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IMPACT OF SHRIMP IMPORTS ON THE UNITED STATES’ SOUTHEASTERN SHRIMP PROCESSING INDUSTRY AND PROCESSED SHRIMP MARKET

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Agricultural Economics and Agribusiness

by

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August 1999
Dedication

This work is dedicated to my wife Dominique Duval-Diop, whose love, patience, understanding and support have taken me through to the completion of my program.
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Abstract

The shrimp harvesting sector is the largest component of the southeastern United States fishing industry, accounting for 57% of the total value of landings in the region in 1996. U.S. shrimp imports were valued at $2.6 billion in 1996. Together, domestic production and imports of the raw product support a large shrimp processing sector, which provides several thousand jobs either directly or indirectly. In 1975 and 1984, the United States International Trade Commission (USITC) investigated the industry to determine whether the volume of shrimp imports was high enough to threaten domestic firms which were producing articles similar to, or directly competitive with the imported product. In both studies, the commission concluded that no harm was done to the processing sector. However, an analysis of the shrimp industry that focused on the processing sector revealed that imports did have a negative impact. The objectives of this research were to quantify the effects of imported shrimp quantities on processor margins and firm size distribution. Results showed that retail prices of shrimp negatively affected per capita shrimp consumption. Red meat and fish products were found to be shrimp substitutes. At the wholesale level, findings support a peeled shrimp sector dominated by imports. The import effects increased after 1983 due to the development of shrimp farming in South Asia and Latin America. Additionally, imports of headless-shell-on and “other” shrimp products have negatively impacted the domestic processing activities. The ex-vessel demand was responsive to changing domestic landings and imported headless-shell-on shrimp quantities. Wholesalers were not passing on increased production costs to consumers. Consequently the margins for processors of peeled shrimp and headless-shell-on shrimp narrowed annually by $0.0323 and $0.0407 per pound. The narrowing in the margins impacted the processor size distribution. In 1973, out of 181 active processors, 45% had total shrimp sales below $1 million a year, 38% between $1 and $10 million, and 21% above $10 million. By 1996, those percentages were 38%, 36% and 32% for categories 1, 2 and 3 with a total of 97 firms processing shrimp.
Chapter 1

Introduction

Shrimp is harvested throughout the world with more than 100 countries reporting production in 1996. Utilization of shrimp, while diverse, tends to be concentrated among a relatively few, highly developed countries. Among these countries, the United States and Japan have accounted for about 50% of world shrimp use since 1986 (Aquatic Farms Ltd., 1989). The United States imports about 70% of its raw shrimp supply (Keithly, Roberts and Ward, 1993). United States imports of processed shrimp grew annually by 8 to 9% between 1973 and 1980. During the period 1980-1990, U.S. imports of processed shrimp grew by more than twofold. The import growth of U.S. processed shrimp was about 15 to 20% between 1990 and 1996. Much of the import growth during the early 1980s was of Ecuadorian origin, coinciding with a growth in farm-raised production in that country. Prior to 1980s, most of the U.S. shrimp supply came from natural fisheries (Keithly, Roberts and Ward, 1993). During the 1980s, an increasing proportion of the foreign supply was farm-raised, which contributed to increasing U.S. edible seafood supply. In 1973, an average of 213 million pounds of shrimp was processed annually by 181 processing firms throughout the Southeastern United States. The processed quantities of shrimp reached a record high of 276 million pounds in 1996.

The nominal value of shrimp processed in the southeastern United States region increased from $398 million in 1973-75 to $1.0 billion in 1989-90. Keithly, Roberts and Ward (1993) cite two reasons for this increase. First, the annual quantity of shrimp processed by the U.S. industry reached 291 million in 1988-90, an increase of 53% over

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1The Southeastern region of the United States includes the states of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas.
the period 1988-90, while the number of processors fell by 15%. Secondly, the nominal price of processed shrimp increased throughout much of the period. However, during the same period, the real price of processed shrimp declined sharply.

1.1. Problem Definition

Shrimp harvesting is the largest component of the southeast U.S. commercial fishing industry, accounting for 57% of the total value of landings in the region in 1996. The U.S. shrimp import market was valued at $2.6 billion in 1996. Together, domestic production and imports of the raw product support a large shrimp processing sector, which provides several thousand jobs either directly or indirectly (Keithly, Roberts and Ward, 1993).

In 1975, the National Shrimp Congress filed a petition with the U.S. International Trade Commission (USITC) for import relief pursuant to section 201 of the Trade Act of 1974 (Gulf of Mexico Fishery Management Council, 1981). The USITC started an investigation to determine whether U.S. shrimp imports were of such increased quantities as to be a substantial cause of serious injury or threat to the domestic industry producing a product directly competitive with the imported product. The conditions defined by the USITC (1976) that are the base for a harm to the domestic industry are:

1. an article is being imported into the U.S. in increasing quantities;
2. the domestic industry producing an article like or directly competitive with the imported article is being seriously injured or threatened with serious injury; and,
3. such increased imports of an article are a substantial cause of serious injury to the domestic industry.

The domestic industry was defined as two industries: shrimp boats and shrimp processors. Some of the USITC commissioners who participated in the investigation found
that shrimp products were not imported in such increased quantities as to be a substantial cause of serious injury or threat to the domestic processing industry. The other commissioners focused on the impact of increased imports on the domestic harvesting industry. The commissioner found that the shrimp harvesting sector was being injured by the increased shrimp imports. Adjustment assistance to the industry was recommended.

In 1984, the U.S. shrimp industry was the focus of another federal investigation conducted under 322(g) of the Tariff Act of 1930 (United States International Trade Commission, 1985). The purpose of the investigation was to evaluate competition affecting the harvesting sector of the U.S. Gulf and South Atlantic shrimp fishery industry. In explaining their situation to the trade commission, the U.S. Gulf of Mexico and South Atlantic harvesters claimed that harvesting businesses were being injured by imports and that shrimp industries in foreign countries were benefiting from government assistance, artificially allowing their product prices to be more competitive in the U.S. market (Keithly, Roberts and Ward 1993). In spite of their claims, the commission issued a report and no further actions were recommended. However, an analysis of the shrimp industry that focused on the processing sector industry revealed that imports did have a negative impact. For example, Keithly, Roberts and Kearney (1990) grouped firms in four sizes based upon their deflated values of annual processed shrimp sales. The following size categories were identified: (I) firms with annual deflated processed shrimp sales of less than $250 thousand, (II) firms with annual deflated processed shrimp sales ranging from $250 thousand to $1.0 million, (III) firms with annual deflated processed shrimp sales of $1.0 million to $10.0 million, and (IV) firms with annual deflated processed shrimp sales of $10.0 million or more. Based on the grouping in 1973, a total of 181 firms was processing shrimp and had a size distribution of 54 in Size I, 31 in Size II, 58 in Size III, and 38 in Size IV. By 1996, the
total number of processors had declined to 97 and exhibited the following size distribution: 19 in Size I, 18 in Size II, 35 in Size III, and 25 in Size IV. During the same period, the total amount of domestically harvested shrimp remained stable while shrimp imports from foreign aquaculture farms experienced a steady increase. A number of trends supported the conclusion that increasing imports impacted the U.S. southeast shrimp-processing sector. These trends are discussed below.

The first trend deals with the fluctuation of the exchange rate. Since the United States and Japan are two major players in the shrimp import market, exchange rate fluctuations between the dollar or the yen and the currencies of the major shrimp exporting countries influence the direction of shrimp trade flows. When U.S. monetary policy results in an appreciation of the dollar vis à vis a foreign currency, U.S. imports from that country usually increase. The imported processed quantities in turn affect the domestic industry in terms of size distribution and number of processors in activity. For example, from 1980 to 1983, when the U.S. dollar began to appreciate at a much faster rate vis à vis the Mexican peso, shrimp exports that would have been sent to the Japanese market were diverted to the U.S. (United States International Trade Commission, 1985).

A second component that affects the firm size distribution is the narrowing of the processor margin defined as the difference between the deflated processed shrimp and the deflated raw shrimp prices. The 1996 observed deflated price per pound for peeled shrimp (converted to a headless shell-on basis) of $2.59 reflects a 58 % decline when compared with the 1973 price of $6.27. The real price of raw shrimp, used as the primary input in peeling activities, declined by more than 44 % from $4.68 per pound in 1973 to a $2.58 per pound in 1996. Similar trends are evident in the production of breaded shrimp and headless shell-on shrimp quantities. The real price per pound for breaded shrimp,
expressed on a headless shell-on basis, declined from $9 per pound in 1973 to $4.39 per pound in 1996, a more than 51% decline. During the same period, the deflated price for the raw shrimp used in the breading process declined from $4.68 per pound to $2.86 per pound, a decline of more than 38%. The real price per pound declined from $6.95 in 1973 to $4.59 in 1996 for headless shell-on shrimp products, a 34% decline in the processed shrimp price. Over the 24-year period, the deflated price of raw shrimp used in the headless shell-on processing activity declined from $6.04 to $3.99, a 34% drop in price. In summary, the spread (margin) between the processed shrimp price and the price of the raw product tightened significantly, largely due to greater decreases in output prices than in raw input prices.

Lastly, two other factors affected the size distribution of processors: interest rates and wage rates. Changes in interest rates may affect the decision of processors to expand or contract their operations. For example, lower interest rates encourage shrimp processors to expand their activities by investing in new technology, while higher interest rates may force shrimp processors to reduce their operation or exit the industry. The United States International Trade Commission (1985) discovered that interest payments represented 2 to 9% of total processing costs depending on the type of the processing activity. From 1980 to 1984, interest rates fluctuated between 11 and 21%, creating unstable conditions for financing capital investments.

Most of the shrimp processing plants in the Gulf and South Atlantic region generally base employee wages on the minimum wage rate set by the Federal government. The minimum wage rate was approximately $2 per hour between 1970 and 1974. By 1996, the minimum wage had risen to $4.75 per hour. Labor costs represent 9 to 10% of total processor costs (United States International Trade Commission 1985). A high labor cost
may act as a barrier to entry, or force existing processors to contract their operations and/or exit the industry.

In summary, the industry firm size distribution has been impacted by the increase in shrimp imports. Additionally, the effect of rising imports was further compounded by unstable shrimp prices, fluctuations in exchange rates, decreasing profit margins, and high interest and wage rates.

1.2. Objectives

The overall goal of this research is to analyze the effects of shrimp imports on the entry and exit patterns of firms in the Southeast U.S. shrimp processing industry. Additionally, the impact of shrimp imports on market demand and supply for processed shrimp will be analyzed. The specific objectives are to:

1. provide a descriptive analysis of the Southeastern U.S. shrimp processing industry;
2. propose and estimate a model for examining U.S. supply and demand for processed shrimp. The proposed model should capture the impact of increasing shrimp imports on processor margins;
3. develop and estimate a model for examining the size distribution of shrimp processing firms in the Southeastern United States; and
4. use the model to project the number of shrimp processing plants distributed over the firm size categories. Steady state probabilities will be determined and the impact of their variation on firm size distribution will be simulated.

To accomplish the objectives, the following tasks are proposed. To accomplish objective 1, the study will be conducted using secondary data available from the National Marine Fisheries Service (NMFS). Data were collected from an annual voluntary end-of-
the-year survey of all processing establishments. The data set includes a unique identification number that allows the researcher to trace a processor over time. Also included are the states and the counties (parishes) where the processing plants are located, the total pounds and values of processed shrimp and other species, and the number of workers in each processing plant. Additional data on seafood prices were obtained from the United States Bureau of Labor and Statistics.

With respect to objective 2, previous econometric models of the U.S. shrimp industry conducted by Doll (1972), Thompson et al. (1985), Prochaska and Keithly (1988), Lea and Shonkwiler (1988) and Keithly, Roberts, and Ward (1993) were extended and respecified. Adoption in improved shrimp farming techniques by several Central and South American countries has led to significant increases of shrimp imports to the U.S. market. Changing shrimp import levels foreshadow increased demand for policy changes in the face of uncertainty relating to fundamental market relationships (Lea, Shonkwiler 1988). The proposed model will investigate how market conditions (supply and demand) for United States processed shrimp are being affected by increased imports. The difference between this model and the previously developed models is that it focuses mainly on processed shrimp products instead of raw products.

With respect to objective 3, the model will assess the impacts of imports on the number and size distribution of firms (entry / exit). The rationale associated with this objective is two-fold. First, most econometric studies of the shrimp processing industry may no longer accurately reflect industry structure given the substantial changes within the industry during the last two to three decades. Second, entry/exit, size distribution and their impact on alternative management measures need to be quantified. Knowledge of the estimated number and size distribution of shrimp processing firms in the future will help
predict the character and intensity of competition within the market. The empirical model from this study will allow estimation of entry/exit and identify and estimate the strength of their determinants.

With respect to objective 4, processing firms will be divided in three groups. We will assume that firm movement from one size category to another size category follows a Markov process. The impact of changes in processors

1.3. Review of Shrimp Industry Studies

A determinant of an industry's structure and its subsequent performance is the ability of equally efficient firms to successfully enter and exit the industry (Carlton and Perloff, 1990). Industries with no barriers to entry or exit are called perfectly competitive industries with firms earning average industry profits. In those industries, entry rates as well as exit rates are high. Likewise, when barriers to entry exist in an industry, firm profits are high and exit rates are low. The shrimp processing industry in the southeastern region of the United States, particularly in the Gulf of Mexico, is characterized by low barrier to entry. Firms are also assumed operating in a competitive environment. Therefore firms are earning zero profits in the long run. The number of firms involved in shrimp processing is in decline due to many factors, including increased competition from imports. About 70 to 80% of the shrimp consumed every year in the U.S. is imported.

The impact of increased imports on U.S. shrimp sector has been addressed by several studies. However, most of these studies were completed during the period of the 1970s and 1980s (Doll (1972); Prochaska and Andrew (1974); Alvarez, Andrew and Prochaska (1976); Thompson, Roberts, and Pawlik (1985)).

Doll (1972) estimated a five-equation demand model of the U.S. shrimp market using annual data from 1950 to 1968. Prices, consumption, and ending stocks were jointly
determined variables, while the predetermined variables were shrimp supplies and consumer incomes. The author determined that ex-vessel price variation resulted largely from variations in domestic landings. Imports reduced the general level of ex-vessel prices but did not contribute to price variability except in isolated instances. The author also found that large price drops occurred during periods of U.S. economic recession when increases in demand were slowed and stocks began to build, while landings and imports increased substantially over the previous year.

Prochaska and Andrew (1974) raised concerns about the impact that a growing dependence on imports would have on the structures of the shrimp processing industry in the Gulf states plus Georgia. The authors investigated entry and exit by examining trends in firm size and concentration within the Florida shrimp industry. They used data on employment within the industry for their analysis. The authors found that the average biannual entry rate for handlers\(^2\) was 9.6% and 15.3% for processors between 1959 and 1971. Exit rates were 16.1% for handlers and 14.2% for processors. Based on employment data, the authors estimated that 14.5% of the processing firms were growing and 11.8% were declining within the period of study. Thus, 26.3% of the processing firms were changing size while 8.4% of the handlers were expanding or decreasing. The authors also found that the Florida shrimp industry had became more concentrated since the late 1950s, and that all firms were not affected equally by the shrimp supply shortage. A few of the largest firms had informal binding agreements with local suppliers, and they controlled a portion of local supply and paid substantially less for raw products than the remaining processing firms. The small competitors paid both a high price for Florida supplies and for imports, domestic and foreign.

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\(^2\)Handlers are those who exclusively freeze and package the headless shell-on shrimp
In a later study, Alvarez, Andrew, and Prochaska (1976) again used data on employment during the 1959-71 period as a measure of firm size. In their study, the authors examined the Florida shrimp processing industry using a stationary Markov chain model. They analyzed the stability, entry/exit, and mobility patterns for six size categories of firms from 1959 to 1971. The measurement of size as well as size categories were defined as follows: 1) firms employing zero individuals and no shrimp sales represented the exit category; 2) firms employing between 1 and 10 individuals and realizing a yearly shrimp total sales less than $2 million were classified in the second category; 3) the third category included the firms employing between 11 and 30 workers and realizing less than $2 million per year of shrimp sales; 4) the fourth category encompassed the firms employing between 31 and 100 workers and making between $2 and $12 million a year; 5) the firms employing between 101 and 300 workers and making between $2 and $12 million a year were classified in the fifth category. All other firms were classified in the sixth category. Entry into the Florida shrimp-processing sector was more common for small firms than for large firms. Larger firms were more likely to maintain their size between any two time periods. They also experienced lower probabilities of declining in size than did medium- and small-sized firms. The authors predicted that structural equilibrium in the industry would be achieved by 1985, resulting in fewer medium-sized firms and more small and large-sized firms. Medium-sized firms were expected to grow in size, to decline in number, and either move to specialty products and services or exit the industry. The forecasted changes in firm distribution indicated that Florida shrimp industry could become increasingly concentrated due to expansion in the number of small and large firms. Alvarez, Andrew, and Prochaska (1976) also pointed out the reliance of the southeastern shrimp processing industry on foreign supplies. The authors also found that domestic
supplies were being replaced by imports. Most of these studies were conducted before the large growth in import supply observed in the mid-80s.

One study conducted in the 1990s (e.g. Roberts, Keithly, and Adams (1990)), found an uninterrupted shrimp import usage among Georgia and Florida processors. Their results show that Alabama and Mississippi processors have imported shrimp regularly since 1982. The imported shrimp help the processing industry increase its output to meet growing domestic demand.

Keithly, Roberts and Keraney (1993) investigated the Southeastern U.S. shrimp processing industry for the 1973-90 period. The authors found a declining number of firms over the period of study, and an increase in the quantities processed. The authors examined shrimp processing activities on the basis of four product forms: (1) raw headless products; (2) peeled products; (3) breaded products, and (4) specialty products (including canned products). The increased processed quantities were mostly peeled products. The decline in the specialty products resulted from an increase in canned products. The authors found stability in terms of industry concentration as measured by market shares based on the value of processed shrimp.

This research will differ from the above studies in that it will analyze the Southeastern U.S. region shrimp processing firms size distribution using a non-stationary Markov model. This research will also provide some insight to how structural supply, demand and import conditions are affecting the size distribution of firms.

1.4. Overview of the Research

The dissertation will be organized into six chapters. The introduction, research problem, brief literature review and research objectives will be included in chapter one. Chapter two will present a descriptive analysis of the southeastern United States region
shrimp processing industry. Chapter three will consist of a description of the theoretical model(s) to be employed. Chapter four will discuss the econometric considerations of the modeling. The empirical applications of the model will be developed in chapter five. The use of the derived relationships to assess impacts of alternative shrimp industry management measures will be discussed in chapter five. The summary, conclusions, policy recommendations and suggestions for further study will be given in chapter six.
Chapter 2

The United States Southeastern Shrimp Processing Industry

This chapter examines the shrimp processing industry in the southeastern region of the United States. The chapter also highlights several interrelationships between shrimp processors and shrimp markets. First, a shrimp processor will be defined; second, the shrimp species that are processed will be identified; third, the industry structure will be presented, and fourth a general conclusion will be drawn.

2.1. Who is a Processor?

The National Marine Fisheries Service (1995) defines a shrimp processor as:

"An establishment engaged in the transformation of substances into new products. The new product may be finished in the sense that it is ready for consumption, or it may be semifinished to become a raw material for an establishment engaged in further manufacturing. The processors may purchase the raw or semiprocessed product directly from fishing vessels, customary trade channels, or secure it by transferring the product from one establishment to another, which is under the same ownership."

The United States International Trade Commission found (1985) that shrimp processors in the Gulf and South Atlantic region are single-plant operations producing several shrimp product forms and a variety of other seafood items, such as crab, oyster, and fish products.

The analysis in the following sections is based on processed shrimp quantity evaluated on a product weight basis. A product weight includes the meat weight of shrimp used in the processing activities, any additional ingredients that may be added such as breading materials, and shell weight when appropriate in the case of raw headless shrimp (Keithly, Roberts and Kearney, 1993).

2.2. Species of Shrimp Processed

Three species dominated the harvest and the processing of shrimp in the Gulf of Mexico and the South Atlantic before the increase in imports in the mid 1980s. Those
species are the brown shrimp (Penaeus aztecus), the white shrimp (Penaeus setiferus), and the pink shrimp (Penaeus duorarum). They represent 98% of each year's harvest of southern shrimp (Hu, Witaker and Kaltreider 1983). The southern shrimp industry is defined as these shrimp species harvested from the Gulf of Mexico and off the Atlantic coast of the Southeastern United States.

Brown shrimp are found along the Atlantic Coast and the Gulf of Mexico, which ranges from Martha's Vineyard, Massachusetts to the northwestern coast of the Yucatan Peninsula in Mexico (United State International Trade Commission, 1985). Most brown shrimp harvested in U.S. waters are caught along the coasts of Texas, Louisiana, and Mississippi.

White shrimp, ranking second in abundance after brown shrimp, are harvested along the Atlantic coast from Fire Island, New York, to Saint Lucie Inlet, Florida, and along the Gulf coast from the mouth of the Ochlockonee River, Florida, to Campeche, Mexico. Most white shrimp harvested in U.S. waters are caught off the North Central and Western Gulf areas, and are found closer to shore than brown shrimp.

Pink shrimp rank third in commercial importance after white shrimp. They are found in the Atlantic Ocean along the coasts from the lower Chesapeake Bay area to the Florida Keys and all along the Gulf coast to Isla Mujeres, Mexico. Most pink shrimp harvested in the U.S. are caught off southwest Florida.

Other species of shrimp, which are relatively minor, are harvested off the South Atlantic and Gulf coasts. Those species include rock shrimp (Sicyonia brevirostris), seabobs (Xiphopenaeus kroyeri), and royal red shrimp (Hymenopenaeus robustus).

Imports include mainly shrimp harvested from aquaculture operations. The main species produced by aquaculture operations are P. japonicus, M. rosebergii, and P. brasiliensis. These species are imported from Central and North America (Mexico, Honduras, Panama, Guatemala, and El Salvador), South America (Ecuador, Venezuela, Brazil, Colombia, and Peru), Asia (Thailand, India, China, Indonesia, and Bangladesh), and marginally from
Europe, Africa and Oceania. In 1973, North America provided 54% of U.S. imports of shrimp quantities. However, in 1996, North America supplied only 28% of the shrimp imported. During the same period, the Asian countries increased their supply to the U.S. from 23% in 1973 to 49% in 1996. In terms of total value, the Asian share measured 17% of U.S. imports in 1973. By 1996, the Asian countries captured nearly 55% of the total value of U.S. shrimp imports. The South American countries maintained a stable market share over the period 1973-1996.

2.3. The Structure of the Shrimp Processing Industry

2.3.1. Overview

This section provides a general description of the southeastern shrimp-processing sector. The changes in total firm numbers, quantities processed and total value will be analyzed. An examination of the number of firms provides insight into whether the industry was composed of a few large firms or a large number of small firms? This question is important because economic theory predicts that the number of firms in an industry influences its total output, and, therefore, the level of profits of firms interacting in that industry.

The number of processors in the Southeastern region of the United States declined steadily from 181 firms in 1973 to 97 firms in 1996, or by more than 45% (Figure 2.1). From 1973 to 1988, the decline in the total number of firms in the shrimp processing industry was 15%. The decrease in the number of firms is more pronounced after 1988, with a 37% drop when compared to the 1988 processing firm number of 153. These trends, however, do not show the variation in processor size distribution, nor the dominance of a specific type of firm.

There was a growing domestic production per firm that arose from the declining number of shrimp processors. For example, the number of shrimp processors declined between 1973 and 1996, while domestic production fluctuated between 200 and 300
million pounds per year (Figure 2.2). During the period 1973 to 1996, U.S. imports of shrimp increased from 200 million pounds to 600 million pounds. Consequently, the average quantity of shrimp processed per firm increased from 1.18 million pounds per year to 2.60 million pounds. A closer look at the industry reveals that the annual processed shrimp production of 275 million pounds in 1988 (product weight basis) represented an increase of 28% when compared to 1973 annual production of 214 million pounds. Overall, 1988-1990 average annual production of 291 million pounds (product weight basis) represented an increase of 53% when compared to the 1973-75 average annual processing activities of 190 million pounds.

The annual value of processed shrimp in the southeastern region increased from $380 million in 1973 to more than $1.10 billion in 1986. Since 1986, however, the current value has fallen to about $900 million in 1996. The value of processed shrimp in 1996 was
a twofold increase when compared to the value of $380 million in 1973. During the 24-year period of analysis, both nominal prices and quantities of processed shrimp increased.

![Figure 2.2: Quantities and Values of Processed Shrimp in the Southeastern Region of the United States, 1973-1996](image)

But, when adjusted for inflation, the value of Southeastern shrimp processing activities declined steadily after the 1976-78 period, despite a general increase in quantity processed. This decline reflects the sharp fall in the real price of the processed product since 1979. The real processed price per pound of $4.61 in 1989 represented a more than 40% decline from the 1979 price of $7.81 per pound and a 30% decline when compared to the per pound deflated price of $6.58 in 1973.

Among the structural characteristics of an industry are: (1) the industry firm size distribution; (2) the industry product differentiation; (3) the industry concentration, and (4)
the industry’s barriers to entry. The sections that follow provide a discussion of these factors for the Southeastern United States.

2.3.2. Shrimp Processor Firm Size Distribution

The theory of industrial organization views the industry as a homogeneous unit (Porter 1979). This means that the industry can be defined as a group of companies offering products or services that are close substitutes for each other. Close substitutes are products or services that satisfy the same basic consumer needs (Hill and Jones, 1992). Each group, which includes firms following similar strategies in terms of the key decision variables, is called a strategic group (Hunt 1972). Firms within a strategic group resemble one another closely and, therefore, are likely to respond in the same way to disturbances, to recognize their mutual dependence, and to be able to quite accurately anticipate each other’s reactions (Porter, 1979).

Given the above definitions, firms are assumed to be alike in all economically important dimensions (Porter, 1979). Keithly, Robert and Kearney (1990) grouped shrimp processors into four size categories based upon the value of their processed shrimp sales: (I) firms with annual deflated processed shrimp sales of less than $250 thousand, (II) firms with annual deflated processed shrimp sales from $250 thousand to $1.0 million, (III) firms with annual deflated processed shrimp sales of $1.0 million to $10.0 million, and (IV) firms with annual deflated processed shrimp sales of $10.0 million or more. Table 2.1 indicates that 30 % (54 firms) of the Southeastern shrimp processing firms had reported annual deflated processed shrimp sales of less than $250 thousand in 1973. This percentage declined to 20 % (19 firms) in 1996. Another 10 to 23 % had reported annual deflated sales in the $250 thousand to $1.0 million range between 1973 and 1996. Approximately 30 to 40 % reported annual real sales in the $1.0 to $10.0 million range.
during the period 1973-1996. Finally, the remaining 10 to 30% of the total number of processors reported processed shrimp sales of $10.0 million or more. Table 2.1 indicated that the shrimp processor size distribution, as measured by the total deflated value of processed shrimp sales, changed significantly between 1973 and 1996. The number of firms in the different size categories has declined. However, in relative terms, the percentage of total firms in size 1 has dropped from 30 in 1973 to 20 in 1996 while the percentage of firms in size category 2 increased from 17 to 19. The largest increase in percentages occurred in the third (32 to 36) and fourth (21 to 26) sizes. These results suggested that firms were exiting more from the first size category than the other categories.

