates

Monopoly and monopsony measures are obtained using the calculated conjectural elasticities. The values of monopoly measures (L) vary from the lowest of 0.384 in 1981 to the highest of 0.547 in 1993. The values were obtained by dividing conjectural elasticity by a constant number (i.e. estimated demand elasticity, η). The pecan shelling industry model produced higher values than the tobacco industry largely due to inelastic demand elasticity. This study's initial prediction was that this monopoly price distortion measure, L, has increased over the years. After fluctuating in the 1970s and 1980s, L increased moderately as was the prediction. This result implies that pecan shellers have a high monopoly distortion measure toward retailers.

Monopsony price distortion values (*M*) turned out to be negative because of the negative supply elasticity (-6.64). Despite the fact that distortion values are negative, they are trivial, the highest value being –0.0356 in 1981 and the lowest –0.0507 in 1993. *M* is close to zero throughout the analysis period. The results indicate that shellers do not possess or exercise market power towards pecan producers.

Table 4.3 Estimates of Conjectural Elasticities
and Monopoly/Monopsony Price Distortions

Year	Conjectural Elasticity Estimates	Conjectural Elasticity Std Dev	Monopoly PD, L Estimates	Monopoly PD, L Std Dev	Monopsony PD, M Estimates	Monopsony PD, M Std Dev
1970	0.2544	0.0526	0.4134	0.1388	-0.0383	0.0012
1971	0.2908	0.0634	0.4725	0.1673	-0.0438	0.0014
1972	0.2996	0.0687	0.4868	0.1813	-0.0451	0.0016
1973	0.2623	0.0585	0.4262	0.1545	-0.0395	0.0013
1974	0.2543	0.0542	0.4132	0.1430	-0.0383	0.0012
1975	0.2987	0.0698	0.4853	0.1843	-0.0450	0.0016
1976	0.3079	0.0822	0.5004	0.2170	-0.0464	0.0019
1977	0.3132	0.0906	0.5089	0.2391	-0.0472	0.0021
1978	0.2946	0.0867	0.4787	0.2290	-0.0444	0.0020
1979	0.2693	0.0815	0.4376	0.2152	-0.0406	0.0019
1980	0.2527	0.0875	0.4106	0.2310	-0.0381	0.0020
1981	0.2362	0.0976	0.3837	0.2576	-0.0356	0.0022
1982	0.2656	0.1152	0.4316	0.3042	-0.0400	0.0026
1983	0.2976	0.1451	0.4836	0.3832	-0.0448	0.0033
1984	0.2944	0.1438	0.4784	0.3798	-0.0444	0.0033
1985	0.3093	0.1659	0.5025	0.4380	-0.0466	0.0038
1986	0.3201	0.1877	0.5202	0.4955	-0.0482	0.0043
1987	0.3216	0.1966	0.5227	0.5191	-0.0485	0.0045
1988	0.3151	0.1939	0.5121	0.5121	-0.0475	0.0044
1989	0.3081	0.1912	0.5007	0.5049	-0.0464	0.0043
1990	0.3144	0.2096	0.5108	0.5535	-0.0474	0.0048
1991	0.3237	0.2390	0.5260	0.6310	-0.0488	0.0054
1992	0.3355	0.2816	0.5451	0.7436	-0.0505	0.0064
1993	0.3368	0.2988	0.5473	0.7890	-0.0507	0.0068
1994	0.3305	0.2950	0.5370	0.7789	-0.0498	0.0067
1995	0.3216	0.2887	0.5226	0.7622	-0.0485	0.0066
1996	0.3248	0.3110	0.5277	0.8213	-0.0489	0.0071

CHAPTER FIVE: SUMMARY AND RECOMMENDATIONS

5.1 Research Summary

Over the years, numerous firms have become significantly larger through mergers and acquisitions that have caused concentration in U.S. industries. There is a rising concern that this high concentration can stifle competition in markets. Firms without market power may face competitive difficulties and fail to survive. In addition, in a highly concentrated industry, large firms can raise their market price and earn monopoly profits and take advantage of consumers. Agriculture is not immune to this phenomenon. In terms of industry sales, several agricultural industries are dominated by a handful of large firms. The beef packing industry has been a center of attention of industry concentration research. This industry experiences federal scrutiny as a result of even a rumor of large processors' interest in merger and acquisition.