2.3.3. Product Differentiation

Shrimp are processed and marketed in a variety of product forms. Because the tail is the edible portion and because they spoil more rapidly if the heads are left on, most shrimp are marketed with the head removed (U.S. International Trade Commission, 1985). Four types of products are produced by the industry: (1) headless shell-on shrimp, (2) peeled shrimp, (3) breaded shrimp, and (4) “other” shrimp. General trends in the data for the different shrimp products are presented in the following sections.

2.3.3.1. The Headless Shell-On Product

The headless shell-on shrimp is produced using the whole shrimp, or to a lesser degree, from shrimp that have been deheaded at sea (United States International Trade Commission, 1985). Processing involves deheading, washing, grading (sorting by size), packing, and usually, freezing. In 1973, the domestic production of headless shell-on shrimp represented 35% of the total southeast processing activities and about 60% of
Table 2.1: Size Distribution of Firms in the Southeastern United States Shrimp Processing Industry, 1973-1996

<table>
<thead>
<tr>
<th>Year</th>
<th>Size 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Size 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Size 3&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Size 4&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Total Firms</th>
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<tbody>
<tr>
<td></td>
<td>No of Firms</td>
<td>% of Total</td>
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<td>% of Total</td>
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<tr>
<td>1973</td>
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<td>1996</td>
<td>19</td>
<td>20</td>
<td>18</td>
<td>19</td>
<td>35</td>
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</tbody>
</table>

Source: Compiled from unpublished data provided by the National Marine Fisheries Service, Fisheries Statistics Division. The base year of the deflated values in the table is 1996.

<sup>a</sup> firms with processed shrimp deflated sales less than $250,000.
<sup>b</sup> firms with processed shrimp deflated sales between $250,000 and $1.0 million.
<sup>c</sup> firms with processed shrimp deflated sales between $1.0 million and $10.0 million.
<sup>d</sup> firms with processed shrimp deflated sales above $10.0 million.

<sup>1</sup> Includes primarily canned and dried products
total U.S. shrimp imports. By 1996, however, the headless shell-on shrimp product had declined to 27% of the total of the southeast supplies and 55% of shrimp imports. Annual domestic production of headless shell-on shrimp fluctuated between 70 and 120 million pounds from 1973 to 1996 (Figure 2.3). During the same period, imports of headless shell-on shrimp quantities increased from about 120 million pounds in 1973 to more than 350 million pounds in 1989, and then declined to 300 million pounds in 1996.

The nominal value of domestic production of headless shell-on shrimp, increased from $150 million in 1973 to more than $500 million in 1986. But, by 1996, this value had fallen to nearly $320 million, which is still an increase of more than twofold when compared to the 1973 value. This increase can be explained by two factors: First, the drop in domestic production of 9% was more than compensated by a 150% increase in imports between 1973 and 1996. Second, the current price of headless shell-on shrimp increased throughout much of the period of analysis from $1.97 per pound in 1973 to $4.59 per pound in 1996.

When adjusted for inflation, the value of domestic production declined steadily after 1978 despite an increase in imports. This decline reflects a sharp fall in the real price of processed product since 1979. The deflated processed price per pound of $4.59 in 1996 represented about a 50% decline from the 1979 price of $9.15 per pound, and about 34% decline when compared to the per pound deflated price of $6.96 in 1973.

2.3.3.2. The Peeled Shrimp Product

Peeled shrimp is processed from shell-on shrimp. The shell-on shrimp is deheaded, washed, graded, and then peeled, either by hand or mechanically. The tail section is usually removed, but may be left on, particularly for larger shrimp. Peeled shrimp may be deveined and cooked, and are usually frozen. In 1973, domestic production of peeled shrimp represented about 12% of total domestic production of all southeast processed shrimp

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products, and about 37% of the total imports of processed shrimp. However, in 1996, importance of the peeled shrimp product increased to 31% of the total domestically processed shrimp and 45% of the imports. The domestic production of peeled shrimp increased from 25 million pounds in 1973 to about 80 million pounds in 1996, an increase of more than 200% (Figure 2.4). During the same period, U.S. imports of peeled shrimp increased from 75 million pounds to more than 260 million pounds.

In 1996, the nominal value of the Southeastern U.S. region peeled shrimp activities was $263 million, an increase of more than 350% when compared to the value of $57 million in 1973. This increase can be traced to two factors: first, the increase in domestic production, and in imports; second, the price of peeled shrimp increased throughout much of the period of analysis from $2.27 a pound in 1973 to $3.31 a pound in 1996.

When adjusted for inflation, however, the value of the domestic production of peeled shrimp activities of $264 million in 1996 represented about a 33% increase when
compared to the $200 million of 1973. During the period 1973 to 1996, the deflated peeled shrimp price declined from $8.02 a pound to a $3.31 a pound in 1996. Consequently, the increase in the deflated value of peeled shrimp can only be explained by the increase in both the domestic production and the imports.

![Graph showing domestic production vs. imports of peeled shrimp, 1973-1996](image)

Figure 2.4: Domestic Production vs. United States Imports of Peeled Shrimp, 1973-1996

### 2.3.3.3. The Breaded Shrimp Product

Breaded shrimp is produced from headless shell-on shrimp. After the head and the shell have been removed from the shrimp, a coating of batter or breading is applied. The shrimp is usually frozen raw, but a significant amount is cooked before freezing. Breaded shrimp may be prepared in four styles: round, tail-on; round, tail-off; butterfly (or fantail) tail-on, and butterfly tail-off. Round refers to the whole shrimp, whereas butterfly refers to splitting the shrimp down the middle and spreading the halves. The domestic production of breaded shrimp increased from 80 million pounds in 1973 to 112 million pounds in 1989, and then declined to 98 million pounds in 1996 (Figure 2.5). During that period,
imports of breaded shrimp dropped from 1 million pounds in 1973 to nearly a half million pounds in 1996.

In contrast to “other” shrimp products, breaded shrimp are largely supplied by domestic production. In 1973, the domestic production of breaded shrimp represented about 46% of total domestic production and less than 1% of U.S. imports of processed shrimp. However, in 1996, breaded shrimp comprised 40% of domestic production and less than 1% of imports. A closer look at the industry reveals that between 1973 and 1980, domestic production declined from about 100 million pounds a year to 70 million pounds, a decline of 22%. After 1980, domestic production increased to 112 million pounds in 1989, an increase of almost twofold. By 1996, domestic production of breaded shrimp decreased to 98 million pounds.

In 1989, the value of U.S. breaded shrimp were about $355 million, an increase of about twofold when compared to $152 million in 1973. This increase can be explained first by the increase in domestic production; and second the current price of breaded shrimp increased throughout much of the period from $1.56 a pound in 1973 to $3.15 a pound in 1989. In 1996, the price of the breaded shrimp was $2.99 a pound.

When adjusted for inflation, the value of the domestic production of breaded shrimp activities declined steadily over the 24-year period of analysis. The decline reflects the sharp fall in the real price of the processed product since 1973. The deflated processed price per pound of $2.99 in 1996 represented about a 46% decline when compared to $5.50 in 1973.
2.3.3.4. The “Other” Shrimp Product

Processors of “other” shrimp primarily rely on domestic production of raw shrimp, specifically, the smaller shrimp grades. As shown in Figure 2.6, domestic production of other shrimp decreased from 14 million pounds in 1973 to 5 million pounds in 1996. During the same period, U.S. imports of other shrimp increased from 3 million pounds to 18 million pounds in the mid-80s, and then declined to 3.5 million pounds in 1996.

The current value of “other” shrimp declined steadily over the 24-year period of analysis. The drop in the current value of “other” shrimp can be explained by the decline in processed quantities.

2.3.4. Industry Concentration

Seller concentration refers to the size distribution of firms that sell a particular product or collection of products. It is usually regarded as a significant dimension of market structure
because it is thought to play an important part in determining market power, and hence, business behavior and performance (Curry and George, 1983). Many methods are used to evaluate industry concentration. One method commonly employed is the $N$-firm ($CRN$) concentration ratio, defined as the cumulative share of the $Nth$ firm. More formally, using $\gamma_i$ to denote the share of the $ith$ firm, we may define

$$CRN = \sum_{i=1}^{n} \gamma_i$$

When applying the $CRN$ formula to the U.S. southeastern shrimp processing industry, one starts with the firms with the largest market share, measured in value of processed shrimp sales, and adds the shares of the next largest firms in succession. Consequently, an estimated cumulative market share is produced. These shares, estimated in term of the largest four firms (CR4), are given in Table 2.2. Concentration is lower for the production of the headless shell-on shrimp and peeled shrimp while concentration is higher for the production of breaded and "other" shrimp. Concentration increased for the production of headless shell-on, breaded and "other" shrimp and...
Table 2.2: Southeastern Region of United States Shrimp Processing Industry Four Firm Concentration Ratios by Type of Shrimp Product, 1973-1996

<table>
<thead>
<tr>
<th>Year</th>
<th>Shell-On</th>
<th>Peeled</th>
<th>Breaded</th>
<th>&quot;other&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>0.25613</td>
<td>0.44163</td>
<td>0.45668</td>
<td>0.53496</td>
</tr>
<tr>
<td>1974</td>
<td>0.30128</td>
<td>0.50328</td>
<td>0.44825</td>
<td>0.47189</td>
</tr>
<tr>
<td>1975</td>
<td>0.27519</td>
<td>0.42628</td>
<td>0.46768</td>
<td>0.47004</td>
</tr>
<tr>
<td>1976</td>
<td>0.28443</td>
<td>0.44722</td>
<td>0.42770</td>
<td>0.47901</td>
</tr>
<tr>
<td>1977</td>
<td>0.28353</td>
<td>0.41568</td>
<td>0.53724</td>
<td>0.48607</td>
</tr>
<tr>
<td>1978</td>
<td>0.30325</td>
<td>0.37355</td>
<td>0.51147</td>
<td>0.46936</td>
</tr>
<tr>
<td>1979</td>
<td>0.27331</td>
<td>0.40420</td>
<td>0.52242</td>
<td>0.55657</td>
</tr>
<tr>
<td>1980</td>
<td>0.33444</td>
<td>0.43122</td>
<td>0.56882</td>
<td>0.53343</td>
</tr>
<tr>
<td>1981</td>
<td>0.25675</td>
<td>0.38578</td>
<td>0.50213</td>
<td>0.53566</td>
</tr>
<tr>
<td>1982</td>
<td>0.25856</td>
<td>0.37306</td>
<td>0.56809</td>
<td>0.61385</td>
</tr>
<tr>
<td>1983</td>
<td>0.29686</td>
<td>0.37050</td>
<td>0.56977</td>
<td>0.51637</td>
</tr>
<tr>
<td>1984</td>
<td>0.32684</td>
<td>0.41218</td>
<td>0.56824</td>
<td>0.48888</td>
</tr>
<tr>
<td>1985</td>
<td>0.33554</td>
<td>0.30418</td>
<td>0.58826</td>
<td>0.63296</td>
</tr>
<tr>
<td>1986</td>
<td>0.27978</td>
<td>0.34665</td>
<td>0.58058</td>
<td>0.55019</td>
</tr>
<tr>
<td>1987</td>
<td>0.28144</td>
<td>0.25553</td>
<td>0.55477</td>
<td>0.63296</td>
</tr>
<tr>
<td>1988</td>
<td>0.27590</td>
<td>0.26351</td>
<td>0.45215</td>
<td>0.62836</td>
</tr>
<tr>
<td>1989</td>
<td>0.30310</td>
<td>0.27802</td>
<td>0.50983</td>
<td>0.68677</td>
</tr>
<tr>
<td>1990</td>
<td>0.36115</td>
<td>0.22814</td>
<td>0.49546</td>
<td>0.63633</td>
</tr>
<tr>
<td>1991</td>
<td>0.41944</td>
<td>0.30910</td>
<td>0.52762</td>
<td>0.68744</td>
</tr>
<tr>
<td>1992</td>
<td>0.37157</td>
<td>0.24432</td>
<td>0.59995</td>
<td>0.79947</td>
</tr>
<tr>
<td>1993</td>
<td>0.42663</td>
<td>0.32234</td>
<td>0.62179</td>
<td>0.73981</td>
</tr>
<tr>
<td>1994</td>
<td>0.39921</td>
<td>0.24890</td>
<td>0.57897</td>
<td>0.79339</td>
</tr>
<tr>
<td>1995</td>
<td>0.44237</td>
<td>0.23222</td>
<td>0.61603</td>
<td>0.66700</td>
</tr>
<tr>
<td>1996</td>
<td>0.40586</td>
<td>0.22846</td>
<td>0.61246</td>
<td>0.74129</td>
</tr>
</tbody>
</table>

decreased for the peeled shrimp during 1973-1996. Concentration is lower for the production of peeled shrimp mainly because this product form involves a relatively low degree of processing and is processed by a large number of firms (United States International Trade Commission, 1985). It is also suspected that very low economies of scales exit in this sector. Breaded shrimp and “other” shrimp are processed by fewer, generally larger plants and require a higher degree of processing compared with the previous products. Although concentration for peeled shrimp has increased over time, it is still relatively low when compared to breaded and other products. The reason for this is that most of the imported shrimp is peeled.

2.3.5. Barriers to entry

Alvarez, Andrew and Prochaska (1976) reported the availability of raw shrimp and labor as being substantial barriers to entry into the shrimp industry. The majority of processors surveyed by the authors believed that competition for scarce raw product, the fluctuation in raw shrimp prices, and the scarcity of labor discouraged businessmen from entering shrimp processing. In recent years, raw shrimp has become more available to processors and constitutes a smaller barrier to entry in the industry.

2.4. Summary

This chapter provided a profile of the southeastern United States shrimp processing industry. The number of firms in the industry declined from 181 firms in 1973 to 97 in 1996. Processors have exited more from the small size category than the large size category. During that same period, shrimp imports by the southeastern industry increased from 200 million pounds in 1973 to about 600 million pounds in 1996. Since shrimp became available year-round during that period, the production per firm increased from 1.8 to 2.6 million pounds a year. Within the same time period, 1973-1996, the total value of production of shrimp increased from $380 million in 1973 to $900 million in 1996. The analysis by product form reveals that peeled, headless shell-on and “other” components were dominated by imports while breaded shrimp was completely a domestic activity.
Except for peeled, most of the product form sectors have become more concentrated during the period 1973-1996, with the largest four firms controlling between 40 and 75% of sales. In recent years, raw shrimp have become available to processors and constitutes a smaller barrier to entry in the industry. The scarcity of labor seems to be the factor discouraging businessmen from entering the shrimp processing industry.
Chapter 3

Theoretical Considerations

Several schools of thought in the field of industrial organization have proposed market structure as the principal explanation for the emergence of common patterns of behavior and similar performance outcomes for firms in an industry (Mauri and Michaels, 1998). However, some of the schools differ regarding the dynamics of industry structure. The traditional school, which originated from Harvard, views market structure as exogenous and stable (Bain 1972, Caves 1980, Porter 1981). In the conventional framework of the Harvard school, market structure means the number of firms in a market defined by some taxonomic range of either homogeneous or differentiated products (Ekelund and Hébert, 1990). This school of thought followed closely the styles of general microeconomics theory and practice. Marshall’s actual conceptions of economic theory and how static microeconomic analysis fits into it were translated into formal, static mathematics. This increased stylization has produced the structure-conduct-performance paradigm (SCP). The SCP stipulates that industry structure shapes firm conduct and firm conduct dictates firm’s performance.

The Austrian (Schumpeter 1934) and the Chicago (Stigler, 1968; Demsetz, 1973) schools view market structure as endogenous and constantly evolving. The Austrian school emphasized the competitive process of an industry in which products are introduced in an ever-unfolding cycle of innovation engineered by entrepreneurs. Hayek (1937, 1945) developed the seminal notion of information (and knowledge) as a product in economic society, which furthered the Austrian view. In the 1960s, the Chicago school expanded the Austrian notion of competition. They retained the traditional notion of equilibrium but evoked a special concern for non-price elements (information search) in the development
and operation of markets. Despite these differences, the literature on industrial organization treats the industry as a unit of analysis, implicitly assuming that firms within an industry are homogeneous (Mauri and Michaels, 1998).

Given the above discussion, one can conclude that the industrial organization (IO) theory is strongly related to neoclassical economics. It is based on the SCP paradigm (Figure 3.1), which stipulates that the market structure faced by a firm dictates its conduct and performance. The basic conditions of the model include key strategic variables such as availability of raw materials, product durability, business attitude, price elasticities, presence or absence of substitute products, and rate of sales or company growth. The IO incorporates the impact of distinct public policies on firm strategies including tax and subsidy regimes, international trade rules, business regulations, price controls, antitrust laws, and information provisions. In addition to basic conditions and public policies that define the firm environment, the I.O. model specifically examines: 1) the market structure of an industry (by focusing on the number of sellers and buyers present in the market place, the barriers to entry experienced by new firms, product differentiation, vertical integration, and product diversification); 2) the conduct of different firms within a market structure (by concentrating on the firm’s pricing behavior, product choice and advertising, research and innovation, plant investment, legal tactics, collusion, mergers and contracts); and, 3) the impact of firm conduct on its performance (production and allocative efficiencies, technical progress, product quality, profits and equity). Recently, a new body of literature called “new empirical industrial organization” (NEIO) theory has emerged. This body of literature focuses on the importance of strategic analysis and micro-econometrics. It involves modeling competitive conditions within individual industries, often-employing
Figure 3.1: Structure – Conduct - Performance Model of Industrial Organization.

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simultaneous equation systems and/or game theory, and empirical testing of these models (Caswell 1992). The NEIO grew out of frustration with results of cross-sectional research that tried to draw conclusions on structure-conduct-performance relationships across industries (Schmalensee, 1989).

The NEIO theory differs from the IO theory only in its extensive use of econometrics. The basic conditions that the organization and structure of the market determine conduct and performance of firms hold. A market is defined as a collection of firms each of which is supplying products that have some degree of substitutability to the same potential buyers (Koch, 1980). Therefore, the term market is not necessarily synonymous with the more commonly used term industry, because firms in the same industry may not supply substitutable products and/or may sell their products to different customers. Using the SCP paradigm, Caves (1967) found the market structure is important because structure determines the behavior of firms in the industry and behavior in turn determines the industry's performance. Recently, Clarkson and Miller (1982) recognized the joint interrelationships and dynamics among structure variables, conduct, actions, and performance outcomes. Baldwin (1969) and Philipps (1970) found a feedback effect going from performance to market structure. In other words, the authors realized that if firms responded or reacted to performance, they would alter conduct or structure.

Following Doll (1972), Adams (1984), Adams, Prochaska and Spreen (1987), and Diop, Harrison and Keithly (1998), we will assume that the shrimp industry is operating in a competitive environment. We will also assume that shrimp processor performance as measured by gross margin has a feedback effect on the industry's structure. Namely, firm margins are impacting the shrimp industry structure (firm size distribution).
3.1. Marketing Margins in Theory

The marketing channels of the Southeastern United States shrimp processing industry are presented in this section. Linkages at different market levels are identified and analyzed in the context of vertical market structure. The price spread between sectors and the impact of changes in the spread on firm size distribution are also analyzed. A system of equations is proposed and discussed. A Markov process is suggested for the analysis of the impact of the changes of shrimp processors’ margins on firm size distribution.

The concept of the marketing margin is heavily documented in agricultural marketing systems theory. An agricultural marketing system is an entity that generally performs three basic functions: concentration, equalization and dispersion (Goodwin, 1994). The pooling of a volume of products sufficient for the two other functions to be performed is called concentration. Examples of marketing businesses that perform concentration would include shrimp harvesting firm and local grain elevators in farming. Once the function of concentration has been accomplished, the function of equalization can begin. Some of the equalization activities performed by the marketing system include sorting, grading, processing, and packaging. Upon completion of the equalization function, the dispersion activity may be undertaken. This function includes activities such as transportation, warehousing, wholesaling and retailing. At the beginning of the marketing system is the production sector.

In the case of the shrimp sector, the beginning consists of the harvesting of shrimp. At the end of the marketing system is the retail sector. The consumer purchases forms in the retail sector and is assumed to be a price taker. Likewise, in the harvesting sector, the producer is assumed to be a price taker. The equalization function takes place between the producer and consumer. The market separation between the consumer and the producer
has created the situation in which the fundamental forces of basic demand operate at a market level different from that at which the fundamental forces of basic supply are observed (Goodwin, 1994).

Within the above framework, consumers’ actions are observed at various retail outlets. Demand at the wholesale, processing or harvesting level, exists if there is a demand at the retail level. Consequently, the retail demand is the primary demand and the demand at the preceding levels of wholesaling, processing, harvesting is derived from the retail demand (Figure 3.2). The concepts of primary and derived supply are similar to those for demand. Primary supply refers to the relations at the producer level. The supply of commodities at the retail level is derived form the primary relation by adding an appropriate margin (Tomek and Robinson, 1990). A retail price is established at the point where the primary demand and the derived supply relations intersect (Figure 3.2). The wholesale price is based on derived demand and primary supply. The marketing margin is defined as the vertical difference between the two prices from the two different marketing levels (Kohl and Uhl, 1980). The marketing margin defined as the price of a collection of marketing services, which are the outcome of the demand for and the supply of such services (Tomek and Robinson, 1990). The nature of the marketing margin has many implications for the production and marketing processes, and for the prices that are likely to emerge at various levels as a result of changes in determinants of basic farm supply or basic consumer demand.

Under some conditions, marketing margins can be expected to be a constant cost per unit of sales, a constant percentage of retail prices, or an increasing cost per unit of sales. The constant (cost per unit of sales) marketing margin is encountered when the supply function
Figure 3.2: Illustration of Primary and Derived Demands and Supplies and the Marketing Margins. Source: Tomek and Robinson (1990).
is perfectly or nearly perfectly elastic. This type of margin is typical for fresh vegetables and fruits. One of the reasons for the existence of the constant cost per unit type of marketing margin is that the most of the costs faced by the marketing system tend to be variable. In the case of vegetables and fruits, the major costs faced by the producer are harvesting labor, grading and sorting labor, packaging materials, and transportation - all of which vary almost perfectly with the volume of the product handled. In this situation, average variable costs and average total costs would be almost identical and both would therefore be almost horizontal. Marginal cost likewise would be almost horizontal implying that each additional unit of product marketed would add essentially a constant amount to the total marketing cost (Goodwin, 1994). With the constant cost per unit of sales, the same marketing margin is subtracted from the primary demand function at all quantity levels, and consequently the derived demand is parallel to the primary demand function when they are straight lines.

Another application of the marketing margins is the situation in which margins are a constant percentage of retail prices. This type of margins is typical for products for which marketing process involves very large fixed investments and substantial economies of scales (Goodwin, 1994). With large fixed investments, average cost will decline as output is increased toward the optimal firm capacity. However, with existing economies of scale, the large firms will be able to operate at a lower cost forcing the small firms to overbuild facilities. Dairy farm products provide an example of the constant percentage marketing margins. The conflicting incentives between large and smaller farms create an environment in which the marketing agencies will absorb a part of any price reduction associated with an enlarged output. Consequently, marketing agencies grant as much price concession as
possible to producers in an effort to limit price disincentives for maintaining the volume of output.

The increasing cost per unit type of marketing margin is another application of this concept. This form of marketing margin is typical for products for which marketing firms face significant levels of fixed investment costs, but have substantial variable costs as well (Goodwin, 1994). While economies of scale may be available, most of these scale economies are realized at relatively low levels of output. Meat products - and most especially the fresh meat products - tend to exhibit increasing cost per unit marketing margins. Under these circumstances, marketing firms will not process products unless the price spread is sufficient to cover the cost of handling the best unit of product.

3.2. Marketing Channels

Processed shrimp is marketed through various channels of distribution (Gulf of Mexico Fishery Management Council, 1981). First, raw shrimp harvested domestically are sold to dockside dealers and domestic brokers or wholesalers, while raw imports are sold to importing brokers or wholesalers (Figure 3.3). The domestic and imported shrimp are then distributed to the processors who in turn sell their products to retailers and consumers.

The domestic dealers are the first handlers of the domestically harvested shrimp product. Usually dealers are involved in deheading, peeling, grading, packaging, refrigerating and storing the product. The dealer’s relationship with the fisherman is that of purchaser and, on occasion, purveyor of fuel, ice, and supplies.

The may also offer financial services ranging from credit extension to the maintenance of records for boats based at his dock. As compensation for providing various services, the dealer is allowed to handle the fishermen’s catch. As a result, this
Figure 3.3: Distribution Channels for the Shrimp Industry, United States, 1990s.
relationship may have a corollary price impact (Gulf of Mexico Fishery Management Council, 1981). The dealer's activities are seasonal in nature because he follows the shrimp harvest, which peaks in June-July and in September-October (Hu, 1983). Dealers sell their product to domestic brokers and wholesalers or to processors.

Processors are generally shrimp companies engaged in peeling and deveining, cooking, freezing, canning, breading, and preparing specialty products. Unlike dealers, processors tend to operate more year-round because of the availability of imports. Brokers facilitate transactions between buyers and sellers at various market levels. The majority of brokers are used in international or interstate contracts and in the sales, promotion, and establishment of business contracts for new products. The wholesalers represent another link in the marketing system. Generally, they provide the storage and the transportation of the shrimp to all parties (brokers, fishermen, and processors).

Now that all the important players in the market have been identified, it is necessary to examine the levels and linkages through which they interact. Adams (1984) identified market linkages and various market levels that characterize the shrimp industry. Those linkages include: 1) the consumer-retail level; 2) the retailer-wholesale processor level; 3) the wholesale-processor-first handler level; and 4) the first handler-producer level (domestic or import). In order to model the behavior of the shrimp industry, one should estimate a supply and a demand function for each level and a linkage between each level. Doll (1972), Adams (1984), and Adams, Prochaska and Spreen (1987) proposed the vertical market theory as a framework for the modeling of the shrimp industry.

3.3. Vertical Market

Individual economic systems are generally divided into two categories: buyers and sellers. Buyers include consumers who purchase shrimp and firms that buy labor, capital
and raw or semi processed shrimp, which they then use to produce goods. Sellers include firms which sell various shrimp products and workers who sell their labor. At the same time, the two functions can be embedded in one economic agent who simultaneously acts as a buyer and a seller.

In a vertical market, the final consumer demand for a product is an element of multi-level supply and demand interactions. The overall demand for a specific product should include the costs of transportation, storage, processing, grading, packaging, merchandising, and other services between the producer, the processor and the final consumer. At each level, certain marketable functions, such as a change in product form, are added. Within this framework, one can conceive of a supply and demand model at each point in the marketing chain where a product (or factor, depending on which stage is being considered) changes ownership (Ferris, 1964). The overall interactions of several levels in the chain provide a setting for a vertical market analysis. Adams (1984) developed a framework for vertical market analysis with four market levels (Figure 3.4). The following equations describe the model depicted in Figure 3.4.