Pecans are a crop produced and consumed predominantly in North America. Wholesale pecan trades are heavily concentrated in southeastern and western U.S., and now in Mexico. The largest four pecan shellers handle nearly an estimated sixty-percent of all in-shell pecans. These large pecan shellers play multiple roles in the traditional pecan value chain stages. Shellers are producers, processors, wholesalers, and retailers. Potential for market power exists all throughout the pecan value chain.

Many industry concentration analyses have been conducted on the beef packing industry. One example is the work of Schroeter who evaluated oligopoly/oligopsony market power of beef packers by a simultaneous equation system. He estimated four equations simultaneously: (1) supply equation, (2) demand equation, (3) profit maximizing equation, and (4) input demand equation. Based on his estimates, Schroeter learned that the beef packing industry's conjectural elasticity was above the expected competitive level. When he derived the price distortion measures utilizing the estimated conjectural elasticity the author found that input and output market price distortions were slight.

This current study examined the market power in pecan shelling industry utilizing Schroeter's beef packing industry model. To some extent, the conditions of the pecan processors are similar to those in beef packing industry. They face many producers in the input market and many retailers in the output market, and there are a limited number of large shellers that compete with each other.

The estimates yielded negative price elasticities of demand and supply. Estimated demand was inelastic. Pecans have a strong demand during the holiday season regardless of their high retail price (pecans are twice as expensive as walnuts in the retail market). The inelastic demand estimate may represent this seasonal high demand, but not a high demand throughout the year.

Negative supply elasticity indicates that pecan supply equation has a negative slope. Producers make decisions whether to enter the market depending on pecan production's profitability in the long run. High prices at the retail level attract new entrants into pecan production, so a negative supply estimate seems inappropriate. Yet there still has been a strong negative relationship between pecan wholesale price and production since the late 1980s. This seems to be attributed to pecans' strong alternate bearing characteristics. Nevertheless, these estimates are not statistically significant.

Conjectural elasticity resulted in moderately high values throughout the observation period. The average value of 0.298 is slightly higher than the levels of the electrical machinery industry that Appelbaum described as "significant." Therefore, the pecan shelling industry is considered to have a significant concentration.

Applying the estimated conjectural elasticity, monopoly and monopsony price distortion measures were derived. Monopoly price distortion measures turned out to be relatively high. The values are higher than conjectural elasticity because of the estimated inelastic demand. The values averaged 0.485 for the observation period. However, monopsony price distortion measures yielded negative values due to negative supply elasticity. The average was -0.045. Appelbaum described the rubber industry's similar degree of oligopoly power as "insignificant." The pecan shelling industry's monopsony price distortion measure is slightly lower in an absolute value. Thus, the measure is considered to be insignificant. However, these results did not turn out to be statistically significant.

Statistically insignificant results may be explained by a strong collinearity between several variables. For example, the real prices of shelled and in-shell pecans have an exceptionally high Pearson correlation coefficient of 0.989. Other high correlation coefficients above 0.9 in absolute value are 'year'-'per capita income' (0.970), 'per capita income'-'population' (0.968), and 'year'-'population' (0.999). A high collinearity causes high variances and therefore low t-values (Kennedy, 1998).

Consequently, this leads to a statistical insignificance of the simultaneous equation system. This means that this hypothesis testing is not powerful with these specific variables.

Multicollinearity can be solved by dropping highly correlated variables from the simultaneous equation system. However, in-shell and shelled pecan prices are two critical variables in this system. The two prices estimate the market equilibrium and the profit maximizing level. Leaving these variables out of the equations would invalidate the modeling system. Other possible solutions are to drop other highly correlated variables: year, population, and per capita income. Each variable was dropped and estimated in the simultaneous equations. This solution improves the significance of the estimates, but does not yield the correct range of estimation (i.e. the value between zero and one) for conjectural elasticity and price distortion measures.