The consumer demand for retail products is given as:

$$Q^C_D = f(p^r, D)$$

where $Q^C_D$ is the quantity demanded, $p^r$ is the retail price paid by the consumer, and $D$ is a set of demand shifters which would include income, the price of substitutes, and other relevant factors. The retailer’s supply of retail products to consumers is given as:

$$Q^R_S = f(p^r, p^w, c^r)$$

where $Q^R_S$ is the quantity supplied, $p^r$ is the retail price paid by the consumer, $p^w$ is the wholesaler-processor price received or the price paid by the shrimp retailer, and
Figure 3.4: Graphical Representation of a Vertical Market with Four Levels. Source: Adams (1984).
\( c^R \) represents other prices for inputs utilized by the retailer to transform the product to its new form. The retailer demand for products from the wholesaler-processor is given as:

\[
Q^R_D = f(p^R, p^\prime, c^R)
\]

where \( Q^R_D \) is the quantity demanded, which is the same function as for \( Q^S_S \). The similarity between \( Q^R_D \) and \( Q^S_S \) is valid in terms of the theory of the firm since \( Q^R_D \) represents the input demand of a retail firm and \( Q^S_S \) represents the output supply of a retail firm (Adams, 1984). Assuming profit maximizing behavior, these two relationships will therefore be functions of the same input and output prices variables (Silberberg, 1978, Adams 1984).

The wholesaler-processor's supply of product to retail firms is given as:

\[
Q^W_S = f(p^\prime, p^w, c^w)
\]

where \( Q^W_S \) is the quantity supplied, \( p^\prime \) is the first handler price received or the price paid by wholesaler-processors to the first handlers or fish house owners, \( p^w \) is as previously defined, and \( c^w \) represents prices for marketing inputs utilized by wholesaler-processors in transforming the semi-processed shrimp input into retail-ready product. The wholesaler-processor firm's demand for product from first handlers is given as:

\[
Q^D_W = f(p^\prime, p^w, c^w)
\]

where \( Q^D_W \) is the quantity demanded. The expressions \( Q^D_W \) and \( Q^S_S \) are functions of the same variables, and represent supply and demand, respectively, for a wholesaler-processor firm.

The first handler's product supply is given as:

\[
Q^F_S = f(p^\prime, p^\prime, c^\prime)
\]
The first handler's demand for raw products from producers is given as:

\[ Q_D^F = f(p_f', p_p, x_f) \]

where \( Q_D^F \) is the quantity demanded, the function is the same as that of \( Q_S^F \). The producer's supply of raw product to first handlers is given as:

\[ Q_S^P = f(p_p^P, x) \]

where \( Q_S^P \) is the quantity supplied and \( X \) is a set of exogenous supply shifters, such as weather, and \( p_p^P \) is as previously defined.

Adams (1984) assumed that inventories remain relatively stable over time and therefore did not include them in his model specification. The author treated domestic landings and the import of shrimp as predetermined. These assumptions are relevant to the study because the factors that determine the domestic supply are biological in nature and exogenous to the market place (Doll 1972). By specifying the model as described above and excluding inventories, then the set of demand equations determines the marketing margins between channel participants. The question that remains to be addressed is how the price spread between the different market levels is changing based on varying levels of shrimp imports. Also of interest is the way in which changes in gross price margins affect the firm size distribution. Those questions will be discussed in Chapter 4. The Markov process, which is appropriate when analyzing firm size distribution, is presented in the following sections.

3.4. Assumptions of the Markov Model

3.4.1. Assumptions

Before developing a Markov model, it is important to ask whether the real world is consistent with the assumptions of the model (Stavins and Stanton, 1980). The basic
Markov model implies four critical assumptions about the size distribution of shrimp processing firms:

1. Shrimp processing firms can be grouped into size classes according to some criteria, such as total output, total sales or a combination of total output and total sales;

2. The evolution of the shrimp processing firm size classes can be regarded as a stochastic process. A stochastic process \{X(t), t \in T\} is a collection of random variables (Ross, 1985). That is, for each \( t \in T \), \( X(t) \) is a random variable. The index \( t \) is often interpreted as time and, as a result, one refers to \( X(t) \) as the state of the process at time \( t \). For example \( X(t) \) might equal the total number of firms that have entered the processing industry by time \( t \).

Ross (1985) defined \( T \) as the index set of the process. When \( T \) is a countable set, the stochastic process is said to be a discrete time process \( (X_n, n = 1, 2, 3, \ldots) \). If \( T \) is an interval of the real line, the stochastic process is said to be a continuous-time process \( (X(t), t \geq 0) \).

The state space of the stochastic process is defined as the set of all possible values that the random variables \( X(t) \) can assume;

3. The probability that a shrimp processing firm will move from one size class to another is a function of some basic stochastic process, and

4. Transition probabilities remain constant over time. The assumption that the transition probabilities are constant means that once the process of change has been identified, the same process of change will continue indefinitely.

### 3.4.2. Applications of Markov Techniques

Two groups of Markov probability models are encountered in the literature. The first group, called stationary Markov models, includes all models in which the probabilities are assumed constant. The second group is composed of models in which the probabilities
of the transition matrix differ from one period to another. These models are termed non-stationary Markov probability models.

3.4.2.1. Stationary Markov Models

The Markov chain process is frequently used to model a stochastic process. Solow (1951) is one of the first investigators to apply such a model to economics, when he conducted a study of wage and price distribution. Hart and Prais (1955) were the first to apply the Markov process to the study of firm size distribution. The process requires that the population of firms or plants be classified into \( n \) different states. The movement between states must be a one discrete time interval. Once states have been defined, it is possible to define \( P_{ij} \) as the probability of moving from any state \( S_i \) in period \( t \) to any other state \( S_j \) in period \( t+1 \). Each \( P_{ij} \) is called the transition probability and \( P \), denotes the matrix of transition probabilities.

The best way to understand the stationary Markov process is to use an example. Assume an industry is composed of two firm sizes, and that those size categories are defined based upon a firm's total output. The first size category includes firms with yearly total output less than 5 million pounds of processed shrimp and the second size category includes those firms with a total annual output above 5 million pounds (Table 3.1).

<table>
<thead>
<tr>
<th></th>
<th>Period 1</th>
<th>Period 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size I</td>
<td>Size II</td>
</tr>
<tr>
<td>Size I</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Size II</td>
<td>10</td>
<td>90</td>
</tr>
</tbody>
</table>

Table 3.1: Firms Size Distribution Between two Periods

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In table 3.1, the first element in cell 1,1 (80) indicates the number of firms in size category one in time period one that remained in size category one in time period two. The element in cell 1,2 (20) shows the number of firms of size-category one in time period one that moved to size two in the second period. A similar interpretation can be given for the cells on the second row of table 3.1.

A transition probability matrix of firm movement can be estimated from table 3.1 by dividing each cell by 100 (row total). This leads to the following matrix

\[
A' = \begin{bmatrix}
0.8 & 0.2 \\
0.1 & 0.9
\end{bmatrix}
\]

The probability of a firm remaining in the same size is expected to be high (Adelman 1958). Therefore, the diagonals of the firm movement matrix are expected to be larger than the off diagonal cells (Chatzopoulou 1995). Also, the elements of the matrix that are closer to the diagonal are expected to be larger than the peripheral elements that are often close to zero. This is attributed to the fact that it is more probable for a firm either to remain in the same size category, or move to the next one, than to move to a more distant category.

An example is used to show the estimation of equilibrium structure. The probability matrix \( A' \) shows the probability of a number of firms remaining or moving from one size category to another. This probability matrix shows that there is a 0.8 probability of a firm being of size 1 in time period 1 to remain in category one in time period 2, and 0.2 probability of a firm moving from size 1 in time period 1 to size two in time period 2. Regular stochastic matrices such as \( A \) have the property that when raised in power, all rows tend to converge to a unique vector \( A^\infty \) which can be called \( K \) (Padberg, 1962).
\[ A^3 = \begin{bmatrix} .66 & .34 \\ .17 & .83 \end{bmatrix} \quad A^3 = \begin{bmatrix} .562 & .438 \\ .219 & .781 \end{bmatrix} \quad A^\infty = \begin{bmatrix} .3333 & .6666 \\ .3333 & .6666 \end{bmatrix} \]

\( K \cdot (0.3333, 0.6666) \) represents the final probabilities of being in each size category. Multiplying \( K \) by the initial number of firms present in the industry during the first period yields the equilibrium configuration of firms in the last period.

\[ 100 \cdot (0.3333, 0.6666) = (33, 67). \]

The steady state equilibrium for this industry at the time period \( t \) should include 33 firms of size 1 and 67 firms of size 2.

### 3.4.2.2. Non Stationary Markov Models

Stavins and Stanton (1980) identified two possible approaches to constructing a variable micro-data Markov model. In the first approach, the probabilities can be viewed simply as functions of time in a time series regression framework (Salkin et al., 1976). In the second approach, a structural model is usually developed, in which the transition probabilities are thought to be associated with changes in causal, exogenous variables (Hallberg, 1969; Mac Millan et al., 1974.)

In an attempt to improve upon the predictive and explanatory power of the Markov chain model, Hallberg (1969) applied the non-stationary Markov model to Pennsylvania manufactured dairy products data. The author tested the hypothesis that factors influencing the demand for and costs of manufactured dairy products would explain a major portion of the variation in the observed transition probabilities. The variables used in the study were:

a) \( z_t \) = Index of hourly earnings of workers engaged in food manufacturing industries in the U.S., deflated;
b) $x_t = \text{Population of Pennsylvania};$

c) $x_t = \text{Per capita income in Pennsylvania, deflated};$

d) $x_t = \text{Price per hundredweight received by Pennsylvania farmers for all milk, deflated};$

e) $x_t = \text{Index of retail prices of all dairy products in the U.S., deflated}.$

Hallberg fitted a least squares regression of the form,

$$
\hat{P}_{ijt} = \alpha_j + \sum_{k=1}^{k} \beta_{ik} x_{kt},
$$

for each of the $n^2$ cells of the transition probability matrix. $P_{ij}$ is an $n \times n$ matrix of transition probabilities, where $p_{ij}$ represents the probability that outcomes $S_j$ will result from the experiment given that outcome $S_i$ occurred on the $(t-1)$ experiment, where $t = 1, 2, ..., n$. $X_{kt}$ represents the set of exogenous variables. The $\alpha_j$ represent the different transition probabilities. The two requirements to meet are:

1. $P_{ijt} \geq 0 \text{ for } i, j, t$

2. $\sum_{i=1}^{n} P_{ijt} = 1 \text{ for all } i \text{ and } t,$

Hallberg (1969) found that the probability of small firms becoming larger increases slightly as the prices received by dairy farmers increase. The author also found that the probabilities of new firms entering the industry declined as per capita income and population increased.

In most applications of Markov analysis to the size distribution of firms, however, many of the transition probabilities will be zero over the entire time frame being observed (Stavins and Stanton, 1980.) This happens because most firms remain the same size, while just a few grow a little larger and others decline in size. It is also reasonable to expect that
some of the exogenous factors, which affect certain probabilities in a given row, would have no effect on others. For both reasons, several authors (Goldberg, 1964; Hallberg, 1969) assumed some of the parameters could be zero. In this case, Ordinary Least Squares (OLS) estimation is inadequate and some type of restricted least squares approach is recommended. Hallberg selected Goldberger's procedure and imposed the restriction that the non-zero intercept terms should sum to unity and the non-zero slope coefficients for a given exogenous variable should sum to zero in any row of the transition probability. A simulation procedure can be derived from this estimation using the matrix calculation of the form,

$$\hat{x} = \hat{x}_{t-1} \hat{p}_{t-1}$$

The forecast made from this model is dependent upon a prediction of the exogenous variables for the model. Hallberg's restricted least squares approach ensures that the Markov condition of rows summing to unity is respected. However, Hallberg does not deal directly with the constraint requiring that all probabilities be greater than or equal to zero. In the event that a negative probability occurred, the author assumed it is zero. In turn, if a probability greater than unity occurred, it is assumed to be equal to one. Lee (1970) suggested an alternative approach, which consisted of using quadratic programming in conjunction with Aitken's generalized least squares techniques so that estimated values of the probabilities would be restricted to the range of zero to one. Hallberg (1970) indicated that Lee's estimation procedure would lead to values of the estimated probabilities being between zero and one within the sample period. However, there is no assurance with the method that the restriction would be satisfied during the forecast period. In conclusion, both Hallberg and Lee models depend upon judgment when used for predictive purposes.
Salkin et al. (1976) developed a time series Markov regression model as an alternative to Hallberg's structural model. The authors identified three desirable properties for dynamic Markov models:

1. The estimated probability relationships should be such that all row sums of the estimated transition matrices continue to equal one for all time periods;
2. The estimated transition probability relationships should fall between zero and one for all time periods, and
3. In order for the asymptotic transition probabilities and the equilibrium vector to be examined, it is desirable that the dynamic model allows for convergence of the transition matrix.

Using a movement data of a cross section of Oklahoma cotton warehouse, the authors estimated transition probabilities for each successive pair of years in the 1963-73 time interval. The probabilities are estimated to be a linear function of time. The estimated time series associated with each transition probability was used to produce regression estimates of the intercept $a_{ij}$ and coefficient $b_{ij}$ found in the following equation

$$P_{ij} = a_{ij} + b_{ij}t \quad t = 1, 2, \ldots,$$

where

$P_{ij} =$ probability of moving from size category $S_i$ to size category $S_j$ during period $t$,

$a_{ij} =$ intercept term associated with the $ij$ transition probability,

$b_{ij} =$ time coefficient associated with the $ij$ transition probability.

The following equations were used to project the cotton warehouse distribution over size categories for the years 1975 through 1995.
If the distribution of firms over size categories in period \( t \) is represented by the row vector \( d_t \), then the projected conditional distribution of firms over size categories in period \( t+1 \) is given by equation 1 above. The projected distribution over firm size categories in all future time periods given the distribution in time \( t \) is given by equation 2. The problem encountered with the linear transition model is that the predicted path of future probabilities goes below zero or above unity. Another problem is that the fit of the regressions in term of \( R^2 \) is poor.

In a second model, Salkin et al. (1976) estimated the transition probabilities as a geometric transformation of time. In this type of model, the magnitude of change is reduced at a constant rate. The structural model is as follows:

\[
P_{y,t+1} = P_{y,t} + \theta_i (P_{y,t} - P_{y,t-1})
\]

where \( \theta_i \) is the constant rate associated with the different transition probabilities in row \( i \). The constant rate of change in the transition probabilities will result in predicted probabilities always falling between zero and unity. When evaluated in term of goodness of fit (\( R^2 \)), the results of the geometric model are better than the results of the linear model.

According to Salkin et al. (1976), better non-stationary Markov models can be developed. Those models should be based on a multinomial logit framework in which it is possible to keep the structural characteristics of Hallberg's model while meeting the need to predict transition probabilities without using arbitrary rules and procedures.

3.4.2.3. Test For Stationary Probabilities

Hallberg (1969) provided the following notation:
s_i = the i^{th} state of a set of n states, \(i = 1, 2, ..., n\)

\[P = [p_{ij}] = \text{the } nxn \text{ matrix of transition probabilities},\]

where \(p_{ij}\) represents the probability that outcomes \(s_j\) will result from the experiment given that outcome \(s_i\) occurred on the \((t-1)\) experiment, \(t = 1, 2, ..., T\).

\[X_0 = [x_{0i}] = \text{the initial starting state vector or the initial configuration of individuals in the } n \text{ states, where } x_{0i} \text{ represents the number of individuals in state } s_i \text{ during time period } t=0.\]

\[X_t = [x_{ti}] = t^{th} \text{ configuration vector, and}\]

\(m_{ij} = \text{number of individuals in } s_i \text{ during period } t-1 \text{ who moved to } s_j \text{ in period } t.\)

In addition, Hallberg imposed two constraints on the elements of the matrix \(P:\)

\[(1) \quad p_{ij} \geq 0 \text{ for all } i, j, t, \text{ and } t = 1, 2, ..., T.\]

\[(2) \quad \sum_{j=1}^{n} p_{ij} = 1 \text{ for all } i \text{ and } t.\]

Given \(P\) and \(X_0\), the future path of the stochastic process is given by \(X_t = X_0 P^t\). If \(P\) is a stochastic matrix satisfying (1) and (2), there exists an \(nxn\) matrix \(P^t\) to which \(P^t\) will converge as \(t\) approaches infinity consisting of \(n\) rows which are exactly alike (Kemeny and Snell 1960). Consequently, \(X_0 P^t\) gives the equilibrium configuration \(X_e\) of the stochastic process. Anderson and Goodman (1954) have shown that the maximum likelihood estimates of the transition probabilities based on actual movements of individuals between states are:

\[
\hat{p}_{ij} = \frac{m_{ij}}{\sum_{j=1}^{n} m_{ij}}
\]

if information is available for several time periods - i.e. - if \(m_{ij}\) are available for each of the \(t = 1, 2, ..., T\) time periods, Anderson and Goodman (1954,1957) have shown that the maximum likelihood estimates of the stationary transition probabilities are:
Given the estimates, \( \hat{P}_{ij} \), it is possible to test the null hypothesis that the true transition probabilities are stationary. The test statistic is (Judge et al. 1988):

\[
-2 \log \lambda = 2\left( \sum_{i}^{n} \sum_{j}^{n} \sum_{t}^{T} m_{ijt} \log \hat{P}_{ijt} - \sum_{i}^{n} \sum_{j}^{n} \sum_{t}^{T} m_{ijt} \log \hat{P}_{ij} \right)
\]

and is distributed as \( \chi^2_\nu \), with \( \nu = (K-1) \) degrees of freedom, \( K \) being the number of restrictions. The null hypothesis is rejected when the value of the Chi-square for the sample period is greater than the tabulated value of the Chi-square. Consequently, one can conclude that the estimated probabilities change from one period to another.

3.5. Summary

In this chapter, a theoretical framework for vertical markets and their relationships to margin analysis were presented. A Markov model was proposed for the analysis of the impact of the change in processor's margins on industry structure. The following chapter will discuss the marketing margin model as it applies to the southeastern U.S. shrimp processing sector. A Markov model will be specified and the different econometric issues pertaining to the estimation of these models and validation will be discussed.
Chapter 4

Econometric Considerations and Validation of the Model

The shrimp model, which will be presented in this Chapter, will be estimated using a simultaneous system of equations. The issues pertaining to the system estimation, model misspecification and validation will be discussed. We will also present the multinomial logit model that is used to estimate the impact of changes of the shrimp processors' margins on firm size distribution.

4.1. Model Development and Specification

4.1.1. Overview

Three sectors are generally considered when modeling the shrimp industry: domestic landings, wholesale (including the imports), and retail (Doll, 1972, Thompson, Roberts and Pawlik 1985, Adams, Prochaska, Spreen 1987, Lea and Shonkwiler 1988). Other studies have focused on shrimp import/export and domestic landings sectors (Keithly, Roberts and Ward (1993) and Gillig, Capps and Griffin (1998)). And lastly, a category of studies (Doll 1972; Adams 1985; and Adams, Prochaska and Spreen 1987) has treated the import sector and the domestic landing sector as predetermined. These studies focused on estimating a system of demand equations for the landing, wholesale and retail sectors. The current research employed the latter approach. Estimating a system of demand equations serves two purposes. First, it will be possible to estimate price dependent equations where the predicted values can be used to calculate processor gross margins as a function of shrimp imports. Secondly, the estimated processor margins can then be used as predetermined variables in the Markov model.
Doll (1972) made the argument that the import sector for shrimp is inherently
more complex than domestic production. Some U.S. importers are domestic firms that are
vertically integrated by maintaining foreign fleets, while others buy on forward contracts.
Although foreign suppliers have a choice of marketing area, prices in the United States
were favorable relative to other markets, causing some fisheries to be developed with the
lucrative U.S. market in mind. From the standpoint of supply, different sizes and several
varieties of shrimp are landed at domestic ports by different types of craft. Fishermen have
different goals and management techniques. Marketing channels also differ depending
upon the uses for which the raw shrimp are suitable. Further, different shrimp products are
marketed to separate demand sectors and at different prices. Moreover, imports depend
both upon the willingness and ability of foreign suppliers to export and of domestic
importers to purchase. A complete model of the shrimp market should include equations
to describe the demand, or derived demand, for each type of product form at each market
level (retail, wholesale, ex-vessel, imports). It should also include supply at each level.
Because of data limitations, one cannot estimate a United States full shrimp import model
for each level. Consequently, U.S. imports of shrimp are assumed to be predetermined.
This specification is similar to previous studies (Doll 1972, Adam Prochaska and Spreen
1987).

United States produces warm water and farm-raised shrimp. For the warm-water
shrimp, Berry (1967) found that annual fluctuations in landings reflect changes in
abundance of shrimp rather than changes in fishing effort. The factors that cause an
abundance of shrimp are biological in nature and exogenous to the market place (Doll
1972). Rothschild and Brunenmeister (1984) suggested that the large variations in both the
number and average size of shrimp caught were environmentally induced by changes in
salinity and water temperature during the shrimp’s growth cycle. Because shrimp are short-lived animals, Poffenberger (1984) indicated that they are resistant to overfishing. Given that shrimp import data are limited (no appropriate data on the supply and demand sector exists), and that the biological nature of shrimp complicates the forecasting of domestic landings, it was assume that the shrimp importer’s expectations respond primarily to domestic market conditions. Therefore, the resulting model is specified so that predetermined supplies (domestic, imports and inventories) and consumer income determine prices, which in turn determine retail consumption (Doll 1972, Adams, Prochaska and Spreen 1987.) This model is illustrated in figure 4.1.

4.1.2. Formulation of the Model

The specification in this study follows the studies of Doll (1972), Adams (1984), and Adams, Prochaska and Spreen (1987). However, while past studies have focused on the aggregate industry level, this study will attempt to analyze the shrimp industry at the product form level. The selected four shrimp products for this study include headless shell-on shrimp, peeled shrimp, breaded shrimp and “other” shrimp. The following model includes seven behavioral equations and no identities. All variables cover the period 1973-1996. The deflated prices (base year 1996) are in dollars per pound and the quantities are in millions of pounds headless shell-on equivalent weight basis.

4.1.2.1. Retail Demand Equation

The retail demand equation is defined as follows:

\[ Q_{ddt} = a_1 + a_2 P_{proc,t} + a_3 Y_{disp,t} + a_4 MeatP_t + a_5 ChickP_t + a_6 FishPPI_t + \mu_t \]  (4.1)

The variable \( Q_{ddt} \) represents the U.S. annual per capita consumption of shrimp in time period \( t \). It is expressed on a headless-shell-on equivalent weight basis.
Figure 4.1: Graphical Representation of the Southeastern U.S. Shrimp Processing Sector
The variable $P_{\text{proc}}$ is a weighted average retail price for processed shrimp. Doll (1972) conducted a principal component analysis on shrimp prices. He concluded that the wholesale shrimp price is an excellent index for the retail price. Since, no national average retail shrimp price is available, Hu (1983) argued that shrimp wholesale prices are a good proxy for the retail prices. Hu (1983) assumed that there is a fixed proportional difference between wholesale and retail prices. Therefore, the computation of elasticities will not be affected. Based on Doll's (1972) and Hu's (1983) findings, the weighted average of different shrimp product prices received by wholesalers was used as a proxy for the retail price. The total shrimp sales per product-form were converted to the headless shell-on equivalent weight basis. Then, percentage to the total per year of every product forms were calculated and used as a weight. The weights were multiplied by the corresponding wholesale prices and summed over corresponding years to obtain the retail prices. The sign associated with $P_{\text{proc}}$ is anticipated to be negative.

The variable $Y_{\text{disp}}$ is the U.S. real per capita disposable income. It is included in the model as a demand shifter. While Adams, Prochaska and Spreen (1987) included an income variable in the ex-vessel price equation to capture the relationships between income and ex-vessel price, Gillig, Capps and Griffin (1998) had an income variable in their import demand equations. In this study, since the focus is on the explanation of the structure of the industry, and since we assumed the imports and landings to be predetermined, we will hypothesize that the shrimp demand will increase as U.S. per capita disposable income increases.

The variables $\text{MeatP}_t$, $\text{ChickP}_t$, $\text{FishPPI}_t$ are U.S. average retail red meat prices, average U.S. retail whole chicken fryer prices, and the fish price index. Price index for fish
was included in the model, because retail prices were not available. The United States
International Trade Commission (1985) estimated that 80 percent of shrimp shipments are
diverted to the restaurant and institutional markets. Within those channels of distribution,
shrimp is likely to compete with fish products, red meat products and poultry products. An
increase in the prices of fish, red meat or poultry will likely result in an increase in the U.S.
demand for processed shrimp product quantities.

4.1.2.2. Wholesale Demand Equations

4.1.2.2.1. Peeled Shrimp

The U.S. wholesale demand for the peeled shrimp (DOM\textsubscript{pp}) is specified as follows

\[ DOM_{pp,t} = b_1 + b_2 DOM_{qp,t} + b_3 INV_{p,t-1} + b_4 IMP_{qp,t} + D83 + \mu_{2,t} \] (4.2)

The variable \( DOM_{qp,t} \) is defined as domestic peeled shrimp quantities in time
period \( t \). Economic theory predicts that shrimp peeled quantities should be negatively
related to shrimp' prices. The U.S. demand for peeled shrimp is also a function of other
available supplies. Those supplies include the peeled shrimp held in cold storage (\( INV_{p,t-1} \))
at the end of the year \( t-1 \) and U.S. imports of peeled shrimp (\( IMP_{qp,t} \)). A negative
relationship is hypothesized between the inventories and imports variables and the
wholesale demand for peeled shrimp price variable.

The variable \( D83 \) represents a dummy variable capturing the structural change that
occurred in the peeled shrimp imports in 1983. The variable \( D83 \) is 0 for the years 1973-
1982 and 1 for the years 1983-1996. Before 1983, imports of peeled shrimp from India
dominated U.S. imports. India exported a large quantity of low quality product at lower
prices during that period (Keithly\textsuperscript{1}, 1998). However, the Japanese market became less important to Indian exporters for a variety of reasons (United States International Trade Commission, 1985). Those reasons include heavy stocks of high priced shrimp in Japan, and weak markets for the principal small peeled Indian shrimp in Japan. These factors depressed average prices of Indian shrimp in Japan and caused Indian exporters to channel more products to U.S. and European markets. Additionally, after 1983, shrimp farming expanded in Asian and South American countries. As a result, large quantities and higher quality (Keithly, 1998) peeled shrimp were diverted to United States. The variable $D83$ should capture any major structural shift in imports.

4.1.2.2.2. Headless Shell-On Shrimp

The U.S. demand for headless shell-on shrimp ($DOM_{ph,t}$) is specified as follows

$$DOM_{ph,t} = c_1 + c_2 DOM_{qh,t} + c_3 INV_{h,t-1} + c_4 IMP_{qh,t} + \mu_{3,t}$$ (4.3)

The variable $DOM_{qh,t}$ is defined as the domestic headless shell-on shrimp quantity in period $t$. Based on economic theory, the quantity of headless shell-on shrimp should be negatively related to its own prices. The U.S. demand for headless shell-on shrimp is also function of other available supplies. Those supplies include the headless shell-on quantities held in cold storage ($INV_{h,t-1}$) at the end of the year $t-1$ and U.S. imports of headless shell-on shrimp ($IMP_{qh,t}$) in time period $t$. A negative relationship is expected between the inventories and imports quantities and the shrimp price variable.

4.1.2.2.3. Breaded Shrimp

The U.S. demand for breaded shrimp ($DOM_{pb,t}$) is specified as follows

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\[ DOM_{qb,t} = c_1 + c_2 DOM_{qb,t} + c_3 INV_{b,t-1} + c_4 IMP_{qb,t} + \mu_{3,t} \] (4.4)

The variable \( DOM_{qb,t} \) is defined as the domestic breaded shrimp quantities in time period \( t \). Based on economic theory, the shrimp breaded quantities are negatively related to shrimp' prices. The U.S. demand for breaded shrimp is also a function of other available supplies. Those supplies include the breaded quantities held in cold storage \( (INV_{b,t-1}) \) at the end of the year \( t-1 \) and the U.S. imports of breaded shrimp \( (IMP_{qb,t}) \). It is hypothesized a negative relationship between the inventories and imports variables and the wholesale demand for breaded shrimp price variable.

4.1.2.2.4. "Other" Shrimp

The U.S. demand for "other" shrimp \( (DOM_{pc,t}) \) is specified as follows

\[ DOM_{pc,t} = e_1 + e_2 DOM_{qc,t} + e_3 IMP_{qc,t} + \mu_{5,t} \] (4.5)

The variable \( DOM_{qc,t} \) is defined as the domestic "other" shrimp quantities in time period \( t \). Economic theory predicts that shrimp "other" quantities must be negatively related to shrimp prices. The U.S. demand for "other" shrimp is also a function of other available supplies. Those supplies include the U.S. imports of "other" shrimp \( (IMP_{qc,t}) \). It is hypothesized a negative relationship between the import variable and the wholesale demand for "other" shrimp price variable. U.S. processors do not hold inventories for "other" shrimp.

4.1.2.3. Ex-Vessel Demand

The U.S. demand for raw shrimp \( (P_{raw,t}) \) is specified as follows

\[ P_{raw,t} = f_1 + f_2 INV_{h,t-1} + f_3 INV_{p,t-1} + f_4 LAND_t + f_5 IMP_{qh,t} + f_6 IMP_{qp,t} + \mu_{6,t} \] (4.6)
Based on economic theory, one can expect the ex-vessel shrimp price ($P_{raw,t}$) to be negatively influenced by the U.S. Gulf of Mexico and U.S. South Atlantic landings ($LAND_t$). According to studies by Doll (1972), Keithly, Roberts, and Ward (1993), Upton, Hoar, and Upton (1992), Gillig, Capps, and Griffin (1998), Keithly and Diagne (1998) imported shrimp and domestic shrimp are close substitutes. Thus, imports of headless shell-on shrimp ($IMP_{qh,t}$) and imports of peeled shrimp ($IMP_{qp,t}$) in time period $t$ are hypothesized to have a negative impact on the U.S. ex-vessel shrimp price. Imports of headless shell-on shrimp and imports of peeled shrimp are included in the model because they are at the first stage or second stage of the processing. They represent the largest part of the shrimp harvest.

The U.S. ending of the year inventories of peeled shrimp ($INV_{p,t-1}$) and headless shell-on shrimp ($INV_{h,t-1}$) are also included in the model. The cold storage holdings are expected to have a negative effect on U.S. ex-vessel shrimp price.

4.1.2.4. Price Linkage Model

The markup pricing or marketing margin can be defined as the difference between the price paid by consumers and the price obtained by producers (Tomek and Robinson 1990). In this case, it is simply the difference between the primary demand and the derived demand curves for the shrimp products. The primary demand for shrimp is determined by consumer tastes, income and preferences. It is usually based on shrimp retail prices and quantities. The derived shrimp demand curves are based on dockside or wholesale prices and quantities for the shrimp activities. Tomek and Robinson (1990) identified situations in which marketing margins can remain constant or vary as the quantity of marketed shrimp increased. When the supply function of marketing services is perfectly elastic, the margin
remains constant as the demand for marketing services associated with increasing quantity
increases. In this case, constant marketing margin is subtracted from the primary demand
functions at all levels. Therefore, the derived demand function is parallel to the primary
demand. When the supply function for marketing services is positively sloped, the price of
services is expected to increase as demand increases. As a result, higher marketing margins
will be observed. If the supply of marketing services were perfectly inelastic, then the entire
incidence of a margin change would fall on the farm price.

The price linkage model describes the relationship between retail shrimp prices,
wholesale processed shrimp prices and ex-vessel raw shrimp prices. Only one other study
was identified, that of Adams, Prochaska and Spreen (1987), which determined the price
relationships between adjacent market levels for various size classes of raw-headless
shrimp. No study has focused on the market level relationships for different shrimp
product forms. Because the knowledge of those relationships is important due to their
potential effect on the structure of the shrimp industry, the current study expands the
Adams model by focusing on several shrimp product forms.

The Linkage price ($P_{proc}$) equation is specified as follows

$$P_{proc} = g_1 + g_2 DOM_{pp} + g_3 DOM_{pc} + g_4 DOM_{ph} + g_5 DOM_{pb} + g_6 P_{raw} + \mu_7 \quad (4.7)$$

The variable $P_{proc,t}$ is the retail shrimp price in time period $t$, which is hypothesized to be a
function of the prices of wholesale peeled shrimp ($DOM_{pp,t}$), wholesale “other” shrimp
($DOM_{pc,t}$), wholesale headless shell-on shrimp ($DOM_{ph,t}$), wholesale breaded shrimp
($DOM_{pb,t}$), and South Atlantic and Gulf ex-vessel price ($P_{raw,t}$). A positive relationship is
anticipated between ex-vessel, wholesale and retail prices.

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In summary, the structural model includes a retail demand equation, four wholesale
demand equations for peeled, headless shell-on, breaded and "other" shrimp, an ex-vessel
demand equations and a marketing margin demand equation. The structural equations will
be used to predict prices and, therefore, the processors' margins. The effects of those
margin changes on firm size distribution will be discussed in the following sections.

4.2. Simultaneous System of Equations

In the model described above, some variables across equations have outcome
values determined through joint interaction with other variables within the system. Those
variables are endogenous to the system. In the shrimp model, the endogenous variables are
U.S. shrimp per capita consumption $Q_{dd,t}$, the U.S. wholesale price for peeled shrimp
$DOM_{pp,t}$, the U.S. wholesale price for headless shell-on shrimp $DOM_{ph,t}$, the U.S.
wholesale price for breaded shrimp $DOM_{pb,t}$, the U.S. wholesale price for "other" shrimp
$DOM_{pc,t}$, the ex-vessel demand $P_{raw,t}$, and finally a price linkage model $P_{proc,t}$.

The second category of variables discussed in the shrimp model is called the
exogenous variable. Those variables are assumed to condition the outcome values of the
endogenous variables but are not reciprocally affected by them because no feedback
relation is assumed. The exogenous variables in the shrimp model are disposable income
($Y_{disp}$), the red meat average retail price ($MeatP_t$), the fish retail price index ($FishPPIt$),
the chicken average retail price ($ChickP_t$), the domestic quantity of peeled shrimp
($DOM_{qp,t}$), end of the year inventories of peeled shrimp ($INV_{qp,t}$), quantities of peeled
shrimp imports ($IMP_{qp,t}$), the dummy variable D83, the domestic quantity of processed
headless shell-on shrimp ($DOM_{qh,t}$), the end of the year inventories of headless shell-on

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shrimp \((INV_{qh,d})\), the import quantities of headless shell-on shrimp \((IMP_{qh,d})\), the domestic quantities of breaded shrimp \((DOM_{qh,d})\), the end of the year inventories of breaded shrimp \((INV_{qb,d})\), the import quantities of breaded shrimp \((IMP_{qb,d})\), the domestic quantities of "other" shrimp \((DOM_{qc,d})\), the import quantities of "other" shrimp \((IMP_{qc,d})\), and, finally, the U.S. domestic landings \((Land_{d})\).

Once the endogenous and exogenous variables are identified, the different equations must be estimated as a simultaneous system. The equations of the system are called structural equations, and the corresponding parameters are called structural parameters.

The system of equations is complete if there are as many equations as there are endogenous variables (Judge et al. 1985). We have seven equations in the proposed shrimp model and seven endogenous variables. Therefore, the shrimp model is complete.

Following Judge et al. (1985), in a simultaneous equation system, the \(T\) observations on the \(M\) endogenous variables can be represented by the \((T \times 1)\) vectors \(y_1, y_2, \ldots, y_M\); the \(K\) exogenous and predetermined variables can be represented by \((T \times 1)\) vectors \(x_1, x_2, \ldots, x_K\); and the \(M\) random error variables can be represented by the \((T \times 1)\) vectors \(e_1, e_2, \ldots, e_M\). A general linear statistical model reflecting the \(M\) equations that represent the relationships among the jointly endogenous variables, the exogenous and predetermined variables, and the random errors, may be stated as

\[
\begin{align*}
y_{11} + y_{21} + \ldots + y_{M1} + x_1\beta_{11} + x_2\beta_{21} + \ldots + x_K\beta_{K1} + e_1 &= 0 \\
y_{12} + y_{22} + \ldots + y_{M2} + x_1\beta_{12} + x_2\beta_{22} + \ldots + x_K\beta_{K2} + e_2 &= 0 \\
&\vdots \quad \vdots \quad \vdots \quad = 0 \\
y_{1M} + y_{2M} + \ldots + y_{MM} + x_1\beta_{1M} + x_2\beta_{2M} + \ldots + x_K\beta_{KM} + e_M &= 0
\end{align*}
\] (4.8)
where the \( \gamma \)'s and the \( \beta \)'s are the structural parameters of the system that are unknown and are thus to be estimated from the data. In matrix notation, the linear statistical model may be written compactly as

\[
Y\Gamma + XB - \varepsilon_i = 0
\]  
(4.9)

where 0 is a \((T \times M)\) matrix of zeros,

\[
Y = \begin{bmatrix}
  y_{11} & y_{12} & \cdots & y_{1M} \\
  y_{21} & y_{22} & \cdots & y_{2M} \\
  \vdots & \vdots & \ddots & \vdots \\
  y_{T1} & y_{T2} & \cdots & y_{TM}
\end{bmatrix} = (y_1, y_2, \ldots, y_M)
\]  
(4.10)

and

\[
X = \begin{bmatrix}
  x_{11} & x_{12} & \cdots & x_{1K} \\
  x_{21} & x_{22} & \cdots & x_{2K} \\
  \vdots & \vdots & \ddots & \vdots \\
  x_{T1} & x_{T2} & \cdots & x_{TK}
\end{bmatrix} = (x_1, x_2, \ldots, x_K)
\]  
(4.11)

are the sample values of the jointly dependent and the predetermined variables, respectively, and

\[
E = \begin{bmatrix}
  e_{11} & e_{12} & \cdots & e_{1M} \\
  e_{21} & e_{22} & \cdots & e_{2M} \\
  \vdots & \vdots & \ddots & \vdots \\
  e_{T1} & e_{T2} & \cdots & e_{TM}
\end{bmatrix} = (e_1, e_2, \ldots, e_M)
\]  
(4.12)

is the matrix of unobservable values of the random error vectors. The matrix

\[
\Gamma = \begin{bmatrix}
  \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1M} \\
  \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2M} \\
  \vdots & \vdots & \ddots & \vdots \\
  \gamma_{T1} & \gamma_{T2} & \cdots & \gamma_{TM}
\end{bmatrix} = (\Gamma_1, \Gamma_2, \ldots, \Gamma_M)
\]  
(4.13)
is the \((M \times M)\) matrix of coefficients of the current endogenous variables, where each column refers to the coefficients for a particular equation.

\[
\beta = \begin{bmatrix}
\beta_{11} & \beta_{12} & \cdots & \beta_{1M} \\
\beta_{21} & \beta_{22} & \cdots & \beta_{2M} \\
\vdots & \vdots & \ddots & \vdots \\
\beta_{M1} & \beta_{M2} & \cdots & \beta_{MM}
\end{bmatrix}
= (\beta_1, \beta_2, \ldots, \beta_M)
\quad (4.14)
\]

is a \((K \times M)\) matrix of unknown coefficients of the exogenous predetermined variables, and each column contains the coefficient of a particular equation. It is important to note that \(Y\) and \(E\) are of the same order. \(\Gamma\) is a square matrix of order \(M\), and \(\beta\) is of order \((K \times M)\), where, in general, \(K\) may or may not be equal to \(M\). The assumptions that define the statistical model are as follows.

1) \(E(e_i) = 0\) for \(i=1,2,\ldots,M\) \quad (4.15)

and

2) \(E(e_i e_i') = \sigma_{ii} I_T = \sigma_i^2 I_T\) for \(i=1,2,\ldots,M\) \quad (4.16)

and

3) \(E(e_i e_j') = \sigma_{ij} I_T\) for \(i \neq j\) and all \(i, j=1,2,\ldots,M\) \quad (4.17)

or compactly, as

\(E(e_i e_j') = \sigma_{ij} I_T\) for \(i, j=1,2,\ldots,M\)

which implies that

\[
E\left(\begin{bmatrix}
e_1 \\
e_2 \\
\vdots \\
e_M
\end{bmatrix} \begin{bmatrix}
e_1 \\
e_2 \\
\vdots \\
e_M
\end{bmatrix}'\right) = \begin{bmatrix}
\sigma_{11} I & \sigma_{12} I & \cdots & \sigma_{1M} I \\
\sigma_{21} I & \sigma_{22} I & \cdots & \sigma_{2M} I \\
\vdots & \vdots & \ddots & \vdots \\
\sigma_{M1} I & \sigma_{M2} I & \cdots & \sigma_{MM} I
\end{bmatrix} = \Sigma \otimes I_T
\quad (4.18)
\]
The unknown contemporaneous covariance matrix $\Sigma$ is a $(M \times M)$ symmetric and positive semidefinite matrix. It may be of less than full rank because some of the equations may appear in the form of identities with null error vectors. When estimating, the identities are substituted for so that the resulting system may be assumed to have an error covariance that is nonsingular. The least squares estimator is biased and inconsistent for the parameters of the structural equation in a simultaneous equation system (Judge et al. 1985). Therefore, it is recommended to use an estimator that will account for the contemporaneous correlations among the error terms across equations.

4.3. Reduced-Forms

Since it is assumed that $\Gamma$ is a nonsingular matrix, it is possible to solve for the vector of endogenous variables $y_i$ by post-multiplying the equation (4.1) by $\Gamma^{-1}$.

The result is

$$y_i = -x_i \Pi + \epsilon_i \Gamma^{-1} \tag{4.19}$$

or

$$y_i = x_i \Pi + u_i \tag{4.20}$$

where

$$\Pi = -\Pi \Gamma^{-1} \quad \text{(or } \Pi \Gamma^{-1} = -\Pi) \tag{4.21}$$

and

$$u_i = \epsilon_i \Gamma^{-1} \quad \text{(or } u_i \Gamma^{-1} = \epsilon_i) \tag{4.22}$$

The equation (4.20) is the reduced-form, which expresses each of the endogenous variables $y_i$ as a linear function of all predetermined variables $x_i$ and the error terms $u_i$.

The coefficient matrix $\Pi$ of equation (4.21) represents the matrix of reduced-form coefficients. The matrix $u_i$ defined in equation (4.22) depicts the vector of reduced-form error terms. The
assumptions made regarding \( \varepsilon \), imply corresponding conditions on \( u \), since from (4.22) the reduced-form error terms are linear functions of the structural equation disturbance terms. Consequently, it is assumed that

1) \( E(\varepsilon_i) = 0 \) for all \( i \) \hspace{1cm} (4.23)

2) \( E(y_i) = x_i \Pi \) \hspace{1cm} (4.24)

3) \( \text{Cov}(\varepsilon_i) = \text{Cov}(\varepsilon_i) = \Sigma = \Gamma^{-1} \Sigma \Gamma^{-1} = \Omega \) for all \( i \) \hspace{1cm} (4.25)

Here \( \Omega \) is the covariance matrix of \( u \). Since \( \Sigma \) is a symmetric and positive definite matrix, \( \Omega \) is also. Equation (4.25) is obtained by pre-multiplying (4.24) by \( \Gamma^{-1} \) and post-multiplying it by \( \Gamma \)

\[ \Sigma = \Gamma^{-1} \Omega \Gamma \] \hspace{1cm} (4.26)

which indicates the relation between the covariance matrix of the structural form \( \Sigma \) and that of the reduced form \( \Omega \).

The problem of identification arises when obtaining estimates of the parameters of the structural form (4.8), namely the coefficients of the matrices \( \Gamma \) and \( B \) and the covariance matrix \( \Sigma \) of (4.16) given the parameters of the reduced-form (4.20), or the coefficient matrix \( \Pi \) and the covariance matrix \( \Omega \) of (4.25).

If unique estimates of the parameters of the structural equation can be derived from the reduced-form equation, the equation is exactly identified. If no estimates can be derived, the equation is unidentified. If more than one estimate can be derived, the equation is overidentified. When many equations are included in the simultaneous system, it becomes difficult to ascertain the identification of an equation by way of the reduced-form. Consequently, one applies the “order” and “rank” conditions of identification to a system of simultaneous equations that contains \( M \) endogenous variables and \( M \) equations.
An equation is just identified if the number of excluded variables (endogenous plus exogenous) in that equation is equal to $M-1$. It is unidentified if the number of excluded variables is less than $M-1$, and overidentified if the number of excluded variables is more than $M-1$. In the shrimp model, the total number of variables is 23 (endogenous plus exogenous), the number of endogenous variables $M$ is 7. For an equation to be exactly identified, the number of variables excluded from it must be 6. However, in the shrimp model, the number of excluded variables from each equation varies from 17 to 20. Therefore, the system is overidentified and unique estimates of the structural parameters can not be obtained.

When unique estimates of the structural parameter estimate can be derived from the reduced-forms, the system is said to be exactly identified. In that case, the reduced-form estimates can be determined consistently by applying the ordinary least-squares method to every structural equation. Unfortunately, if one attempts to model the underlying data generation process, one will find that not all structural-equations are of the just identified forms. Consequently, specifying models that are consistent with the way in which the economic data were generated leads in many cases to structural equations that are overidentified (Judge et al. 1988).

The use of the reduced-form coefficients to estimate the structural equation parameters will result in a non-unique solution. To correct this problem, one can use the two stages least-squares (2SLS) estimation process. In stage 1, estimate the reduced-form parameters $\pi_i$ by $\hat{\pi}_i = (X'X)^{-1}X'Y_i$ and use these estimates to predict the sample values of $\hat{Y}_i$, where $\hat{Y}_i = X(X'X)^{-1}X'Y_i = X\hat{\pi}_i$. In stage 2, $y_i = [\hat{Y}_i \ X_i] \beta_i + \epsilon_i$ is estimated. The second stage is conducted via least-squares estimators for which $Y_i$ is replaced by the
predicted values $\hat{Y}_t$ from the first stage. Thus, 2SLS involves two stages, each of which necessitates the least-squares estimation of $n$-equations. Those $n$-equations include reduced-forms in the first stage and structural-forms in the second stage.

Another way of addressing the issue of overidentification is through the use of the three stages least-squares (3SLS). The first two stages of the 3SLS are those of 2SLS. The third stage is the generalized least-squares estimation of all the structural coefficients of the system, using a covariance for the stochastic disturbance terms of the structural equations that is estimated from the second stage residuals (Intriligator 1978).

The use of that covariance matrix will improve the efficiency of the estimates. In fact, in terms of properties of estimators, the 3SLS technique is an improvement over 2SLS. While both are consistent, the 3SLS technique is asymptotically more efficient than 2SLS. Thus, the basic rationale of the 3SLS, as compared to 2SLS, is its use of information on the correlation of the stochastic disturbance terms of the structural equations in order to improve asymptotic efficiency. However, the 3SLS estimator gains no efficiency over the 2SLS estimator if the covariance matrix is diagonal, or if all structural equations are just identified. In these cases, the 3SLS estimator reduces to the 2SLS estimator, which is equal to the ILS estimator in the latter. In the case of the shrimp model, we cannot obtain unique estimates of the reduced form coefficients because the equations are overidentified. Consequently, we will use 2SLS or 3SLS, whichever is more appropriate for the estimation in case of overidentified equations. Once the model is estimated using a system of equation approach, various methods are used to validate the model. Those methods are discussed below.
4.4. Model Validation

Different techniques allow an investigator to validate a system of equations model. Among the techniques are specification tests and goodness-of-fit statistics. The following section will discuss the Hausman specification test and the different goodness-of-fit statistics used to validate a model.

4.4.1. Hausman Specification Test

Within the system of equations for the shrimp model, it is assumed that predetermined variables are not correlated with the structural equation errors. However, if the endogenous variables under consideration are correlated with the structural equation errors, they should be treated as endogenous. If they are not, the use of ordinary least squares or two stages least squares will lead to biased and inconsistent parameter estimates. To correct the problem, one may use an instrumental variable technique similar to the one developed by Hausman (1978).

Hausman (1978) proposed a general form of the specification test. The basic requirement of the test is the existence of two estimators: one that is consistent and asymptotically efficient under the null hypothesis of no misspecification, and another that is consistent under both the null and alternative hypotheses. In other words, under the null hypothesis of no misspecification, both the systems of equations under the 2SLS and 3SLS are consistent, while 2SLS is inefficient. Under the alternative hypothesis 2SLS is consistent and 3SLS is not. By comparing the estimates from both estimators and noting that their difference is uncorrelated with the efficient estimator when the null hypothesis is true, a test is derived based on the asymptotic distribution of the difference in the two estimators (Judge et al., 1985). The Hausman specification test is:

\[ m = q' (\text{var}(q))^{-1} q \] 

(4.27)
where \( q \) is the difference between the 3SLS and the 2SLS estimators or \( \text{Vec}(\pi_{3SLS}) - \text{Vec}(\pi_{2SLS}) \) and the variance of \( q \) is \( \text{var}(q) = \Omega_{3SLS} - \Omega_{2SLS} \). This test is distributed as chi-square with degrees of freedom equal to the number of elements in \( q \).

### 4.4.2. Goodness-of-Fit Statistics

In assessing the shrimp model's ability to simulate or predict, one can use various goodness-of-fit statistics. Most of those statistics are discussed in Pyndick and Rubenfield (1991). Among the most widely used are the mean error, the mean percent error, the mean absolute error, the mean absolute percent error, the mean square error, the root mean square error, and the root mean square percent error.

The mean square error is defined as:

\[
\frac{1}{T} \sum_{i=1}^{T} (Y_i^s - Y_i) \tag{4.28}
\]

where \( Y_i^s \) is the simulated value of the shrimp total per capita consumption for example \( Y_i \), \( Y_i \) is the actual value of the shrimp per capita consumption series, and \( t \) is the number of periods in the simulation. The mean error is the average of all computed residuals, i.e., the sum of all the errors \((Y_i^s - Y_i)\) divided by the number of residuals \( T \).

When a model has a good fit, the value of the mean error should be zero or close to zero. The problem with the mean error statistic is that it may be close to zero if large positive errors cancel out large negative errors.

The mean percent error is defined as:

\[
\frac{1}{T} \sum_{i=1}^{T} \left( \frac{Y_i^s - Y_i}{Y_i} \right) \times 100 \tag{4.29}
\]
The mean percent error is similar to the mean error, except that the errors are multiplied by 100 and divided by the original data series. The mean percent error provides another way to check whether the mean error is significantly large. When a model has a good fit, the value of the mean error should be zero or close to zero.

The mean absolute error is defined as:

\[
\frac{1}{T} \sum_{i=1}^{T} |Y_i' - Y_i|
\]  \hspace{1cm} (4.30)

and represents the average of the errors regardless of their signs, i.e., all errors are treated as positive values. If the residuals are truly random errors, then the mean absolute error indicates how big the error component of the original series is on average. The desired value for the mean absolute error is zero or close to zero.

The mean absolute percentage error is defined as:

\[
\frac{1}{T} \sum_{i=1}^{T} \left| \frac{Y_i' - Y_i}{Y_i} \right| \times 100
\]  \hspace{1cm} (4.31)

The mean absolute percent error is similar to the mean absolute error except that the residuals are compared with the magnitude of the original series values. This statistic allows the investigator to judge the magnitude of the residuals relative to the magnitude of the original series values.

The mean absolute error and the mean percent error can be calculated to avoid the problem of positive and negative errors canceling out, since they penalize large individual errors more heavily.

The mean square error or MSE is defined as:

\[
\frac{1}{T} \sum_{i=1}^{T} (Y_i' - Y_i)^2
\]  \hspace{1cm} (4.32)
Frequently, one takes the square root of the MSE in order to obtain a measure that has the same dimension of the prediction and actual data series. One obtains the root mean square error, or RMSE, defined as:

$$\sqrt{\frac{1}{T} \sum_{i=1}^{T} (Y_i^s - Y_i^r)^2}$$  \hspace{1cm} (4.33)

The RMSE is a measure of the deviation of simulated variables from their actual time path. The magnitude of this error can be assessed only by comparing it with the average size of the variable in question.

The root mean square percent error is defined as:

$$\sqrt{\frac{1}{T} \sum_{i=1}^{T} \left( \frac{Y_i^s - Y_i}{Y_i} \times 100 \right)^2}$$  \hspace{1cm} (4.34)

It indicates the percentage deviation of the simulated variables from their actual time path. A problem with the mean square criterion is that it does not discriminate between signs. More precisely, whether the prediction error is $c$ or $-c$, in both cases the seriousness of the error is the same (Theil, 1966).

The closer the above statistics are to zero, the closer the simulated model follows the actual values. Useful simulation statistics related to the RMSE and applied to the evaluation of historical simulations is Theil's Inequality Coefficients.

**4.4.3. Theil’s Inequality Coefficients**

Another statistic that will help to identify how well the shrimp model fits the actual data is the Theil U statistic. The Theil U statistic (1971), also known as Theil’s Inequality, is defined as the square root of the following equation:
where the numerator represents the mean square errors and the denominator the mean square of the actual value. The Theil U statistic is always between 0 and 1. If U is equal to zero, then \( Y^* = Y_t \), and the model simulates history perfectly. If \( Y^*_t = 0 \), then \( U = 1 \) and the model's performance is said to be poor.