Moreover, another reason for statistically insignificant results can be the limited access to pecan industry specific data. Schroeter obtained proprietary beef packing industry data. However, similar pecan shellers' information was not available to the researcher. Therefore, this study substituted proxy data of close industries from the government agency databases. These data may not reflect pecan industry characteristics precisely. USDA does not publish other types of information for the pecan industry such as bearing acreage and gross return per bearing acreage. If these types of data had been available the results may have represented market power in the pecan shelling industry more accurately.

5.2 Recommendations on Future Research

This study could not yield statistically significant estimates for the pecan shelling industry model. One primary reason is that there are not sufficient data to examine market power in the pecan shelling industry. Input quantity such as labor and capital from the individual firms or from the shellers' association would represent the industry more accurately.

Unlike beef, almost all in-shell pecans are traded in a particular time of the year. Pecan shellers purchase in-shell pecans during a short time period (four months) after harvest. Annual data does not represent this seasonality. Monthly or quarterly data would have reflected the pecan wholesale market more accurately. For instance, a study on the D'Anjou pear industry's "seasonal market power" utilized monthly data (Gutman and McCluskey 2001). The authors argue that seasonality exists in D'Anjor pear industry because the crop is supplied by different sources during different seasons. They claim that annual data do not capture this seasonality.

A critical distinction between the pecan shelling industry and the beef packing industry is that pecan production is more contingent on biological factors out of the control of decision makers. Pecan producers have limited control of their production levels. Pecan production levels are driven by the alternate bearing characteristics of pecan trees and long-term investment decisions given the eight-year period to reach the commercial nut bearing stage. Pecan producers can not respond to year-to-year price fluctuations. Other factors such as weather, maturing trees, and producers' price expectations in the very long run have more impact on the industry over pecan than the annual market price fluctuations. Therefore, Schroeter's beef packing industry model does not fit the uniqueness of the pecan shelling industry.

Alternate bearing characteristics in pecans have been prominent since the late 1980s. Today, pecan production levels seem to be influenced more than ever by this biological characteristics. In contrast, shellers are more flexible as pecan market prices fluctuate. Shellers are able to alter their purchases from producers depending on the stock levels and current and expected pecan prices. As a consequence, producers are exposed to more uncertainties than shellers are.

A possible solution to the previously outlined limitations is the development of a hybrid industry model for perennial crops that integrates the work of Schroeter and others with work like that of Elnagheeb and Florkowski who estimated the perennial crop supply using pecan industry data (1993). They attempted to estimate the supply by modeling the number of non-bearing pecan trees using two models, one directly and the other indirectly. The authors concluded that the second model that estimated the non-bearing tree numbers indirectly was the most accurate model. The independent variables of this model included total potential output as a function of output per acre in two different stages: after first increase in production and after reaching an yield plateau. By separating the output of pecan trees into three yield phases the biological feature of the trees is modeled more accurately modeled when compared to estimating pecan output aggregately. The assumption was that pecan trees start to bear a significant amount of nuts after six years of age. Production then increases as trees age. Yield increases become insignificant after thirteen years of age. Other variables in Elnagheeb and

Florkowski's model were yield per tree, number of trees, price, climate, and lagged output. The variable lagged output represented the alternate bearing character of pecans. The large output in the preceding year led to the lower output in current year.

Elnagheeb and Florkowski found a positive relationship between lagged pecan prices and current plantings and pecan supply, and a negative relationship between the index of input price and current plantings. Moreover, increases in a lagged two year pecan price had the largest effect on pecan supply. Responses to current market price seem to have lagged time effects in perennial crop production. This result probably captures the alternate bearing characteristic of pecans than a management response to higher prices.

The particular data set came from "Georgia Agriculture Facts." Although, the authors utilized national data, certain information such as the pecan price, quantities, and number of non-bearing trees are from the Georgia Agricultural Extension Service. Georgia is the largest producer of pecans in the nation and the state agencies have greater access to industry data than other states. Nevertheless, Elnagheeb and Florkowski, also emphasized the data availability difficulties associated with perennial crops.

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