The denominator of \( U^2 \) is simply a device used to obtain an appropriate unit of measurement. Theil (1971) showed that, by algebra manipulation, the numerator of \( U^2 \) could be decomposed into the following equation:

\[
U^2 = \frac{\sum_{t=1}^{T} (Y^*_t - Y_t)^2}{\sum_{t=1}^{T} Y^2_t / T} = \frac{\sum_{t=1}^{T} (Y^*_t - Y_t)^2}{\sum_{t=1}^{T} Y^2_t}
\]

\[
U^2 = \frac{\sum_{t=1}^{T} (Y^*_t - Y_t)^2}{\sum_{t=1}^{T} Y^2_t / T} = \frac{\sum_{t=1}^{T} (Y^*_t - Y_t)^2}{\sum_{t=1}^{T} Y^2_t}
\]

\( \text{where the numerator represents the mean square errors and the denominator the mean square of the actual value. The Theil U statistic is always between 0 and 1. If U is equal to zero, then } Y^* = Y_t, \text{ and the model simulates history perfectly. If } Y^*_t = 0, \text{ then } U = 1 \text{ and the model's performance is said to be poor.} \)

The denominator of \( U^2 \) is simply a device used to obtain an appropriate unit of measurement. Theil (1971) showed that, by algebra manipulation, the numerator of \( U^2 \) could be decomposed into the following equation:

\[
\frac{1}{T} \sum_{t=1}^{T} (Y^*_t - Y_t)^2 = (\bar{Y}^* - \bar{Y})^2 + (\sigma^*_s - \sigma)^2 + 2(1 - \rho)\sigma^*_s \sigma
\]

\[
\frac{1}{T} \sum_{t=1}^{T} (Y^*_t - Y_t)^2 = (\bar{Y}^* - \bar{Y})^2 + (\sigma^*_s - \sigma)^2 + 2(1 - \rho)\sigma^*_s \sigma
\]

\( \text{where } \bar{Y}^* \text{ and } \bar{Y}, \sigma^*_s \text{ and } \sigma \text{ are the means and standard deviations of the series } Y^*_t \text{ and } Y_t \text{, respectively, and } \rho \text{ is the correlation coefficient between } Y^*_t \text{ and } Y_t \text{ (Pyndick and Rubenfield, 1991). The first term in the right hand side } (\bar{Y}^* - \bar{Y})^2 \text{ is zero if and only if the average predicted change coincides with the average realized change. Errors leading to a positive value for this term may be called errors in central tendency. The second term is zero if and only if the standard deviations of predicted and realized changes are equal. Prediction errors, which lead to a positive value of that term, may be referred to as errors due to unequal variation. The third term is zero if the correlation coefficient is 1, or, also, if and only if the covariance of predicted and realized changes } \rho \sigma^*_s \sigma \text{ takes its maximum value. Therefore, prediction errors, which lead to positive values of the third term, may be} \)
termed errors due to incomplete covariation (Theil, 1965). By dividing each of the discussed terms by their sum, one obtains the following:

\[
U^m = \frac{(\bar{Y}^s - \bar{Y})^2}{\frac{1}{T} \sum_{i=1}^{T} (Y^s_i - Y_i)^2}
\]  
(4.37)

\[
U^s = \frac{(\sigma^s_s - \sigma)^2}{\frac{1}{T} \sum_{i=1}^{T} (Y^s_i - Y_i)^2}
\]  
(4.38)

\[
U^c = \frac{2(1 - \rho)\sigma_s \sigma}{\frac{1}{T} \sum_{i=1}^{T} (Y^s_i - Y_i)^2}
\]  
(4.39)

These three components are the Theil Inequality proportions. The component \( U^m \) represents the bias proportion, \( U^s \) is the variance proportion and \( U^c \) is the covariance proportion. The three factors should sum to one.

The bias proportion \( U^m \) captures a systematic error in the estimation, since it measures how the average values of the simulated and actual series deviate from each other. The proportion \( U^m \) is expected to be close to zero. The proportion \( U^m \) is considered large when it is above .1 or .2 and should lead to model revision (Pyndick and Rubenfield, 1991).

The variance proportion \( U^s \) indicates the model's ability to replicate the degree of variability in the variable of interest. If \( U^s \) is large, it means that the actual series has fluctuated considerably while the simulated series shows little fluctuation or vice versa. When this problem is encountered, the model should be revised.

The covariance proportion \( U^c \) measures unsystematic error, i.e., it represents the remaining error after deviations from average values have been accounted for. Since it is
unreasonable to expect predictions that are perfectly correlated with actual outcomes, this component error is less worrisome (Pyndick and Rubenfield, 1991). For any \( U > 0 \), the ideal distribution of inequality over the three statistics is \( U^m = U^s = 0 \) and \( U^c = 1 \).

4.5. A Markov Model for the Shrimp Industry

Quandt (1966) maintains that four groups of factors should affect the transition probabilities of the sizes of firms in an industry. Those factors are: 1) the nature of the short-run cost function; 2) the nature of the long-run cost function; 3) the nature of oligopolistic arrangements in the industry, and 4) the general configuration of competing products, changes in relative technology, and changes in relative demand. Assuming that the structural model discussed earlier captures the changes in the above listed factors, predictions of the structural model are used to calculate the processor margins. A nonstationary Markov model is developed using those margins. We hypothesize that changes in processor margins affect the industry structure through the change in the transition probabilities. The proposed Markov model is as follows:

\[
\hat{P}_{ijt} = \sum_{k} \beta_{ij} x_{kt} + v_{jt} \tag{4.40}
\]

where \( \hat{P}_{ijt} \) is a time series of transition probability representing the movement of firms from one size category in period \( t-1 \) to another size category in period \( t \), \( x_{kt} \) represents the changes in processor margins between the period \( t-1 \) and \( t \), and \( v_{jt} \) is a random variable. Each of the n-rows of the time series of the transition probability matrices may be handled as a separate multinomial logit model. For a given row, we assume that the transition probabilities are function of the processor margins \( x_{kt} \).
4.6. Multinomial Logit

The multinomial logit will be used to estimate the impact of the changes in processor margins on shrimp processing firm movement. In other word, the multinomial will help to quantify the impact of shrimp processing sector performance on the shrimp industry structure. If \( y_{ij} \) is assumed to be a binary variable that takes the value of one if the \( j_{th} \) alternative, \( j=1, \ldots, J \) is chosen and zero if otherwise. And if one lets \( P_{ij} = \Pr[y_{ij} = 1] \), then

\[
\sum_{j=1}^{J} y_{ij} = \sum_{j=1}^{J} P_{ij} = 1 \tag{4.41}
\]

and given a sample of \( T \) individuals the likelihood function is

\[
l = \prod_{i=1}^{T} P_{j_1 y_{i1}} P_{j_2 y_{i2}} \ldots P_{j_T y_{iT}} \tag{4.42}
\]

Each observation is assumed to be drawn from independent, but not identical, multinomial distributions; hence the name multinomial choice models.

Multinomial logit can be viewed as a special case of utility maximization (Green, 1998). A typical multinomial logit considers subjects who face \( J>2 \) alternatives and must choose one of the following alternatives

\[
U(\text{alternative } 0) = x'_0 \beta_0 + \varepsilon_0
\]

\[
U(\text{alternative } 1) = x'_1 \beta_1 + \varepsilon_1 \tag{4.43}
\]

\[
\ldots
\]

\[
U(\text{alternative } J) = x'_J \beta_J + \varepsilon_J
\]
Observed $Y = \text{choice } J$ if $U(\text{alternative } J) > U(\text{alternative } K) \ \forall J \ldots K$. The multinomial logit assumes that the errors $\varepsilon_{ij}$ are independently and identically distributed with Weibull density functions (Johnson and Kotz, 1970). The difference between any two random variables with this distribution has a logistic distribution function, giving the multinomial logit model (Judge et al. 1985). The probabilities from the model can be represented as:

$$\text{Prob (choice } J) = \frac{e^{\varepsilon_{i0} \beta_j}}{\sum_{j=1}^{J} e^{\varepsilon_{ij} \beta_j}}, \quad j = 0, \ldots, J \quad (4.44)$$

where $i$ indexes the observation and $j$ indexes the choices. The above expression of the multinomial logit is a generalization of the logistic distribution function.

Following Judge et al. (1985), first consider the effects on the odds of choosing alternative 1 rather than alternative 2 where the number of alternatives facing the individual are increased from $J$ to $J^*$. The odds of alternative 1 being chosen rather than alternative 3 where $J$ alternatives are available are:

$$\frac{P_{i1}}{P_{i2}} = \frac{\sum_{j=1}^{J} e^{\varepsilon_{ij} \beta_j}}{e^{\varepsilon_{i3} \beta}} = \frac{e^{\varepsilon_{i1} \beta}}{\sum e^{\varepsilon_{ij} \beta}} \quad (4.45)$$

Given (4.45), the odds of a particular choice are unaffected by the presence of additional alternatives. This property is called the independence of irrelevant alternatives and can represent a serious weakness in the logit model.
Second, in the formulation above, none of the \( k \) variables represented in \( x_2 \) can be constant across all alternatives since the associated parameters would not be identified. For example consider

\[
\frac{P_{i1}}{P_{i2}} = \frac{e^{x_{i1}\beta}}{e^{x_{i2}\beta}} = e^{(x_{i1}-x_{i2})\beta}
\]  

(4.46)

If corresponding elements of \( x_{ij} \) and \( x_{i2} \) are equal, the associated variable has no influence on the odds. If this is the case for all alternatives, then the variables in question do not contribute to the explanation of why one alternative is chosen over another and its parameter cannot be estimated. In general, the odds of obtaining the \( k^{th} \) alternative relative to the first are

\[
\frac{P_{ik}}{P_{i1}} = \frac{e^{x_{ik}\beta}}{e^{x_{i1}\beta}} = e^{(x_{ik}-x_{i1})\beta} \quad k=2, \ldots, J
\]  

(4.47)

If \( x_{ik} \) and \( x_{i1} \) contain variables that are constant across alternatives, then \( x_{ik} = x_{i1} = x_j \), for \( k=2,\ldots, J \) and (4.47) becomes

\[
\frac{P_{ik}}{P_{i1}} = e^{[i(\beta_k-\beta_1)]}
\]  

(4.48)

Some normalization rule is clearly needed and a convenient one is to assume \( \beta_1 = 0 \) (Judge et al. 1985). This condition, together with the \((J-1)\) equations (4.48) uniquely determines the selection probabilities and guarantees the sum to equal 1 for each \( i \). The resulting selection probabilities are

\[
P_{i1} = \frac{1}{1 + \sum_{j=2}^{J} e^{x_{ij}\beta_j}}
\]  

(4.49)
\[ P_{ij} = \frac{e^{x_i \beta_j}}{1 + \sum_{j=2}^{J} e^{x_i \beta_j}} \quad j = 2, \ldots, J \] (4.50)

Using maximum likelihood procedures, one can carry out the estimation of the parameters of the multinomial logit model. The appropriate likelihood function is obtained by substituting the relevant expression for \( P_{ij} \) into (4.42).

4.7. Summary

This chapter has presented the shrimp model and a framework for its estimation and validation. Issues related to misspecification were presented and discussed. Many tools that will help to validate the model were introduced and discussed. A framework for analyzing the firm’s size distribution was presented. The empirical analysis, based on the framework discussed above, will follow in the next chapter.
Chapter 5

Results and Discussion

Two main assumptions underlie the shrimp model. First, changes in import quantities are assumed to impact the shrimp industry's structure through their effects on processor gross margins. Second, the changing margins affect the industry structure by altering the shrimp processing firm size distribution. The estimation of the shrimp model was accomplished using a three-stages least squares (3SLS). The entire system of equations was estimated and simulated using the Statistical Analysis System software PROC SYSLIN and PROC MODEL. The first section will discuss the misspecification test, the goodness of fit statistics and the validation of the model. The second section will be related to the presentation of the results for the structural analysis and the impact multipliers (reduced-forms). The last section will deal with the firm size distribution resulting from the changes in shrimp processors' margins.

5.1. Misspecification Test

The Hausman test, presented in chapter 4, was calculated using the SAS software Model procedure. The calculated Hausman $m$ statistics value is 54.0481 with 33 degrees of freedom. At the 5% alpha level, the computed $m$ statistics value is above the Chi-square critical value of 47.12 with 33 degrees of freedom. Therefore, we reject the null hypothesis and conclude that 3SLS is preferred over 2SLS.

5.2. Goodness of Fit Statistics

5.2.1. Retail Demand Model ($Q_{dd,t}$)

The standard deviations of the actual and predicted means are 0.4670 and 0.4389 (Table 5.1). This indicates that the simulated values have less variability than the actual
Table 5.1 Descriptive Statistics for the Endogenous Variables of the United States Southeastern Region Shrimp Processing Industry Model (1973-1996).

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Mean (actual)</th>
<th>Standard deviation (actual)</th>
<th>Mean (predicted)</th>
<th>Standard deviation (predicted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_{dd,i} )</td>
<td>24</td>
<td>1.9476</td>
<td>0.4670</td>
<td>1.9476</td>
<td>0.4389</td>
</tr>
<tr>
<td>( P_{raw,i} )</td>
<td>24</td>
<td>5.2733</td>
<td>1.5405</td>
<td>5.2733</td>
<td>1.3262</td>
</tr>
<tr>
<td>DOM_{pp,i}</td>
<td>24</td>
<td>6.2063</td>
<td>1.2887</td>
<td>6.2063</td>
<td>0.9665</td>
</tr>
<tr>
<td>DOM_{pb,i}</td>
<td>24</td>
<td>4.6004</td>
<td>1.2561</td>
<td>4.6004</td>
<td>1.0537</td>
</tr>
<tr>
<td>DOM_{pc,i}</td>
<td>24</td>
<td>6.8896</td>
<td>1.1639</td>
<td>6.8896</td>
<td>0.4585</td>
</tr>
<tr>
<td>DOM_{ph,i}</td>
<td>24</td>
<td>2.6504</td>
<td>0.6211</td>
<td>2.6504</td>
<td>0.4256</td>
</tr>
<tr>
<td>( P_{proc,i} )</td>
<td>24</td>
<td>5.4000</td>
<td>1.3386</td>
<td>5.4000</td>
<td>1.1087</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>N (year)</th>
<th>Mean error</th>
<th>Mean % error</th>
<th>Mean absolute error</th>
<th>Mean absolute % error</th>
<th>RMS* error</th>
<th>RMS % error</th>
<th>R-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{dd,t}$</td>
<td>24</td>
<td>-2.760E-15</td>
<td>-0.6097</td>
<td>0.1081</td>
<td>6.0319</td>
<td>0.1403</td>
<td>8.3090</td>
<td>.9351</td>
</tr>
<tr>
<td>$P_{raw,t}$</td>
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<td>8.606E-15</td>
<td>-1.6423</td>
<td>0.4737</td>
<td>9.1688</td>
<td>0.5669</td>
<td>10.9097</td>
<td>.8181</td>
</tr>
<tr>
<td>$DOM_{pp,t}$</td>
<td>24</td>
<td>6.834E-15</td>
<td>-1.6505</td>
<td>0.5023</td>
<td>9.1245</td>
<td>0.6424</td>
<td>10.6161</td>
<td>.6674</td>
</tr>
<tr>
<td>$DOM_{ph,t}$</td>
<td>24</td>
<td>1.058E-14</td>
<td>-2.8349</td>
<td>0.6051</td>
<td>14.6370</td>
<td>0.6912</td>
<td>17.6468</td>
<td>.6841</td>
</tr>
<tr>
<td>$DOM_{pc,t}$</td>
<td>24</td>
<td>8.824E-15</td>
<td>-2.9633</td>
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<td>12.5266</td>
<td>1.0187</td>
<td>20.5652</td>
<td>.2004</td>
</tr>
<tr>
<td>$DOM_{ph,t}$</td>
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<td>1.138E-14</td>
<td>-1.4870</td>
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<td>9.1980</td>
<td>0.7281</td>
<td>11.2719</td>
<td>.5822</td>
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<tr>
<td>$P_{proc,t}$</td>
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<td>6.289E-15</td>
<td>-2.4389</td>
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<td>12.2333</td>
<td>0.3909</td>
<td>14.6984</td>
<td>.9917</td>
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</tbody>
</table>

*RMS is Root mean square*

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>MSE*</th>
<th>Corr (R)</th>
<th>Bias (UM)**</th>
<th>Reg (UR)</th>
<th>Dist (UD)</th>
<th>Var (US)</th>
<th>Covar (UC)</th>
<th>U1</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q_{dd,t}$</td>
<td>24</td>
<td>0.01969</td>
<td>0.952</td>
<td>0</td>
<td>0.001</td>
<td>0.999</td>
<td>0.038</td>
<td>0.962</td>
<td>0.0701</td>
<td>0.0351</td>
</tr>
<tr>
<td>$P_{raw,t}$</td>
<td>24</td>
<td>0.41370</td>
<td>0.906</td>
<td>0</td>
<td>0.017</td>
<td>0.983</td>
<td>0.122</td>
<td>0.878</td>
<td>0.1173</td>
<td>0.0589</td>
</tr>
<tr>
<td>$DOM_{pp,t}$</td>
<td>24</td>
<td>0.52934</td>
<td>0.821</td>
<td>0</td>
<td>0.022</td>
<td>0.978</td>
<td>0.209</td>
<td>0.791</td>
<td>0.1149</td>
<td>0.0577</td>
</tr>
<tr>
<td>$DOM_{pb,t}$</td>
<td>24</td>
<td>0.47776</td>
<td>0.827</td>
<td>0</td>
<td>0.000</td>
<td>1.000</td>
<td>0.086</td>
<td>0.914</td>
<td>0.1452</td>
<td>0.0729</td>
</tr>
<tr>
<td>$DOM_{pc,t}$</td>
<td>24</td>
<td>1.03804</td>
<td>0.449</td>
<td>0</td>
<td>0.001</td>
<td>0.999</td>
<td>0.429</td>
<td>0.571</td>
<td>0.1459</td>
<td>0.0734</td>
</tr>
<tr>
<td>$DOM_{ph,t}$</td>
<td>24</td>
<td>0.15443</td>
<td>0.770</td>
<td>0</td>
<td>0.027</td>
<td>0.973</td>
<td>0.269</td>
<td>0.731</td>
<td>0.1445</td>
<td>0.0728</td>
</tr>
<tr>
<td>$P_{proc,t}$</td>
<td>24</td>
<td>0.31996</td>
<td>0.906</td>
<td>0</td>
<td>0.042</td>
<td>0.958</td>
<td>0.179</td>
<td>0.821</td>
<td>0.1018</td>
<td>0.0511</td>
</tr>
</tbody>
</table>

* Mean Square error  
** The values are zero because of rounding.
values. The mean error and mean percent errors are \(-2.760E-15\) and \(-0.6097\) (Table 5.2). The mean absolute error and the mean absolute percent error are 0.1081 and 6.0319 indicating positive and negative errors. There is a small downward bias in the simulated values of this model. The actual and simulated values have a correlation of 0.952. The regression of the actual values on the simulated values has a mean square error (MSE) of 0.01969, a RMS error of 0.1403, a RMS percent error of 8.3090 and an R-square of 0.9351.

The Theil forecast error statistics U1 and U are 0.0701 and 0.0351 (Table 5.3). These statistics are close to the ideal value of zero, and indicate that the model simulates the data well. The areas of concern are revealed in decompositions of the Theil statistics. The Dist and Covar components are 0.999 and 0.962 while the Bias, Reg and Var components are 0.000, 0.001, and 0.038. These statistics indicate that the model fits the data well (Figure 5.1) since the Dist and Covar components are close to desired value of 1 and while the Bias, Reg and Var components are close to the desired value of zero.

5.2.2. Wholesale Demands

5.2.2.1. Peeled Shrimp (DOMppj)

The standard deviations of the actual and predicted means are 1.2887 and 0.9965, (Table 5.1). This indicates that the simulated values have less variability than the actual values. The mean error and mean percent error are 6.834E-15 and -1.6505 (Table 5.2). The mean absolute error and the mean absolute percent error are 0.5023 and 9.1245 indicating positive and negative errors. There is a small downward bias in the simulated values of this model. The actual and simulated values have a correlation of 0.91. The regression of the

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Figure 5.1: Actual Versus Predicted U.S. Per Capita Shrimp Consumption, 1973-1996

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actual values on the simulated values has a mean square error (MSE) of 0.37962, a RMS
error of 0.5414, a RMS percent error of 10.3511 and an R-square of 0.83. The above
statistics indicate that the simulated values are correlated with the actual values (Figure 5.2).

The Theil forecast error statistics U1 and U are 0.1123 and 0.0564, (Table 5.3).
These statistics are close to the ideal value of zero, and indicate that the model simulates
the data well. The areas of concern are revealed in decompositions of the Theil statistics.
The Dist and Covar components are 0.98 and 0.88 , while the Bias, Reg and Var components
are 0.000, 0.017, and 0.116. These statistics indicate that the model fits the data well since
the Dist and Covar components are close to desired value of 1, while the Bias, Reg and Var
components are close to the desired value of zero.

5.2.2.2. Headless Shell-On Shrimp ($DOM_{ph,t}$)

The standard deviations of the actual and predicted means are 1.2887 and 0.9665
(Table 5.1). This indicates that the simulated values have less variability than the actual
values. The mean error and mean percent error are 1.138E-14 and -1.4870, (Table 5.2).
The mean absolute error and the mean absolute percent error are 0.5737 and 9.1080
indicating positive and negative errors. There is a small downward bias in the simulated
values of this model. The actual and simulated values have a correlation of 0.97. The
regression of the actual values on the simulated values has a mean square error (MSE) of
0.15443, a RMS error of 0.7281, a RMS percent error of 11.2719 and an R-square of
0.5822. The above statistics indicate that the simulated values are correlated with the actual
values.

The Theil forecast error statistics U1 and U are 0.1445 and 0.0728, (Table 5.3).
These statistics are close to the ideal value of zero, and indicate that the model simulates
Figure 5.2: Actual Versus Predicted Prices for U.S. Southeastern Region Headless-Shell-On Shrimp, 1973-1996
the data well (Figure 5.3). The areas of concern are revealed in decompositions of the Theil statistics. The Dist and Covar components are 0.973 and 0.731, while the Bias, Reg and Var components are 0.000, 0.027, and 0.269. These statistics indicate that the model fits the data well since the Dist and Covar components are close to desired value 1, while the Bias, Reg and Var components are close to the desired value 0. However, the variance of the simulated values is different from the variance of the actual values and may be of some concern.

5.2.2.3. Breaded Shrimp ($DOM_{pb,i}$)

The standard deviations of the actual and predicted means are 1.2561 and 1.0537, (Table 5.1). This indicates that the simulated values have less variability than the actual values. The mean error and mean percent error were 1.058E-14 and -2.8349, (Table 5.2). The mean absolute error and the mean absolute percent error are 0.6051 and 14.6392 indicating positive and negative errors. There is an upward bias in the simulated values of this model. The actual and simulated values have a correlation of 0.827. The regression of the actual values on the simulated values has a mean square error (MSE) of 0.47776, a RMS error of 0.6912, a RMS percent error of 17.6468 and an R-square of 0.6841. The above statistics indicate that the simulated values are highly correlated with the actual values.

The Theil forecast error statistics U1 and U2 are 0.1452 and 0.0729, (Table 5.3). These statistics are close to the ideal value of zero, and indicate that the model simulates the data well (Figure 5.4). The areas of concern are revealed in decompositions of the Theil statistics. The Dist and Covar components are 1.000 and 0.914, while the Bias, Reg and Var
Figure 5.3: Actual Versus Predicted Prices for U.S. Southeastern Region Breaded Shrimp, 1973-1996
components are 0.000, 0.000, and 0.086. These statistics indicate that the model provides a good fit for the data since the Dist and Covar components are close to the desired value of 1, while the Bias, Reg and Var components are close to the desired value of zero.

5.2.2.4. "Other" Shrimp \((DOM_{pct})\)

The mean error and mean percent error are \(-1.034E-14\) and \(-2.9944\), (Table 5.2). The mean absolute error and the mean absolute percent error are 0.7660 and 12.5989 indicating positive and negative errors. There is a downward bias in the simulated values of this model. The standard deviations of the actual and predicted means are 1.1639 and 0.4585, (Table 5.1). This indicates that the simulated values have less variability than the actual values. The actual and simulated values have a correlation of 0.447. The regression of the actual values on the simulated values has a mean square error (MSE) of 1.04206, a RMS error of 1.0208, a RMS percent error of 20.5949 and an R-square of 0.1973. The above statistics suggest that the simulated values are correlated with the actual values but the model does not provide a good fit (Figure 5.5).

The Theil forecast error statistics \(U_1\) and \(U_2\) are 0.1462 and 0.0735, (Table 5.3). These statistics are close to the ideal value of zero, and indicate that the model simulates the data well. The areas of concern are revealed in decompositions of the Theil statistics. The Dist and Covar components are 0.996 and 0.542 while the Bias, Reg and Var components are 0.000, 0.004, and 0.458. The variance of the simulated values is different from the variance of the actual values and may be of some concern.

5.2.2.5. Ex-Vessel Demand \((P_{raw,t})\)

The standard deviations of the actual and predicted means are 1.5405 and 1.3262, (Table 5.1). This indicates that the simulated values have less variability than the actual
Figure 5.5: Actual Versus Predicted Prices for U.S. Southeastern Region Raw Shrimp, 1973-1996
values. The mean error and mean percent error are 8.606E-15 and -1.6423, (Table 5.2). The mean absolute error and the mean absolute percent error are 0.4737 and 9.1688 indicating positive and negative errors (Figure 5.6).

There is a small downward bias in the simulated values of this model. The actual and simulated values have a correlation of 0.906. The regression of the actual values on the simulated values has a mean square error (MSE) of 0.41370, a RMS error of 0.5669, a RMS percent error of 10.9097 and an R-square of 0.8181. The above statistics indicate that the simulated values are correlated with the actual values.

The Theil forecast error statistics $U_1$ and $U$ are 0.1173 and 0.0589, (Table 5.3). These statistics are close to the ideal value of zero, and indicate that the model simulates the data well. The areas of concern are revealed in decompositions of the Theil statistics. The $Dist$ and $Covar$ components are 0.98 and 0.88, while the $Bias$, $Reg$ and $Var$ components are 0.000, 0.017, and 0.112. These statistics indicate that the model fits the data well since the $Dist$ and $Covar$ components are close to the desired value of 1, while the $Bias$, $Reg$ and $Var$ components are close to the desired value of 0. However, the variance of the simulated values is different from the variance of the actual values and may be of some concern.

5.2.2.6. The Price Linkage Model ($P_{proc,t}$)

The standard deviations of the actual and predicted means are 1.3386 and 1.1087, (Table 5.1). This indicates that the simulated values have less variability than the actual values. The mean error and mean percent error were $-6.289E-15$ and $-2.4389$, (Table 5.2). The mean absolute error and the mean absolute percent error are 0.3168 and 12.2333 indicating positive and negative errors. There is a small upward bias in the simulated values.
Figure 5.6: Actual Versus Predicted Retail Price for U.S. Southeastern Region Shrimp, 1973-1996
of this model (Figure 5.7). The actual and simulated values had a correlation of 0.91. The regression of the actual values on the simulated values had a mean square error (MSE) of 0.31996, a RMS error of 0.3909, a RMS percent error of 14.6984 and an R-square of 0.9917. The above statistics indicate that the simulated values are correlated with the actual values. The Theil forecast error statistics U1 and U are 0.1018 and 0.0511, (Table 5.3). These statistics are close to the ideal value of zero, and indicate that the model simulates the data well. The areas of concern are revealed in decompositions of the Theil statistics. The Dist and Covar components are 0.96 and 0.821 while the Bias, Reg and Var components are 0.000, 0.042, and 0.179. These statistics indicate that the model fits the data well because the Dist and Covar components are close to the desired value of 1 and the Bias, Reg and Var components are close to the desired value of 0. However, the variance of the simulated values is different from the variance of the actual values and may be of some concern.

5.3. Structural Analysis

One of the major purposes of performing an econometric study is to use the estimated econometric model for structural analysis (Intriligator, 1978). With the structural analysis, the investigator can, in a first phase, identify the different interrelationships among the variables in the simultaneous system of equations. The second phase of the structural analysis involves the quantitative estimation of the identified relationships. The third phase involves the inferential analysis and the various implications of the findings. The inferential analysis encompasses the interpretation of certain coefficients or a combination of coefficients. Intriligator (1978) identified three important ways of interpreting the coefficients, which are the comparative statics results, the elasticities and the multipliers. In
Figure 5.7: Actual Versus Predicted Prices for U.S. Southeastern Region Peeled Shrimp, 1973-1996
the comparative statics analysis, we are interested in comparing two equilibrium points of a system of equations, describing the phenomenon under consideration. The two equilibrium points typically involve equilibrium before and after displacement by a change in one of the parameters of the system of equations. In the comparative analysis, we are just changing one variable at a time; everything else is held constant. For example suppose that the demand curve for shrimp can be represented by

$$Q_{dd} = D(P_{proc}, \alpha)$$

where $P_{proc}$ is the shrimp retail price and $\alpha$ is a demand shifter. It might be consumer income, the price of shrimp substitutes, the change in tastes and preferences. In general, we expect $\frac{\partial D}{\partial P_{proc}} = D_{P_{proc}}(0)$, but $\frac{\partial D}{\partial \alpha} = D_{\alpha}$ may have any sign, depending on what the parameter $\alpha$ represents. The supply of shrimp can be represented as follows

$$Q_{ss} = S(P_{proc}, \beta)$$

where $\beta$ is a supply shifter. It might represent input prices or technical changes. We expect $\frac{\partial S}{\partial P_{proc}} = S_{P_{proc}}(0)$, but $\frac{\partial S}{\partial \beta} = S_{\beta}$ may have any sign. The equilibrium condition for this model would be

$$Q_{dd} = Q_{ss}$$

To conduct the comparative statics of this simple model, we can write the total differentials of equations representing the supply and the demand as

$$dQ_{dd} = D_{P_{proc}} dP_{proc} + D_{\alpha} d\alpha$$
$$dQ_{ss} = S_{P_{proc}} dP_{proc} + S_{\beta} d\beta$$
$$dQ_{dd} = dQ_{ss}$$
We can solve these equations for the change in equilibrium price for any combination of shifts in demand ($\alpha$) or supply ($\beta$). For example, suppose that in the shrimp demand model, the parameter $\alpha$ were to change while $\beta$ remains constant. Then using the equilibrium condition we have

$$D_{\alpha} \frac{dP_{\alpha}}{d\alpha} + D_{\alpha} = S_{\alpha} \frac{dP_{\alpha}}{d\alpha}$$

or,

$$\frac{\partial P_{\alpha}}{\partial \alpha} = \frac{D_{\alpha}}{S_{\alpha} - D_{\alpha}}$$

Since the denominator of this expression is positive, the sign of $\frac{\partial P_{\alpha}}{\partial \alpha}$ will be the same as the sign of $D_{\alpha}$. If $\alpha$ represents consumer disposable income and shrimp is a normal good, $D_{\alpha}$ would be positive. Hence, an increase in disposable income would be associated with a rightward shift in shrimp demand resulting in a rise of equilibrium prices.

By further manipulating the last comparative static result, we can obtain the elasticity. In fact, we need only to multiply both sides of our equation by $\frac{\alpha}{P_{\alpha}}$ to obtain

$$\varepsilon_{P_{\alpha}} = \frac{\partial P_{\alpha}}{\partial \alpha} \frac{\alpha}{P_{\alpha}} = \frac{D_{\alpha}}{S_{\alpha} - D_{\alpha}} \frac{\alpha}{P_{\alpha}} = \frac{D_{\alpha} \frac{\alpha}{\bar{Q}}}{\left(S_{\alpha} - D_{\alpha}\right) \frac{P_{\alpha}}{\bar{Q}}}$$

According to economic theory, the elasticity of the demand curve, which is derived above, is used to describe the effect of a change in price on quantity demanded. Fluctuations in quantity and price are measured in percentage changes. Consequently, the value of elasticity is independent of the units in which price and quantity are expressed. For a specific demand curve, elasticity values can vary between 0 and $-\infty$ because quantity and price move in opposite directions. When the value of elasticity is -1, this is described as
unit elasticity of demand. In that situation, the percentage change in price is equal in absolute value to the percentage change in quantity. In other words, an absolute increase in price is completely offset by an absolute increase in quantity, leaving total revenue unchanged. The percentage change in price can be less than the percentage change in quantity. In that case, the effect of the change in quantity will dominate, causing total revenue to move in the same direction as total quantity and in the opposite direction of price. One will observe an increase in total revenue when prices decline and a decline in total revenue when prices rise. In this elastic portion of the demand curve, the value of the elasticity ranges between $-1$ and $-\infty$. If the percentage change in price is larger in absolute terms than the percentage change in quantity, the price effect is dominant. Consequently, total revenue will move in the same direction as price, declining when price declines and rising when price rises. We are in the inelastic portion of the demand curve, and the value of the elasticity ranges between $0$ and $-1$.

The last category of analysis that can be conducted is the interpretation of the impact multipliers. The impact multipliers are the reduced form coefficients of the exogenous variables and measure the effect of a unit change in an exogenous variable upon the value of the endogenous variable in the same time period (Doll, 1972). The reduced form equations are found by solving the system of structural equations for the endogenous variables as functions of the exogenous variables. A reduced-form coefficient is determined by many structural coefficients and is a measure of a total effect, whereas a structural coefficient measures a partial effect, which holds only within the limit of the studied sector. The following sections will use the comparative statics, the elasticities and the impact-multiplier techniques to analyze the Southeastern United States shrimp industry.
5.3.1. Comparative Statics and Elasticities Analysis

5.3.1.1. Retail Demand

Generally, shrimp prices are set in competitive markets where conditions are determined by supply and demand factors (United States International Trade Commission, 1985). Economic theory predicts that one can expect a large production of processed shrimp to depress prices. As expected, the retail price for processed shrimp is statistically significant at the 5% level and is of correct sign. The estimation results indicate that a dollar increase in retail shrimp price leads to a 0.2513 pound (Table 5.4) decrease in domestic per capita consumption of shrimp.

Table 5.4: Parameter Estimates for Southeastern U.S. Shrimp Retail Demand, 1973-1996

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Elasticities</th>
<th>Standard Error</th>
<th>T-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.6295</td>
<td>-</td>
<td>1.8967</td>
<td>-0.859</td>
<td>0.4016</td>
</tr>
<tr>
<td>$P_{proc,t}$</td>
<td>-0.2513</td>
<td>-0.6968</td>
<td>0.0551</td>
<td>-4.563</td>
<td>0.0002</td>
</tr>
<tr>
<td>$Y_{disp,t}$</td>
<td>0.0001</td>
<td>0.9385</td>
<td>0.0001</td>
<td>1.083</td>
<td>0.2930</td>
</tr>
<tr>
<td>Meat$P_t$</td>
<td>1.1556</td>
<td>1.8285</td>
<td>0.4816</td>
<td>2.400</td>
<td>0.0275</td>
</tr>
<tr>
<td>Fish$PPI_t$</td>
<td>0.8357</td>
<td>0.2921</td>
<td>0.4338</td>
<td>1.927</td>
<td>0.0700</td>
</tr>
<tr>
<td>Chick$P_t$</td>
<td>-0.3349</td>
<td>0.1779</td>
<td>1.6999</td>
<td>-0.197</td>
<td>0.8460</td>
</tr>
</tbody>
</table>
Many studies, including Doll (1972), Batie (1974), Robert et al. (1982), Prochaska et al. (1983), and Thompson et al. (1984), have found that the demand for shrimp is price inelastic. In the estimated structural model, the price elasticity of the demand is consistent with previous studies. This finding implies that the percentage change in shrimp price is larger in absolute value than the percentage change in shrimp quantity. Consequently, total revenues for shrimp retailers will move in the same direction as shrimp prices, declining when shrimp price declines and rising when shrimp price rises. Any governmental policy that will restrict or enhance the shrimp retail prices will restrict or enhance shrimp retailer revenues.

The consumer’s decision to purchase shrimp may be influenced by red meat, fish, and poultry prices. Results indicate that the variables $MeatP_i$ and $FishPPI_t$ are statistically significant at the 5 % and 10 % level. An increase by $1 per pound in red meat prices is associated with 1.1556 pound increase in shrimp per capita consumption. An increase by one unit in fish price index leads to 0.8357 pound increase in U.S. shrimp per capita consumption. The chicken price is not statistically significant, hence, poultry do not play a significant role as a shrimp substitute. When shrimp substitute products are assessed in term of elasticity, the shrimp red meat cross price elasticity is 1.83 implying that a 10 % rise in red meat retail prices leads to a 18.3 % augmentation in shrimp per capita consumption and a higher revenue for shrimp retailers. However, the cross price relationship between shrimp and fish falls in the inelastic range. A 10 % increase in the fish price index causes a 2.92 % increase in shrimp per capita consumption and a small increase in shrimp retailers’ receipts. The implications of these findings regarding government policies are important. Any restrictions imposed on red meat or fish will likely impact the shrimp retailer demand.
5.3.1.2. Wholesale Sector

The wholesale shrimp sector was divided into four components representing the four shrimp product forms. For each product form, a demand equation was estimated. The following section presents the results pertaining to the peeled shrimp, the headless shell-on shrimp, the breaded shrimp, and the “other” shrimp sectors.

5.3.1.2.1. Peeled Shrimp Sector

The peeled shrimp model was specified as a price dependent model with the wholesale peeled shrimp price ($DOM_{pp,t}$) as the endogenous variable and the available supplies and structural change as exogenous variables. The available supplies include domestically harvested and peeled shrimp ($DOM_{qp,t}$), inventories of peeled shrimp ($INV_{qp,t-1}$) and imports of peeled shrimp ($IMP_{qp,t}$).

For the peeled shrimp equation, the coefficient on the import variable ($IMP_{qp,t}$) is statistically significant at the 10% level and of correct sign (Table 5.5). This implies that a 1 million pounds increase in peeled shrimp imports is associated with on average 0.0035 dollar per pound decline in domestic peeled shrimp prices.

Under certain conditions, the price flexibility is the reciprocal of the price elasticity. However, in most cases the price flexibility is the lower bound of the price elasticity since different variables are held constant under the equations defining the two measures (Tomek and Robinson, 1990). The peeled shrimp import flexibility is -0.1195 implying that 1% increase in import peeled shrimp is associated with 0.1195% decline in peeled shrimp wholesale prices. The finding that imports of peeled shrimp are substitutes for domestic...
peeled shrimp has some policy implications for the shrimp industry. Any shrimp import regulation policy will enhance or restrict the domestic wholesale shrimp price.

The relationship between domestic wholesale peeled shrimp prices and imports of peeled shrimp quantities can be characterized as price inflexible. Tomek and Robinson (1990) suggested that an inflexible price is consistent with an elastic demand; that is a small change in peeled shrimp import quantities has a large impact on domestic wholesale shrimp prices.

Table 5.5: Parameter Estimates for the Peeled Shrimp Wholesale Demand, 1973-1996

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Flexibility Coefficient</th>
<th>Standard Error</th>
<th>T-Statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>7.2278</td>
<td></td>
<td>0.6355</td>
<td>10.733</td>
<td>11.3730</td>
</tr>
<tr>
<td>DOM_{qp,t}</td>
<td>-0.0108</td>
<td>-0.1551</td>
<td>0.0068</td>
<td>-1.5670</td>
<td>0.1335</td>
</tr>
<tr>
<td>INV_{qp,t-1}</td>
<td>0.0190</td>
<td>0.0728</td>
<td>0.0260</td>
<td>0.732</td>
<td>0.4729</td>
</tr>
<tr>
<td>IMP_{qp,t}</td>
<td>-0.0035</td>
<td>-0.1195</td>
<td>0.0018</td>
<td>-1.926</td>
<td>0.0692</td>
</tr>
<tr>
<td>D83*</td>
<td>-1.5149</td>
<td>-0.1675</td>
<td>0.3451</td>
<td>-4.390</td>
<td>0.0003</td>
</tr>
</tbody>
</table>

* The D83 dummy variable is zero for the period 1973-1983 and 1 for the period 1983-1996.

The coefficient for D83 is significant at the 5% level and of correct sign. The wholesale peeled shrimp sector was heavily affected by the structural change that occurred in the industry in 1983. In fact, before 1983, supplies of peeled shrimp from India dominated U.S. imports. During that period, India exported a low quality product at lower
prices (Keithly, 1998). After 1983, shrimp farming expanded in the Asian and South American countries. As a result, large quantities of high quality peeled shrimp were targeted to the United States. The structural variable $D83$ captured that major shift in imports. The coefficient on $D83$ is statistically significant at the 5% level and negative. This implies that the structural change in the industry has led to a leftward shift (because it is a price dependent model) in U.S. wholesale demand for peeled shrimp. Consequently, shrimp wholesale prices are lower by $1.51$ per pound.

The coefficient of the inventory for peeled shrimp ($INV_{p,t-1}$) has the incorrect sign and is not significant. This may imply that shrimp processors are no longer using peeled shrimp inventories to speculate. Because shrimp are available year round, processors can cut their cost by holding fewer inventories from one period to another.

The coefficient for the domestically harvested and peeled shrimp ($DOM_{qp,t}$) is of correct sign, but is not statistically significant at the 10% level. The implications of this finding are that the wholesale peeled shrimp market is completely dominated by shrimp imports. Over time, domestic peeled shrimp have been replaced by imports of peeled shrimp.

**5.3.1.2.2. Headless Shell-On Shrimp Sector**

The headless shell-on shrimp model was specified as a price dependent equation with the wholesale headless-shell-on shrimp price ($DOM_{ph,t}$) as the endogenous variable, and the available supplies as exogenous variables. Available supplies include the domestically harvested headless shell-on shrimp quantities ($DOM_{qh,t}$), inventories of...
headless shell-on shrimp quantities ($INV_{qh,t-1}$) and imports of headless shell-on shrimp quantities ($IMP_{qh,t}$).

Although, the domestic headless shell-on coefficient is wrongly signed, it is statistically not significant at the 10 % level (Table 5.6). This implies that changes in domestic production of headless shell-on shrimp do not significantly affect headless shell-on shrimp prices. The cold storage holdings of peeled shrimp ($INV_{qh,t-1}$) coefficient is not statistically significant at the 10 % level and is not of correct sign. The fact that shrimp are available year-round diminishes the ability of shrimp processors to hold inventories for speculative purposes. This may explain the reason why inventories do not significantly impact the demand for U.S. headless shell-on shrimp.

Table 5.6: Parameter Estimates for the Headless Shell-On Shrimp Wholesale Demand, 1973-1996

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>Flexibility Coefficient</th>
<th>Standard error</th>
<th>T-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>7.5515</td>
<td>-</td>
<td>0.8942</td>
<td>8.444</td>
<td>0.0001</td>
</tr>
<tr>
<td>$DOM_{qh,t}$</td>
<td>0.0004</td>
<td>0.0058</td>
<td>0.0074</td>
<td>0.058</td>
<td>0.9541</td>
</tr>
<tr>
<td>$INV_{qh,t-1}$</td>
<td>0.0190</td>
<td>0.0892</td>
<td>0.0181</td>
<td>1.052</td>
<td>0.3051</td>
</tr>
<tr>
<td>$IMP_{qh,t}$</td>
<td>-0.0083</td>
<td>-0.3127</td>
<td>0.0019</td>
<td>-4.311</td>
<td>0.0003</td>
</tr>
</tbody>
</table>

The import coefficient of headless shell-on is statistically significant at the 5 % level and is of correct sign. A million pound increase in imports of headless shell-on shrimp
leads to a 0.0083 dollar per pound decrease in the domestic wholesale shrimp price. The relationship between domestic wholesale headless shell-on shrimp prices and imports of headless shell-on shrimp quantities can be characterized as price inflexible. The headless shell-on import flexibility is \(-0.3127\) implying that a percent increase in headless shell-on import quantities is associated with 0.3127 % decline in headless shell-on wholesale prices. Tomek and Robinson (1990) suggested that an inflexible price is consistent with an elastic demand. Therefore, a small change in headless shell-on import quantity has a large impact on domestic headless shell-on shrimp price. This finding indicates that any governmental regulation placed on imports of headless shell-on shrimp will restrict or enhance the domestic wholesale shrimp price. Consequently, processor revenues may be enhanced or reduced.

5.3.1.2.3. Breaded Shrimp Sector

The breaded shrimp model was specified as a price dependent equation with the wholesale breaded shrimp price \((DOM_{pb,t})\) as the endogenous variable and the available supplies as exogenous variables. Available supplies include domestically harvested and breaded shrimp quantities \((DOM_{qb,t})\), inventories of breaded shrimp quantities \((INV_{bt-1})\), and imports of breaded shrimp quantities \((IMP_{qb,t})\).

The domestic breaded shrimp quantity coefficient \((DOM_{qb,t})\) was statistically significant at the 5 % level and was of correct sign (Table 5.7). A one million-pound increase in breading activity of domestically harvested shrimp would lead to a 0.0623 dollar per pound decline in breaded shrimp prices. The domestic breaded shrimp activity is price flexible. A percent increase in domestic processed quantities is associated with a 1.5305 % decline in processed prices. Since the inverse of the price flexibility is the lower bound of 110...
the price elasticity, one can conclude that domestically harvested and breaded shrimp demand is price inelastic. The implications in terms of industry management are that any governmental regulation that will restrict the wholesale breaded shrimp demand will restrict wholesalers' receipts because of the inelastic demand curve they are facing.

The coefficient on inventories of breaded shrimp quantities (\( INV_{qb,t-1} \)) and imports of breaded shrimp quantities (\( IMP_{qb,t} \)) are not statistically significant at the 10% level. This implies that imports of breaded shrimp and cold storage holdings of breaded shrimp are not important factors that affect domestic demand of breaded shrimp. Regulation on imports of breaded shrimp will have little impact on U.S. wholesale demand for breaded shrimp. This result is expected because little breaded shrimp is imported to the U.S. market. Most U.S. imports are headless shell-on shrimp, whole shrimp or peeled shrimp.

Table 5.7: Parameter Estimates for the Breaded Shrimp Wholesale Demand, 1973-1996

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>Flexibility coefficient</th>
<th>Standard error</th>
<th>T-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>11.0777</td>
<td>-</td>
<td>0.9846</td>
<td>11.250</td>
<td>0.0001</td>
</tr>
<tr>
<td>( DOM_{qb,t} )</td>
<td>-0.0623</td>
<td>-1.5305</td>
<td>0.0082</td>
<td>-7.592</td>
<td>0.0001</td>
</tr>
<tr>
<td>( INV_{qb,t-1} )</td>
<td>0.1107</td>
<td>0.1003</td>
<td>0.0844</td>
<td>1.311</td>
<td>0.2048</td>
</tr>
<tr>
<td>( IMP_{qb,t} )</td>
<td>0.1496</td>
<td>0.0231</td>
<td>0.2073</td>
<td>0.722</td>
<td>0.4788</td>
</tr>
</tbody>
</table>
5.3.1.2.4. "Other" Shrimp Sector

The "other" shrimp model was specified as a price dependent equation with the wholesale "other" shrimp price ($DOM_{pc,t}$) as the endogenous variable and the available supplies as exogenous variables. Available supplies include the domestic "other" shrimp quantities ($DOM_{qc,t}$) and the imports of "other" shrimp quantities ($IMP_{qc,t}$). Processors do not hold inventories of "other" shrimp. Consequently, that variable is not included in the model.

Table 5.8: Parameter Estimates for the "Other" Shrimp Wholesale Demand, 1973-1996

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>Flexibility coefficient</th>
<th>Standard error</th>
<th>T-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>7.4643</td>
<td>-</td>
<td>0.5138</td>
<td>14.527</td>
<td>0.0001</td>
</tr>
<tr>
<td>$DOM_{qc,t}$</td>
<td>0.0074</td>
<td>0.0136</td>
<td>0.0191</td>
<td>0.388</td>
<td>0.7023</td>
</tr>
<tr>
<td>$IMP_{qc,t}$</td>
<td>-0.0342</td>
<td>-0.0970</td>
<td>0.0162</td>
<td>-2.110</td>
<td>0.0470</td>
</tr>
</tbody>
</table>

The coefficient on domestic "other" shrimp is not statistically significant at the 10 % level (Table 5.8). However, the coefficient on imported "other" shrimp quantities is significant at the 10 % level. A one million pound increase in the import of "other" shrimp leads to a 0.0342 dollar per pound decrease in the domestic price. The flexibility coefficient is -0.0970, meaning that a 10 % increase in "other" shrimp import quantities is associated with 0.97 % decline in wholesale "other" shrimp prices. Since the inverse of the price flexibility is the lower bound of the price elasticity, one can conclude that the relationship...
between imports for “other” shrimp and its domestic wholesale price is elastic. This implies that import restrictions will affect wholesale processor receipts in the following way: a tariff will put a downward pressure on imported shrimp quantities and an upward pressure on domestic wholesale “other” shrimp prices. Consequently, domestic processors’ revenues will increase.

5.3.1.3. Ex-Vessel Demand

The ex-vessel demand model was specified as a price dependent equation with the dockside raw shrimp price \( P_{raw,t} \) as the endogenous variable and the available supplies as exogenous variables. Available supplies include inventories of peeled shrimp \( INV_{qp,t-1} \), inventories of headless shell-on shrimp \( INV_{qh,t-1} \), quantities of peeled shrimp imported \( IMP_{qp,t} \), quantities of headless shell-on shrimp imported \( IMP_{qh,t} \), and U.S. Gulf and South Atlantic shrimp landings \( LAND_t \).

The raw shrimp price is not statistically affected by inventories of headless shell-on shrimp \( INV_{qh,t-1} \) and the inventories of peeled shrimp \( INV_{qp,t-1} \) (Table 5.9). Because shrimp is available year round, processors are holding fewer inventories to minimize their costs. Surprisingly, peeled shrimp import quantities have no impact on shrimp dockside prices. Imports of peeled component included shrimp of different quality and size. Consequently, it is suspected that the domestic market absorbs the domestic peeled shrimp without affecting raw shrimp prices. Peeled shrimp are purchased and placed in storage or processed (for breaded shrimp for example) and then stored or placed into the marketing channels. In the long run, when inventory facilities, processing and other facilities are fully utilized, raw prices will adjust through a leftward shift in the demand.
The coefficient associated with headless shell-on imported shrimp ($IMP_{qh,t}$) is statistically significant at the 5% level and of the correct sign. This implies that headless shell-on shrimp imports have a significant negative impact on dockside raw shrimp prices. Since headless shell-on includes large sized shrimp, an increase in its imports will lower its prices. Consequently, demand for the headless shell-on will increase. This may indirectly affect the raw shrimp market by depressing the ex-vessel price. A million pound increase in the imports of headless shell-on shrimp will cause ex-vessel raw shrimp prices to drop by 0.0035 dollar per pound. The relationship between imports of headless shell-on shrimp quantities and ex-vessel raw shrimp prices can be characterized as inflexible meaning that a 1% increase in headless shell-on import quantities result in a 0.0173% decline in shrimp ex-vessel price.

Table 5.9: Impacts of Inventories, Landings and Imports on the U.S. Raw Shrimp Ex-Vessel Prices, 1973-1996.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter estimate</th>
<th>Flexibility coefficient</th>
<th>Standard error</th>
<th>T-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.8155</td>
<td>-</td>
<td>0.5968</td>
<td>8.068</td>
<td>0.0001</td>
</tr>
<tr>
<td>$INV_{qh,t-1}$</td>
<td>0.0028</td>
<td>0.0151</td>
<td>0.0079</td>
<td>0.347</td>
<td>0.7327</td>
</tr>
<tr>
<td>$INV_{qp,t-1}$</td>
<td>-0.0186</td>
<td>-0.0696</td>
<td>0.0111</td>
<td>-1.678</td>
<td>0.1107</td>
</tr>
<tr>
<td>$LAND_t$</td>
<td>-0.0039</td>
<td>-0.1831</td>
<td>0.0018</td>
<td>-2.188</td>
<td>0.0421</td>
</tr>
<tr>
<td>$IMP_{qh,t}$</td>
<td>-0.0035</td>
<td>-0.0173</td>
<td>0.0010</td>
<td>-3.573</td>
<td>0.0022</td>
</tr>
<tr>
<td>$IMP_{qp,t}$</td>
<td>-0.0004</td>
<td>-0.0133</td>
<td>0.0008</td>
<td>-0.475</td>
<td>0.6402</td>
</tr>
</tbody>
</table>
The South Atlantic and Gulf of Mexico raw shrimp landings ($LAND_t$) coefficient is statistically significant at the 5% level and has the correct sign. A million-pound increase in raw shrimp landings is associated with a 0.0039 decline in shrimp ex-vessel prices. The relationship is price inflexible since a 1% increase in South Atlantic and Gulf of Mexico landings induces a 0.1831% drop in the shrimp ex-vessel prices.

5.3.1.4. Price Linkage Model

The price linkage model was specified as a price dependent model with the shrimp retail price ($P_{proc,t}$) as the endogenous variable. The independent variables are the domestic wholesale prices of peeled shrimp ($DOM_{pp,t}$), headless shell-on shrimp ($DOM_{ph,t}$), breaded shrimp ($DOM_{pb,t}$), "other" shrimp ($DOM_{pc,t}$), and the South Atlantic and Gulf of Mexico ex-vessel price for raw shrimp ($P_{raw,t}$).

Empirical estimates indicate that shrimp retail prices were very sensitive to changes in wholesale peeled shrimp prices. The coefficient on $DOM_{pp,t}$ is statistically significant at the 5% level and of correct sign. A dollar increase in the price of domestic peeled shrimp yields a 0.1927 dollar per pound increase in shrimp retail prices (Table 5.10). Peeled shrimp is a low cost processing activity. Therefore, one can reasonably understand why the markup is about 19 cents per pound. Because this markup is less than one dollar, the retailers' margin can be characterized as decreasing over time.

Retail shrimp prices are responsive to changes in wholesale headless shell-on shrimp prices. The coefficient on $DOM_{ph}$ is statistically significant at the 5% level and of correct sign. A dollar increase in wholesale headless shell-on shrimp ceteris paribus is associated with a 0.5721 dollar per pound increase in retail shrimp prices. Headless shell-on
shrimp prices more strongly affect retail prices when compared with the impact of peeled shrimp prices. The higher margin associated with the headless shell-on shrimp may be explained by the fact that this product form includes larger sized shrimp than the peeled form product. Hence, one may expect the markup on the headless shell-on shrimp to be bigger than the margins on the peeled shrimp because of its high wholesale and retail prices.

Table 5.10: Price Linkages Between Retail, Wholesale and Ex-Vessel Sectors of the Southeastern U.S. Region Shrimp Industry, 1973-1996

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>Flexibility Coefficient</th>
<th>Standard Error</th>
<th>T-Statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.4846</td>
<td>-</td>
<td>0.1708</td>
<td>-2.840</td>
<td>0.0109</td>
</tr>
<tr>
<td>$DOM_{pp}$</td>
<td>0.1927</td>
<td>0.1882</td>
<td>0.0389</td>
<td>4.954</td>
<td>0.0001</td>
</tr>
<tr>
<td>$DOM_{ph}$</td>
<td>0.5753</td>
<td>0.6612</td>
<td>0.0672</td>
<td>8.565</td>
<td>0.0001</td>
</tr>
<tr>
<td>$DOM_{pb}$</td>
<td>0.4216</td>
<td>0.3592</td>
<td>0.0342</td>
<td>12.335</td>
<td>0.0001</td>
</tr>
<tr>
<td>$DOM_{pc}$</td>
<td>-0.0021</td>
<td>-0.0027</td>
<td>0.0218</td>
<td>-0.098</td>
<td>0.9233</td>
</tr>
<tr>
<td>$P_{raw}$</td>
<td>-0.2367</td>
<td>-0.1162</td>
<td>0.1308</td>
<td>-1.550</td>
<td>0.1385</td>
</tr>
</tbody>
</table>

Empirical estimates indicate that the retail shrimp price is also responsive to changes in wholesale breaded shrimp prices. The coefficient on $DOM_{pb}$ is statistically significant at the 5% level and of correct sign. A dollar increase in wholesale breaded shrimp prices ceteris paribus is associated with 0.4216 dollar per pound increase in shrimp
retail prices. Usually, peeled shrimp is further processed into breaded shrimp. Therefore, the markup is higher than for peeled shrimp, but lower than the markup on the headless shell-on product. The markups on "other" shrimp and raw shrimp were not statistically significant at the 10% level.

5.3.2. Reduced Form Estimates and Impact Multiplier Analyses

By solving the system of equations for the endogenous variables as a function of the predetermined variables, one can obtain the reduced-form equations. The reduced-form coefficients describe the total effect of a change in a predetermined variable on the value of an endogenous variable, after taking into consideration all the interdependencies among the jointly determined variables (Doll 1971). All relationships specified in the structural model are preserved in the reduced form. The following section will discuss the various reduced-form equations and the different implications that may be drawn from them. As in the previous section, the discussion will be carried out in terms of sector and product form.

Predictions of the jointly determined variables within the system can be compared to the observed values. This procedure allows the investigator to verify how well the model conforms to reality. In the shrimp model, the amount of variation that can be explained by the reduced-form equations are 99% for the retail demand for shrimp, 81% for the wholesale demand for peeled shrimp equation, 64% for the wholesale demand for headless shell-on shrimp equation, 77% for the wholesale demand for breaded shrimp equation, 26% for the wholesale demand for the "other" shrimp equation, 52% for the South Atlantic and Gulf of Mexico ex-vessel shrimp demand, and 85% for the price
linkage-model (Table 5.11). Except for the "other" shrimp, the reduced-form equations predict the actual data well.

Goldberg (1964) and Doll (1972) referred to the reduced-form coefficients as the impact multipliers. When there are no lagged variables in the estimated reduced-form, the impact multipliers measure the changes in the endogenous variables resulting from a unit change in the exogenous variables in the same year. These multipliers are called "contemporaneous responses." The impact multipliers and their effects on the U.S. shrimp industry are discussed in the following sections.

To analyze the impact of income change on U.S. shrimp per capita consumption, shrimp prices and consumer tastes and preferences are held constant. The points of tangency between the U.S shrimp consumer indifference curves and the consumer budget lines will form the income per capita consumption curve. From this curve, an Engel curve, which shows how shrimp per capita consumption rate varies at different income levels, can be derived. Since shrimp prices, tastes and preferences are held constant, the consumer budget lines will shift in parallel to proportionate changes in income. Shift in consumer budget lines will result in parallel shifts in the consumer shrimp demand curve. If shrimp are normal goods, the increase in consumer incomes will lead to an increase in shrimp per capita consumption. In contrast, if shrimp are inferior goods, the increase in consumer income will lead to a decrease in shrimp per capita consumption.

Results show that a $100 increase in U.S. per capita disposable income ($y_{disp,p}$) is associated with a small change in U.S. shrimp per capita consumption. A closer look at the U.S. per capita disposable income trend reveals that between 1973 and 1996, this variable increased from $16,120 to $21,117. The average annual increase in the per capita disposable income is $217. The average change in U.S. shrimp per capita consumption
Table 5.11: Reduced Form Estimates for the Southeastern U.S. Shrimp Industry Model (1973-1996).

<table>
<thead>
<tr>
<th>Variables</th>
<th>$Q_{dd,t}$</th>
<th>$DOM_{pp,t}$</th>
<th>$DOM_{ph,t}$</th>
<th>$DOM_{pb,t}$</th>
<th>$DOM_{pc,t}$</th>
<th>$P_{raw,t}$</th>
<th>$P_{proc,t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{disp,t}$</td>
<td>0.0001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat$P_{t}$</td>
<td>1.557</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish$PPI_{t}$</td>
<td>0.8357</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chick$P_{t}$</td>
<td>-0.3350</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$DOM_{qp,t}$</td>
<td>0.0005</td>
<td>-0.0108</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.0021</td>
</tr>
<tr>
<td>$INV_{qp,t-1}$</td>
<td>-0.0020</td>
<td>0.0190</td>
<td></td>
<td></td>
<td>-0.0186</td>
<td>0.0081</td>
<td></td>
</tr>
<tr>
<td>$IMP_{qp,t}$</td>
<td>0.0001</td>
<td>-0.0035</td>
<td></td>
<td></td>
<td>-0.0004</td>
<td>-0.0006</td>
<td></td>
</tr>
<tr>
<td>$D83$</td>
<td>0.0734</td>
<td>-1.5149</td>
<td></td>
<td></td>
<td>-0.2920</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$DOM_{qh,t}$</td>
<td>-0.0001</td>
<td></td>
<td>0.0004</td>
<td></td>
<td></td>
<td></td>
<td>0.0002</td>
</tr>
<tr>
<td>$INV_{qh,t-1}$</td>
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<td>0.0190</td>
<td></td>
<td>0.0028</td>
<td>0.0103</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$IMP_{qh,t}$</td>
<td>0.0010</td>
<td>-0.0083</td>
<td></td>
<td>-0.0035</td>
<td>-0.0039</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$DOM_{qb,t}$</td>
<td>0.0066</td>
<td></td>
<td>-0.0623</td>
<td>-0.0263</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$INV_{qb,t-1}$</td>
<td>-0.0117</td>
<td></td>
<td>0.1107</td>
<td>0.0467</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$IMP_{qb,t}$</td>
<td>-0.0159</td>
<td></td>
<td>0.1496</td>
<td>0.0631</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$DOM_{qc,t}$</td>
<td>0.00001</td>
<td></td>
<td></td>
<td>0.0074</td>
<td>-0.0004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$IMP_{qc,t}$</td>
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<td>-0.0342</td>
<td></td>
<td>0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Land_{t}$</td>
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<td></td>
<td></td>
<td></td>
<td>-0.0039</td>
<td>0.0009</td>
<td></td>
</tr>
</tbody>
</table>

can be found by multiplying the reduced-form coefficient of income from Table 5.11 (0.0001) by the yearly average change in income ($217). The outcome is an annual increase of 0.0217 pound of per capita shrimp consumed domestically. This implies that changes in
U.S. per capita disposable income are associated with rightward shift in demand for shrimp.

Most studies conducted before the 1980s support the hypothesis that shrimp is income elastic (absolute value of elasticity is greater than one). However, later studies challenge the findings. To illustrate, one can cite Doll's study (1972), which reported an income elasticity of 1.12. The investigator assumed that although shrimp had grown in popularity in the United States, it remained more costly than red meat, poultry or other seafood products. This explained why the per capita consumption of shrimp was thought to be relatively elastic with regard to changes in income (United States International Trade Commission, 1985). However, Roberts et al. (1982) found an elasticity of demand with respect to restaurant expenditures of 0.42. Hu (1983) reported an income elasticity of 0.73. The results of this current study are consistent with the more recent findings. The demand elasticity with respect to income is found to be 0.9385, and can be characterized as inelastic. This finding implies that a percentage increase in U.S. per capita disposable income is associated with 0.9385 % increase in U.S. shrimp per capita consumption.

The inelasticity of shrimp demand with respect to disposable income can be explained by structural changes that have occurred in the shrimp industry, changes that were not accounted for in previous studies (United States Trade Commission, 1985). In support of the finding that shrimp demand is income inelastic, some shrimp industry representatives argue that shrimp is no longer a “luxury” good. New generations of seafood dinner-houses and restaurants offer moderately-priced seafood to broader categories of consumers at more convenient locations (particularly suburban locations), with shrimp as a main part of the menu (United States Trade Commission, 1985). Additionally, many non-seafood restaurants have included shrimp on their menus because
it is available year round. In conclusion, one can argue that the structural changes in the industry have made the relationship between shrimp demand and consumer income less elastic.

An important question to ask is the extent to which shrimp demand is responsive to changes in the price of red meat, fish or chicken products. From 1973 to 1996, the price of red meat declined from $3.17 to $2.80 per pound. On average, red meat prices fell $0.01609 per pound every year. Multiplying the average drop in red meat prices by its impact multiplier (1.1557) yields a 0.0186 pound drop in shrimp per capita consumption per year due to the substitution effect between shrimp and red meat. Different fish products also seem to be substitute for different shrimp products. From 1973 to 1996 the fish price index increased yearly by 0.03174 units. Multiplying this value by the fish impact multiplier (0.8357) yields a 0.0265 pound annual increase in shrimp per capita consumption due to substitution effect between shrimp products and fish products. Chicken retail prices declined by a yearly average of 0.0087 dollars a pound between 1973 and 1996. Consequently, U.S. shrimp per capita consumption increased by 0.0029 pound a year. However, this result is not significant because our investigation indicated that poultry products do not have any effect on shrimp products.

Actual data indicate that domestic quantities of peeled shrimp rose by 3 million pounds a year. The impact of this increase on U.S. shrimp per capita consumption can be obtained by multiplying 3 million pounds by its corresponding impact multiplier from different shrimp sectors. The results are:

\[ Q_{dd,t} = 0.0005 \times 3 = 0.0015 \text{ pound} \]

\[ DOM_{pp,t} = -0.0108 \times 3 = -0.0324 \text{ dollars per pound} \]
The 3 million-pound yearly increase in peeled shrimp quantities led to a drop of 32 and 6 cent in wholesale and retail prices. This implies that the margin between the retailers, and the processor is widening. Therefore, the retailer benefited from the increase in peeled shrimp production. The effect of peeled shrimp on U.S. per capita consumption is larger than what we just calculated. In fact, with the structural change (D83) that occurred in the industry, the following impact can be isolated. After 1983, with the increase in imported peeled shrimp, U.S. per capita consumption rose by 0.0734 pound in 13 years (1983-1996). Consequently, the wholesale domestic prices of peeled shrimp were lower by 1.5 dollars per pound. The retail price of peeled shrimp was also lower by 0.2920 dollar per pound.

The rate of commodity substitution (RCS) between imported peeled shrimp and domestic peeled shrimp is defined as the rate at which shrimp consumers are willing to substitute domestic peeled shrimp for imported peeled shrimp per unit of imported shrimp to maintain the same level of utility or satisfaction. The rate of commodity substitution can be obtained using the following formula:

\[
RCS = -\frac{\partial Q_{dd,t}}{\partial Q_{dp,t}} = -\frac{\partial Q_{dd,t}}{\partial D_{dd,t}} = -\frac{0.0001}{0.0005} = -0.20
\]

In the U.S. shrimp industry, consumers are giving up 0.20 units of domestic peeled shrimp for every additional unit of peeled imported shrimp. In other words, imports of peeled shrimp are replacing domestic peeled shrimp at a rate less than one. This rate of commodity substitution could be higher if we include the change in shrimp imports due to

\[
P_{proc,t} = -0.0021*3 = -0.0063 \text{ dollars per pound}
\]
structural changes in the industry. Positive changes in domestic processing activity also affect the wholesale and the retail sectors.

Imports of peeled shrimp increased by 10.42 million pounds per year from 1973 to 1996. The impact of that increase on the U.S. shrimp sector can be obtained by multiplying the corresponding coefficients of the reduced-form equations by 10.42. The results are:

\[ Q_{dd,t} = 0.00001 \times 10.42 = 0.0010 \text{ million pounds} \]
\[ DOM_{pp,t} = -0.00035 \times 10.42 = -0.0365 \text{ dollars per pound} \]
\[ P_{raw,t} = -0.0004 \times 10.42 = -0.0042 \text{ dollars per pound} \]
\[ P_{proc,t} = -0.0006 \times 10.42 = -0.0063 \text{ dollars per pound}. \]

The above results indicate that the 10.42 million pounds annual rise in peeled shrimp imports led to a 0.0365 dollar per pound drop in wholesale peeled shrimp prices, a 0.0042 dollar per pound decline in raw shrimp prices, and a 0.0063 dollar decrease in retail shrimp prices. Because of these lower prices, shrimp per capita consumption increased at a rate of 0.0010 pound per year. The result implies that the growth in peeled shrimp imports has a greater effect on the wholesale sector than on the retail or ex-vessel sectors.

Analysis of actual data suggested that inventories of headless shell-on shrimp declined at a rate of 1.6 million pounds per year. The effect of this decline on the shrimp sector is:

\[ Q_{dd,t} = -0.0026 \times 1.6 = 0.0042 \text{ pound} \]
\[ DOM_{ph,t} = 0.0190 \times 1.6 = -0.0304 \text{ dollars per pound} \]
\[ P_{raw,t} = 0.0028 \times 1.6 = -0.0045 \text{ dollars per pound} \]
\[ P_{proc,t} = 0.0103 \times 1.6 = -0.0165 \text{ dollars per pound}. \]
Actual data suggested that cold storage holdings of headless shell-on shrimp declined on average at a rate of 1.6 million pounds a year. The impact of a drop in headless shell-on inventories on the shrimp industry led to lower shrimp prices in other shrimp sectors. Additionally, domestic per capita consumption increased by 0.0042 pound a year. Here again, changes in shrimp inventories affect the wholesale sector more than the retail and the ex-vessel sectors.

Actual data revealed that imports of headless shell-on shrimp increased at an annual rate of 8.48 million pounds between 1973 and 1996. The impact of rising imports on the shrimp sector can be traced as follows:

\[ Q_{dd,t} = 0.0010 \times 8.4782 = 0.0085 \text{ pound a year} \]

\[ DOM_{ph,t} = -0.0083 \times 8.4782 = -0.0704 \text{ dollars per pound} \]

\[ P_{raw,t} = -0.0035 \times 8.4782 = -0.0297 \text{ dollars per pound} \]

\[ P_{proc,t} = -0.0039 \times 8.4782 = -0.03306 \text{ dollars per pound} \]

The above results indicate that an annual growth in headless shell-on imports of 8.4782 million pounds results in a 0.0704 dollar per pound drop in wholesale peeled shrimp prices, a 0.0297 dollar per pound decline in raw shrimp prices, and a 0.03306 dollar decrease in shrimp retail prices. Because of lower prices, shrimp per capita consumption rose at a rate of 0.0085 pound a year. The increase in headless shell-on shrimp imports affects the wholesale sector more than the retail and ex-vessel sectors.

The rate of commodity substitution between imported headless shell-on shrimp for domestically processed headless shell-on shrimp can be obtained using the following formula:
\[ RCS = -\frac{\partial Q_{dd,t}}{\partial IMP_{qh,t}} = \frac{-0.0001}{0.0010} = -0.1000 \]

In the U.S. shrimp industry, consumers give up 0.1000 units of domestic headless shell-on shrimp for every additional unit of imported headless shell-on shrimp. In other words, imports of headless shell-on shrimp are replacing domestic peeled shrimp in per capita consumption at a rate less than one.

Actual data on breaded shrimp product indicates that on average domestic quantities remained constant. Consequently, the effect of domestic breaded shrimp on the shrimp sector can be considered negligible. However, the inventories of breaded shrimp yearly declined by 0.25878 million pounds. Consequently, the impact of the decline on the shrimp sector is:

\[ Q_{dd,t} = -0.0117*(-0.25878) = 0.003 \text{ pound per year} \]

\[ DOM_{pb,t} = 0.1107*(-0.25878) = -0.0286 \text{ dollars per pound} \]

\[ P_{proc,t} = 0.0467*(-0.25878) = -0.0121 \text{ dollars per pound} \]

Additionally, breaded shrimp imports declined by a yearly average of 0.01394 million pounds. The effects of that decline on the shrimp sectors is

\[ Q_{dd,t} = -0.0159*(-0.01394) = 0.0002 \text{ pound per year} \]

\[ DOM_{pb,t} = 0.1496*(-0.01394) = -0.0021 \text{ dollars per pound} \]

\[ P_{proc,t} = 0.0631*(-0.01394) = -0.0009 \text{ dollars per pound} \]

To sum up, one can argue that the effects of breaded shrimp on the industry are almost insignificant.
The domestic quantities of "other" shrimp declined yearly by 1.5154 million pounds. This translates into the following effects

\[ Q_{dt,t} = 0.00001 \times (-1.5154) = -0.00001 \text{ million pounds} \]

\[ DOM_{pc,t} = 0.0074 \times (-1.5154) = -0.0112 \text{ dollars per pound} \]

\[ P_{proa} = -0.00004 \times (-1.5154) = -0.00006 \text{ dollars per pound} \]

Imports of "other" shrimp declined yearly by 0.15463 million pounds which translates into

\[ Q_{dd,t} = -0.00001 \times (-0.15463) = 0.000001 \text{ pound per year} \]

\[ DOM_{pc,t} = -0.0074 \times (-0.15463) = 0.0053 \text{ dollars per pound} \]

\[ P_{proc,i} = 0.00004 \times (-0.15463) = -0.00002 \text{ dollars per pound} \]

Clearly, one can see that the decrease in the per capita consumption due to decline in the domestic "other" shrimp is not offset by the increase in the imports of "other" shrimp.

The South Atlantic and the Gulf of Mexico raw shrimp landings increased in average by 4.82609 millions pounds a year between 1973 and 1996. The impact of that increase on the shrimp sector is

\[ Q_{dd,t} = -0.0002 \times (4.82609) = -0.0010 \text{ pound per year} \]

\[ P_{raw,t} = -0.0039 \times (4.82609) = -0.0188 \text{ dollars per pound} \]

\[ P_{proc,i} = 0.0009 \times (4.82609) = 0.00483 \text{ dollars per pound} \]
The increases in shrimp per capita consumption due to changes of domestic shrimp harvest are small. This result combined with the other findings seems to indicate that the shrimp industry is dominated by imports.

5.4. The Impact of the Processor Margin on Firm Size Distribution

Padberg (1962) and Disney et al. (1988) have described the conditions under which a Markov process is appropriate for modeling structural change in an industry. If environmental factors dictate a general type of structural development in an industry, the Markov model may be useful in approximating the development pattern. Low entry when the industry is young and correspondingly higher rates of entry later characterize this type of industry. Soon, however, barriers to entry exist in that prospective entrants may be handicapped by scale economies, lack of experience, and inadequate financing. Hence few firms enter after the “start-up” period. Instead, competition among existing firms, typically in the form of rivalry in technical progress, results in declining firm numbers. Successful innovators expand, while firms which are unsuccessful in adopting new technology become weak and drop out. Thus, if firm growth is at least partly due to technical innovation, Padberg (1962) concludes that the Markov model may be used to model the impact of economic factors on the firm size distribution.

It seems highly likely that the conditions described by Padberg (1962) and Disney et al. (1988) are applicable to the shrimp processing industry. Recall that the industrial organization (IO) paradigm stipulates that the market structure faced by a firm dictates its conduct and performance. The basic components of the model include strategic key variables, such as the availability of raw materials, product durability, business attitude, price elasticity, presence or absence of substitute products, and rate of sales or company

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growth. The IO therefore includes the impact of distinct public policies on firm strategies. Among the policies are tax and subsidy regimes, international trade rules, various other regulations, price controls, antitrust laws and information provisions. Besides the basic components and the public policies that define the firm environment, the I.O. model specifically examines:

1. The market structure by focusing on the number of sellers and buyers present in the market place, the barriers to the entry of new firms, product differentiation, vertical integration, and product diversification;

2. The conduct of different firms within a market structure by examining the firm’s pricing behavior, its product choice and advertising, research and innovation, plant investment, legal tactics, and firm collusion, mergers and contracts; and,

3. The performance of firms as impacted by their conduct where production and allocative efficiency, technical progress, full employment and equity moderate the firm’s performance.

Given the IO framework as explained in the previous section, the shrimp processor’s environment (imports and domestic production) affects the structure and conduct of the shrimp industry through the pricing mechanisms. Using the Markov chain analysis, this section will investigate the impact of industry performance on firm size distribution.

5.4.1. The Markov Model Estimates

The predicted prices for processed shrimp products, obtained from the estimated model, were compared to the predicted prices for raw shrimp. Results indicated that the processor margins declined by 56% for peeled shrimp, 30% for headless shell-on product and 39% for breaded shrimp. “Other” shrimp is the only product that showed a widening
in margin. The overall processor margins for the four product, declined by 35%. The results from previous sections indicated that processor margins narrowed also because of the increase in shrimp imports. This section will present the impact of the changes in processor margins on the shrimp processing firm size distribution. Figure 5.8 presents the overall predicted margins and their relationships with the number of firms in the processing sector.

Figure 5.8 indicates that the number of firms declined from 181 in 1973 to 97 in 1996. The hypothesis is that increasing imports have reduced processor margins, causing the size distribution to change. We assume that processing firms can be grouped into four categories according to their total yearly shrimp sales. The first group, size zero, is the “entry / exit” category. It includes firms that can potentially process shrimp or exit the processing activities at any given time period. The second group, size one, includes firms that average less than $1 million a year in shrimp sales. The third group, size two, encompasses firms with yearly shrimp sales ranging between $1 million and $10 million. The last group, size three, includes firms that average an annual shrimp sale above $10 million.

The impact of changes in processor margins on the firm size distribution can be analyzed by estimating a multinomial logit model using the above grouping. The first step in the modeling involves the construction of transition matrices. The different transition matrices are presented in Tables A1 to A22 (Appendix A). From those transition matrices, transition probability matrices were obtained (Tables B1 to B22 - Appendix B). The transition probability matrices represent the dependent variables in the multinomial logit model. The independent variable is the difference in processor margins between two
Figure 5.8: Number of Firms and Processors Margins for the Southeastern United States Shrimp Processing Industry, 1973-1996
consecutive periods. The processor margin is the predicted value of retail shrimp prices minus the predicted value of the raw shrimp price obtained from the reduced form equations discussed in the previous section.

5.4.2. Results and Discussion

5.4.2.1. Testing for Non-stationarity

A discrete time Markov chain is said to be stationary if the probability of moving from one state to another state is independent of the time at which the step is being made (Isaacson and Madson, 1976). That is for all states i and j,

\[ P(X_{k+1} = j | X_k = i) \]

for \( k=-(n-1), -(n-2), \ldots, 1,0,1,2, \ldots \). The Markov chain is said to be non-stationary if the condition for stationarity fails. Isaacson and Madson (1976) give the following example of a stationarity process. Assume a machine is producing items independently at a rate of one a minute. Let \( n \) denote the number of defectives items produced by time \( n \). If the probability of producing a defective item remains constant throughout the life of the machine, then \( n \) would be a stationary Markov chain. However, if the probability of producing a defective item changes, as the machine grows older, then the Markov chain would be nonstationary.

To test the null hypothesis of stationarity, we first run the model with a constant as an independent variable and the transition probabilities as a dependent variable and obtain the log likelihood function estimate (\( \text{LnL}_0 \)). Second, we run the model with the transition probability as the dependent variables and the economic variables in our case the margins as independent variables and obtain the log likelihood function (\( \text{LnL} \)). The stationarity test is
\[-2 \log \lambda = 2(LnL - LnL_0)\]

This test is distributed as $\chi^2$, with $\nu = (K - 1)$ degrees of freedom, with $K$ being the number of restrictions. The null hypothesis is rejected when the value of the Chi-square for the sample period is greater than the tabulated value of the Chi-square. Consequently, one can conclude that the estimated probabilities change from one period to another. The log of the likelihood function of the unrestricted (nonstationary) model is $-92.94017$, while that of the restricted (stationary) model is $-102.6048$. The Chi-square statistic is $19.32$. With four restrictions, the Chi-square, corresponding to the rejection region at alpha equals $0.05$, is $7.81$. The null hypothesis of stationarity is rejected and one can conclude that the transition probabilities vary over time.

### 5.4.2.2. Results

The number of firms in different size categories is expected to decrease with a decrease in the margins. Table 12, which displays the results of the Markov model, indicates that a decrease in processor margins is significantly associated with a change in the industry transition probabilities. In the multinomial logit model, the nonlinearity of the relationship between $P(Y=1)$ and the margins is less straightforward.

Care must be taken in interpreting the coefficients of the transition probabilities, because they do not directly measure the impact of prices (margins in this case) on the transition probabilities and the number of firms (Zepeda, 1995). An alternative would be to examine the predicted probabilities from the model that are presented in the five first columns of Table 13.

Results indicate that the chances of a firm exiting the industry $P(Y=0)$ and the chances of a firm remaining in size category 1 $P(Y=1)$ increase with time as processor

<table>
<thead>
<tr>
<th>Label</th>
<th>Estimate</th>
<th>T-statistics</th>
<th>Probabilities</th>
</tr>
</thead>
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<tr>
<td>P(Y=1)</td>
<td>0.9681</td>
<td>4.104</td>
<td>0.0000</td>
</tr>
<tr>
<td>P(Y=2)</td>
<td>0.8786</td>
<td>3.696</td>
<td>0.0002</td>
</tr>
<tr>
<td>P(Y=3)</td>
<td>0.6879</td>
<td>2.822</td>
<td>0.0048</td>
</tr>
</tbody>
</table>

Margins decrease, the chances of firms staying in size category 2 \( P(Y=2) \) and the chances of firms staying in size category 3 \( P(Y=3) \) increase. We were expecting firm size to decline with the narrowing of the processor margins.

The reasons for those discrepancies can be explained by the fact that the different probabilities for one time period must be positive and sum to one. If two probabilities are increasing, one or both of the two remaining probabilities must decline or be equal to zero. Consequently, the sign of the coefficients presented in Table 5.12 and the results discussed above are not sufficient to determine the direction of change of the corresponding probabilities. Figures 5.9 to 5.11 present the actual versus the predicted probabilities of firms falling in categories 1 to 3.

A more practical view of the behavior of the multinomial logit is one that focuses not on the probabilities themselves but rather on their ratios (Aldrich and Nelson, 1984), that is the odds of one event occurring relative to another. The odds of the event \( Y=1 \) occurring relative to the event \( Y=2 \), is given by
Table 5.13 Predicted Probabilities from the Markov Model of the United States Southeastern Region Shrimp Processing Industry (1973-1996)

<table>
<thead>
<tr>
<th>Label</th>
<th>P0</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P0/P1</th>
<th>P0/P2</th>
<th>P0/P3</th>
<th>P1/P2</th>
<th>P1/P3</th>
<th>P2/P3</th>
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<tr>
<td>73-74</td>
<td>0.02352</td>
<td>0.44624</td>
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<td>0.19036</td>
<td>0.05270</td>
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<td>0.45836</td>
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Figure 5.9: Actual versus Predicted Probability for Firms Entering the Size Category 1 in the Southeastern United States Shrimp Processing Industry, 1973-1996
Figure 5.10: Actual versus Predicted Probability for Firms Entering or Staying in the Size Category 2 in the Southeastern United States Shrimp Processing Industry, 1973-1996
Figure 5.11: Actual versus Predicted Probability for Firms Entering or Staying in the Size Category 3 in the Southeastern United States Shrimp Processing Industry, 1973-1996
\[
\frac{P(Y = 1)}{P(Y = 2)} = \frac{\exp\left(\sum \beta_{1k} X_k^*\right)}{\exp\left(\sum \beta_{2k} X_k^*\right)} = \exp\left[\sum (\beta_{1k} - \beta_{2k}) X_k^*\right]
\]

It is useful to examine these odds as the exogenous variable changes. Since the function \(\exp(.)\) increases as its argument ascends the difference in the two coefficients alone determines the direction of the changes (Aldrich and Nelson, 1984). Consider the alternative of firms moving from size 1 to size 2 given the changes in processor margins. If the difference in the two relevant coefficients, \(\beta_{1k} - \beta_{2k}\), is positive, then increases in the margins will raise the likelihood of observing alternative 1 rather than 2. The different ratios are presented in columns 6 to 11 in Table 5.13.

Between 1973 and 1983, the ratios \(P_0/P_1\), \(P_0/P_2\) and \(P_0/P_3\) are declining. This indicates that the odds of a firm entering the industry or staying in size category 1, 2 or 3 are higher than the odds of a firm exiting the industry. During that same period, the ratios \(P_1/P_2\) and \(P_1/P_3\) were increasing. This implies that the likelihood of firms moving from size category 2 and 3 to size category 1 is higher than the likelihood of a firm moving from size category 1 to size category 2 or 3. The ratio \(P_2/P_3\) also increased between 1973 and 1983 suggesting that the odds of a firm moving from a size category 2 to a size category 3 are higher than the odds of a firm moving from size category 3 to a size category 2. One explanation may be that between 1973 and 1996, processor margins were high enough to attract or maintain firms in the industry, resulting in higher competition among firms. Those margins were high because of the limited shrimp supply.

After 1983, because of the increased shrimp imports from South Asian and Latin American countries, shrimp became available to U.S. processors year round. Consequently, the domestic retail prices and ex-vessel prices for shrimp declined, leading to a narrowing
of the processor margin. During that same period, the odds of observing P0/P1, P0/P2 and P0/P3 increased. This suggests that the chances of a firm exiting the industry are higher than the chances of a firm staying in size category 1, 2 or 3. Results also indicated that P1/P2 and P1/P3 declined suggesting that the firms of size 2 and 3 have higher chances of staying in their categories than moving to size category 1. The ratio p2/p3 declined between 1983 and 1996 suggesting that the likelihood of a firm staying in size category 3 rather than moving to a size category 2 are higher than the odds of a firms moving from a size category 3 to size category 2.

In summary, firm size distribution is affected by the changes in processor margins. The narrowing in the margins seems to impact more the small size firm than the medium or large firm. Between 1973 and 1996, the number of processors in size category 1 declined from 85 firms to 37 firms. During that same period, the number of processors in size category 2 declined from 58 to 35 while the number of processors in size category 3 declined from 38 to 25. Additional examination of the data can shed some light on what happened in the processing industry. Before 1983, small, medium and large sized firms averaged their production at about 32 thousand pounds, 536 thousand pounds and 3.6 million pounds. During that same period, the shrimp production per worker was 1 thousand pounds for the small firm, 15 thousand pounds for the medium sized firm and 24 thousand pounds for the large firm. After 1983, the total production per firm for different sizes increased. A small firm averaged 51 thousand pounds a year, while the medium and large firms averaged 910 thousand pounds and 5 million pounds a year. The production per worker increased also to 26 thousand pounds for size 2 and 32 thousand pounds for size 3. The production per worker did not change significantly for the small size firms. In
some shrimp processors were able to remain in the industry by adjusting their input mixes.

5.5. Summary

Results showed that retail shrimp prices significantly and negatively affected the domestic per capita consumption. The demand for shrimp is price inelastic which is consistent with findings by previous studies on shrimp. Red meat and fish prices significantly affected the domestic shrimp consumption. Red meat and fish were found to be shrimp substitute.

At the wholesale level, findings support a peeled shrimp sector dominated by the imports. The import effects increased after 1983 due to the development of shrimp farming activities in South Asia and Latin America. The relationship between the wholesale demand prices of shrimp and the quantities for peeled shrimp can be characterized as being negative and inelastic. Additionally, imports of headless shell-on and "other" shrimp products have significantly and negatively impacted the domestic shrimp processing activities. The ex-vessel demand was found to be responsive to changes in domestic landing and imports of headless-shell on shrimp. The price linkage model showed that wholesalers of peeled, headless shell-on and "other" shrimp product are not fully passing their cost increase to the retailers.

The analysis of the United States southeastern region shrimp processing industry also indicated that the shrimp processor margins were narrowing due to the increase in shrimp imports. The import impacts on processor margins are the following:

1) For peeled shrimp, the drop in wholesale prices is 0.0365 dollar per pound and the drop in the raw shrimp prices is 0.0042 dollar per pound. Therefore, the net
annual drop in the margins is 0.0323 dollars per pound for the peeled shrimp. This effect may be larger given the 1983 structural change that led to the increase in import quantities from South Asian and Latin American countries; and,

2) For the headless shell-on shrimp, the increase in imports is associated with a 0.0297 dollar per pound drop in ex-vessel prices and a 0.0704 dollar per pound drop in wholesale prices. The net drop in the margins is 0.0407 dollar per pound.

The results also indicated that changes in the margins have significant impact on the processor size distribution. In 1973, 181 firms were actively processing shrimp in the southeastern region of the United States. During that year, 45% of firms had total shrimp sales below $1 million a year, 38% between $1 million and $10 million dollars a year, and 21% with sales of greater than $10 million dollars a year. By 1996, those percentages were 38, 36 and 32 for categories 1, 2 and 3, with a total of only 97 firms processing shrimp. The firms that remained in sizes 2 and 3 increased their production per firm and production per worker. The odds of a firm being in the first category were higher in the period 1973-1983 than the odds of a firm being of the same size in the period 1984-1996. The odds of a firm falling in the second size category in the period 1973-1996 are similar to those of a firm falling in the same category during the periods 1984-1996. For the last category, the odds of a firm being of size 3 in the period 1973-1983 are lower than the odds of a firm being of the same size during the period 1984-1996. Those probabilities may be explained by the fact that all size categories were competing against new entrants for the limited supply of raw shrimp between 1973 and 1983. After 1983, the increase in shrimp imports made raw shrimp available to processors year round. This caused processor margins to narrow.
rapidly when compared to the margins realized by processors prior to 1983, thus greatly increasing the odds of firms exiting the industry.
Chapter 6

Summary and Conclusions

The objectives of the study were, first, to analyze the impact of shrimp imports on the southeastern United States region shrimp processing industry. The second objective was to examine how processor margins were changing and the impacts of those changes on firm size distribution. To carry out the first objective, the analysis focused on four shrimp product-forms: peeled shrimp, headless shell-on shrimp, breaded shrimp and “other” shrimp. A system of equations was developed to analyze the effects of imports on the ex-vessel, wholesale, and retail sectors of the U.S. shrimp industry. Based on the Hausman specification test results, the three stage least square procedure was used to estimate the system of equations rather than the two stages least square. For the second objective, a Markov model was estimated, thus allowing the investigator to measure the impacts of the changes in processor margins on firm size distribution. Stationarity test concluded that the processor margins should have significant impacts on the processor size distribution. The multinominal logit procedure, which restricts the predicted probabilities between 0 and 1, was used to estimate the Markov model. For the second objective, three firm size categories were defined: 1) firms with total yearly shrimp sales less than $1 million; 2) firms with total yearly shrimp sales between $1 million and $10 million included, and 3) firms with total shrimp sales above $10 million a year.

This section will present a summary of the findings with sections 6.1.1 and 6.1.2 covering results obtained in the systems of equations estimation, and 6.1.3 covering results from the Markov model. The implications of these findings and the limitations of the current study will be discussed in sections 6.2 and 6.3.
6.1. Summary

6.1.1. Structural Analysis

Results obtained from the estimation of the system of equations indicated that retail shrimp prices significantly and negatively affect domestic shrimp per capita consumption. This implies that an increase in retail shrimp prices is associated with a leftward movement along the shrimp retail demand curve leading to lower shrimp per capita consumption. The retail demand for shrimp was found to be price inelastic meaning that the percentage change in prices is larger than the percentage change in quantities. Thus, the price effect is dominant and any increase in shrimp prices will consequently be associated with an increase in retailers' total shrimp sales revenues. The study also found that red meat retail prices and fish prices significantly and positively affect domestic shrimp per capita consumption. Meat and fish products are therefore substitutes to shrimp products. These are significant findings because most available studies that attempt to capture the relationships between shrimp, red meat, and fish products used a composite meat, fish and poultry index in their estimation. This is the first study to be conducted that separated fish, poultry, and red meat effects on shrimp products. The poultry effect on shrimp was not a significant factor. The cross-effects between shrimp and fish can be characterized as inelastic, whereas the shrimp per capita consumption is price elastic with respect to meat products. The implications of these findings will be further addressed in section 6.1.2.

At the wholesale level, findings support a peeled shrimp sector dominated by imports. The import effect increased after 1983 due to the development of shrimp production activities in south Asia and Latin America. The relationship between the wholesale demand prices of shrimp and the import quantities for peeled shrimp can be
characterized as being negative and inelastic. An increase in peeled shrimp imports causes the domestic wholesale demand for peeled shrimp to shift downward resulting in lower shrimp prices. Since the wholesale demand for peeled shrimp was found to be inelastic with respect to prices, a drop in shrimp prices will be associated with a drop in peeled shrimp processor revenues. Additionally, imports of headless shell-on and “other” shrimp have significant and negative impacts on the domestic shrimp processing activity. This relationship can be characterized as being negative and elastic. This implies that increases in headless shell-on and “other” shrimp imports will shift the wholesale demand curves for those products downward resulting in lower domestic prices. Because of the lower prices and the elastic nature of the wholesale demand for processed headless shell-on and “other” shrimp, total processor revenue decreases. Lastly, the production of breaded shrimp is a domestic activity and its demand was found to be price inelastic. An increase in the domestic breaded shrimp quantities is associated with lower wholesale prices. This is a movement along the breaded shrimp demand curve. Since the demand is price inelastic, the decrease in prices is associated with lower revenues for the processors.

For the ex-vessel demand, the levels of imports of peeled shrimp do not have an effect on ex-vessel demand. It is surprising that the domestic market can absorb the domestic peeled shrimp imports without affecting the raw shrimp prices. One explanation might be that peeled shrimp are purchased and placed in storage or processed for (breaded shrimp for example) and then stored or placed into marketing channels. In the long run, when facilities processing inventories and other facilities are fully utilized, raw shrimp prices will adjust through a leftward shift in demand. The relationships between peeled products (imports) and ex-vessel demand can be characterized as elastic. Consequently, a decrease in ex-vessel prices due to increased imports for peeled shrimp is associated with
lower revenues for the domestic shrimp harvesters. It was also found that imports of headless shell-on shrimp have a significant and negative impact on the ex-vessel demand for raw shrimp. This implies that an increase in imports will lower the prices for the headless shell-on shrimp leading to higher domestic per capita consumption. Since headless shell-on shrimp include large sized shrimp, consumers may substitute other shrimp products for the headless shell-on. This effect will indirectly impact the ex-vessel price by depressing it. The relationship between the ex-vessel demand and the headless shell-on imports can be characterized as elastic implying that a decrease in headless shell-on prices due to increased imports is associated with a decrease in revenues for domestic shrimp harvesters. The domestic landings significantly and negatively effect the ex-vessel demand. An increase in South Atlantic and Gulf of Mexico shrimp landings is associated with a movement along the ex-vessel shrimp demand curve and lower ex-vessel shrimp prices. Since the ex-vessel demand is price elastic, reduced prices due to more landings is associated with lower revenues for shrimp harvesters.

6.1.2. Reduced-Form Analysis

The reduced-form of the model expresses each endogenous variable of the model in terms of only exogenous variables. A reduced-form estimate provides a clearer interpretation of the relationships between endogenous and predetermined variables since the impact of a predetermined variable on each endogenous variable has now been isolated (Adams, 1984). Results indicate that increases in U.S. per capita disposable income over the period of 1973 to 1996 led to a 0.0217 pound increase in shrimp per capita consumption. Moreover, the relationships between those two variables can be characterized as inelastic. The implication of this finding is that United States shrimp per capita consumption is not very sensitive to increases in per capita consumption disposable income. This result
contradicts earlier studies, which found shrimp to be a "superior good". One explanation for this is that the rapid growth in imports after 1983 caused a change in the income effect associated with shrimp per capita consumption.

Results also indicate that red meat prices declined over the study period and that shrimp per capita consumption dropped yearly by 0.0186 pound. As a result of the substitution effect, however, this decline was offset by an 0.0265 pound increase in per capita consumption due to the increasing fish price cross-effect.

Actual data show that inventories of headless shell-on products were declining at a rate 1.6 million pounds a year between 1973 and 1996. The impact of that decline on the wholesale and retail prices are a drop in their respective prices by 0.0304 dollar per pound and 0.0045 dollar per pound. The same trend is observed in the breaded sector. The inventories of breaded shrimp declined on average by 0.25878 million pounds a year between 1973 and 1996. The impact of that decline is a leftward shift in the demand for breaded shrimp resulting in a drop in wholesale prices of 0.0286 dollar per pound. Because of the low retail prices, per capita consumption increased by 0.003 million pounds a year. Peeled shrimp inventory levels did not change on average during the study period. Therefore, its effects on the different prices and per capita consumption levels are not considered in this section. In general, decreasing inventories of shrimp products caused wholesale and retail prices to decrease. Because of low prices, per capita consumption of processed shrimp increased. The changes in inventories between 1973 and 1996 have a larger impact on wholesale prices than on retail prices.

As expected, the increase in the quantity of shrimp domestically harvested and processed was associated with a 0.0188 dollar per pound decline in ex-vessel prices. This is a movement along the demand curve, which exhibits the expected characteristics. Peeled
imported shrimp also negatively affected dockside prices. As imports of peeled shrimp increased, domestic wholesalers substitute domestic peeled shrimp for imported peeled shrimp. This leads to a movement along the wholesalers demand curve and lower prices for peeled shrimp. This also places downward pressure on raw shrimp prices and forces it to drop by 0.0045 dollar per pound. The imports of headless shell-on shrimp following the same reasoning leads to a drop in the raw shrimp prices of 0.0297 dollar per pound.

Imported shrimp product coefficients are consistent with expectations. Actual data revealed that increased imports of peeled shrimp led to greater availability of large amounts of peeled shrimp in the wholesale market and lower prices for that product. The impact of higher import quantities is a lowering of the wholesale, ex-vessel and retail prices by 0.0365 dollar per pound, 0.0042 dollar per pound and 0.0063 dollar per pound. Following the same reasoning, imports of headless shell-on is associated with a drop in wholesale, ex-vessel and retail prices by 0.0704 dollar per pound, 0.0297 dollar per pound and 0.03306 dollar per pound. The drop in shrimp prices due to increased shrimp imports caused peeled and headless shell-on shrimp per capita consumption to increase by 0.0010 and 0.0085 pound a year. However, it is suspected that the increase in shrimp per capita consumption due to increases in peeled shrimp imports are higher than 0.0010 million pounds a year. The structural variable D83 indicated that peeled shrimp prices were lower by 1.5 dollars per pounds for the period 1984-1996 when compared to the period 1973-1983. This lower price for peeled shrimp was associated with 0.0734 increase in per capita consumption. The predicted prices for processed shrimp products obtained from the estimated model were compared to the predicted prices for raw shrimp. Results indicated that processor margins declined by 56 % for the peeled shrimp, 30 % for the headless shell-on product, and 39 % for the breaded shrimp. “other” shrimp is the only product that...
showed a widening in the margins. The import impacts on processor margins are the following:

1) For peeled shrimp, the drop in wholesale prices is 0.0365 dollar per pound and the drop in the raw shrimp prices is 0.0042 dollar per pound. Therefore, the net annual drop in the margins is 0.0323 dollars per pound for the peeled shrimp. This effect may be larger given the 1983 structural change that led to the increase in import quantities from South Asian and Latin American countries.

2) For the headless shell-on shrimp, the increase in imports is associated with a 0.0297 dollar per pound drop in ex-vessel prices and a 0.0704 dollar per pound drop in wholesale prices. The net drop in the margins is 0.0407 dollar per pound. These are significant findings because they indicate that imports have detrimentally and negatively effected shrimp prices resulting in the narrowing of processor margins.

6.1.3 Changes in Processor Margins and Their Impact on Firm Size Distribution

Overall processor margins for the four products declined by 35 %. Results of the Markov analysis show that the narrowing of processor margins impacted the firm size distribution. Before 1983, a firm’s chances of entering the industry in size category 1 varied between 0.4462 and 0.4876. The firm’s chances of entering the industry in size category 2 or moving to it from another size category varied between 0.3399 and 0.3418. Lastly, the chances of a firm entering the shrimp industry in size category 3 or moving toward it fluctuated between 0.1675 and 0.1904. During that period, the chances of a firm exiting the industry fluctuated between 0.0104 and 0.0235. After 1983, a firm’s chances of entering the industry in size category 1 varied between 0.4597 and 0.3832. The firm’s chances of entering the industry in size category 2 or moving to it varied between 0.3175 and 0.3412.
Lastly, the odds of a firm entering the shrimp industry in size category 3 or moving toward it fluctuated between 0.1808 and 0.2363. During that period, the chances of a firm exiting the industry fluctuated between 0.0183 and 0.0813. To sum up, the odds of a firm being in the first category were higher in the period 1973-1983 than the odds of a firm being of the same size in the period 1984-1996. The odds of a firm falling in the second size category in the period 1973-1996 are similar to those of a firm falling in the same category during the periods 1984-1996. For the last category, the odds of a firm being of size 3 in the period 1973-1983 are lower than the odds of a firm being of the same size during the period 1984-1996. Those probabilities may be explained by the fact that all size categories were competing against new entrants for the limited supply of raw shrimp between 1973 and 1983. After 1983, the increase in shrimp imports made raw shrimp available to processors year round. This caused processor margins to narrow rapidly when compared to the margins realized by processors prior to 1983, thus greatly increasing the odds of firms exiting the industry. In 1973, 181 firms were actively processing shrimp in the southeastern region of the United States. During that year, 45% of firms had total shrimp sales below $1 million a year, 38% between $1 million and $10 million dollars a year, and 21% with sales of greater than $10 million dollars a year. By 1996, those percentages were 38, 36 and 32 for categories 1, 2 and 3, with a total of only 97 firms processing shrimp. The firms that remained in sizes 2 and 3 increased their production per firm and production per worker. They also decreased their number of workers. It is suspected that firms in sizes 2 and 3 are benefiting from substantial scale economies.

6.2. Implications

These results reveal that the rise in shrimp import levels over the last decade is associated with a narrowing of shrimp processor margins. The narrowing in processor
margins accelerated after 1983 when imports from South Asian and Latin American countries increased. This implies that if this import trend continues, the shrimp processor margins are likely to continue to fall. Results also indicated that the narrowing in processor margins have negatively impacted firm size distribution. Therefore, if the import trend continues, one will observe fewer and fewer firms in the processing industry.

Results also show that the wholesale headless shell-on, peeled and “other” shrimp sectors face an elastic demand. This finding implies that the effect of a change in quantities will dominate the effect of a change in prices. Therefore, any governmental regulation placed on the quantity of shrimp imported will restrict processed shrimp quantities meaning processor receipts will decline. An import tariff, for example, will put a downward pressure on import quantities and cause domestic wholesale shrimp prices to increase. Consequently the domestic per capita consumption of “other” shrimp will increase by more than the price falls and the processor revenue will also increase. Since the wholesale breaded shrimp sector faces an inelastic demand, any restriction on wholesale breaded shrimp will limit the demand for this product, causing total processor revenue to decrease.

Raw shrimp demand is price elastic with respect to inventories of peeled shrimp, imports of headless shell-on shrimp, and landings from the South Atlantic and the Gulf of Mexico. The policy implications are that placing restrictions on imports of headless shell-on shrimp causes domestic raw shrimp prices to rise. Because of the elastic nature of the demand, the percentage change in prices is less than the percentage change in quantities. In this case, the effect of the change in quantity will dominate, causing total revenue to decrease. To summarize, restrictions on headless shell-on imports will be associated with lower import quantities and lower revenue for domestic harvesters of raw shrimp. The same is true for the landings and the inventories of peeled shrimp. A restriction on the
quantities of those products will be associated with lower revenue for the shrimp harvesters.

Results also indicated that retail demand is price inelastic while wholesale demands are elastic with respect to prices except in the case of breaded shrimp. This will lead to a narrowing in the processor margins as shifts in supply are observed. It is suspected that economies of scale exist over a certain range in the shrimp processing industry, and that a processor faces a significant level of fixed investment costs and a substantial level of variable costs as well. Processor margins are narrowing over time not only because of the retail changes associated with changes in the volume of output charged exclusively to processors, the change in the level of marginal cost for marketing services is charged to them as well. That is, processor prices will decline more than retail prices when output is expanded and will increase more than retail prices when output is reduced. This is evident in the decline in wholesale prices as the total output expanded between 1973 and 1996. The result is a narrowing in processor margins, which affects the downsizing of the shrimp processing industry and the firm size distribution. Firms in the first size category suffered the most from the narrowing in the margin, with their number falling from 85 in 1973 to 37 in 1996.

In conclusion, the estimated model suggests that all market levels will be affected by changes in policy measures. For example, the impact of the shrimp imports on the wholesale sector is larger than on the retail or the ex-vessel sectors. Therefore, a policy of increased trade restrictions would then decrease the available supplies, cause prices to rise, ultimately increase wholesale processor margins.
6.3. Limitations and Further Improvements

The National Marine Fisheries Service does not report retail prices for shrimp by product forms. An improvement of this research can be done if the retail sector can be divided into different shrimp product forms. This will allow the investigator to gain more insight into the industry.

Cost data for processing, wholesaling, and retailing of shrimp products are scarce (Adams 1984). The costs, if obtained, are useful in understanding the processor margins and could help improve the study.

A complete model for the shrimp sector should include supply and demand functions at each sector level for each product. This implies that additional equations must be specified. Attempt to treat shrimp imports as endogenous failed because data limitations did not allow that type of estimation at this time. Efforts in the future should be made to improve the collection of this data.

Future research should focus more on the import sector given its importance to the industry. Potential studies could focus on determining the behavioral variables that affect the import process. The Markov analysis using the multinomial logit can be improved if firm-specific attributes can be obtained. The relative prices of shrimp between Japan and U.S. are suspected to influence the shrimp imports by the United States. Early models specified in this study with exchange rate as an import shifter did not performed well. Future studies should consider modeling the effects of the relative price of shrimp between U.S. and Japan on U.S. shrimp processing industry.
References


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## Appendix A

### Table A1: Transition Matrix for Firm Movement Between 1973-1974

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### Table A2: Transition Matrix for Firm Movement Between 1974-1975

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### Table A3: Transition Matrix for Firm Movement Between 1975-1976

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### Table A4: Transition Matrix for Firm Movement Between 1976-1977

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Table A6: Transition Matrix for Firm Movement Between 1978-1979

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Table A7: Transition Matrix for Firm Movement Between 1979-1980

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Table A8: Transition Matrix for Firm Movement Between 1980-1981

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Table A9: Transition Matrix for Firm Movement Between 1981-1982

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Table A10: Transition Matrix for Firm Movement Between 1982-1983

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Table A11: Transition Matrix for Firm Movement Between 1983-1984

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Table A12: Transition Matrix for Firm Movement Between 1984-1985

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Table A13: Transition Matrix for Firm Movement Between 1985-1986

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Table A14: Transition Matrix for Firm Movement Between 1986-1987

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Table A15 Transition Matrix for Firm Movement Between 1987-1988

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Table A16: Transition Matrix for Firm Movement Between 1988-1989

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Table A17: Transition Matrix for Firm Movement Between 1989-1990

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Table A18: Transition Matrix for Firm Movement Between 1990-1991

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Table A19: Transition Matrix for Firm Movement Between 1991-1992

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<td>56</td>
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Table A20: Transition Matrix for Firm Movement Between 1992-1993

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Table A21: Transition Matrix for Firm Movement Between 1993-1994

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Table A22: Transition Matrix for Firm Movement Between 1994-1995

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Table A23: Transition Matrix for Firm Movement Between 1995-1996

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Appendix B

Table B1: Transition Probability Matrix 1973-1974

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Table B3: Transition Probability Matrix 1975-1976

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Table B4: Transition Probability Matrix 1976-1977

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Table B5: Transition Probability Matrix 1977-1978

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Table B6: Transition Probability Matrix 1978-1979

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Table B7: Transition Probability Matrix 1979-1980

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Table B8: Transition Probability Matrix 1980-1981

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Table B9: Transition Probability Matrix 1981-1982

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Table B10: Transition Probability Matrix 1982-1983

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Table B11: Transition Probability Matrix 1983-1984

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Table B12: Transition Probability Matrix 1984-1985

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Table B13: Transition Probability Matrix 1985-1986

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Table B14: Transition Probability Matrix 1986-1987

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Table B15: Transition Probability Matrix 1987-1988

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Table B16: Transition Probability Matrix 1988-1989

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Table B17: Transition Probability Matrix 1989-1990

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Table B22: Transition Probability Matrix 1994-1995

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Table B23: Transition Probability Matrix 1995-1996

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Vita

Hamady Diop graduated from Lycée National de Nouakchott-Mauritania (High School) in 1980. He was awarded a scholarship from the Mauritanian Government in 1981, and enrolled at the college of economics in Côte d'Ivoire. He received his bachelor of science degree in general economics in June 1985. He worked at the Oceanographic Research Center of Nouadhibou-Mauritania from 1986 to 1991.

In 1991, Hamady Diop was awarded a scholarship by the USAID/Mauritania education project to pursue an English training program and graduate studies in Salt Water Fisheries at Louisiana States University. After completion of his master's degree in 1994, Hamady Diop was awarded an assistantship from the Department of Agricultural Economics and Agribusiness at Louisiana State University. He is now candidate for the degree of Doctor of Philosophy in Agricultural economics, in August 1999.
Candidate: Hamady Diop

Major Field: Agricultural Economics

Title of Dissertation: Impact of Shrimp Imports on the United States' Southeastern Shrimp Processing Industry and Processed Shrimp Market

Approved:

[Signature]
Major Professor and Chairman

[Signature]
Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

May 7, 1999

[Signature]