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The impact of catfish imports on U.S. wholesale and farm sectors

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THE IMPACT OF CATFISH IMPORTS ON U.S.

WHOLESALE AND FARM SECTORS

By

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The importing of tra, basa, and channel catfish at relatively lower prices has resulted in less catfish purchased from U.S. farmers and processors. Claims have been filed with the U.S. International Trade Commission (ITC) accusing Vietnamese exporters of selling catfish to the U.S. at less than fair market value. Consequently, the U.S. International Trade Commission ruled against Vietnam in 2003 and recommended tariffs from 37% to 64%.

The primary objective of this research is to assess the impact of the tariffs on imported Vietnamese catfish on the U.S. catfish industry. In this study, we develop a supply and demand model of the U.S. catfish industry at the farm and wholesale level. In this model, we incorporate the effects of imports and estimate the short-run and long-run effects of changes in import prices on U.S. prices, quantities and welfare at the farm and wholesale level.

Key words: tariffs, Vietnamese catfish, imports, equilibrium price and quantity

DEDICATION

I would like to dedicate this research to my parents, Sammy and Brenda Neal, and my sisters, Angie, Alisha, and Sabrina.

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INTRODUCTION

In 2006, the quantity of processed catfish sold in the U.S. was 142,004 tons. This was a decrease of 7,980 tons when compared to 2005, and a decrease of 6,574 tons when compared to 2000 (Hanson and Sites, 2006). The decrease in quantity of processed catfish sold could be attributed to increases in per capita consumption of other fish and seafood products during this period (2000-2006). Per capita consumption of fish products increased from 16.2 lbs/person/year in 2005 to 16.5 lbs/person/year in 2006, which is a 1.3 lbs/person/year increase when compared to 2000 when per capita consumption levels were 15.2 lbs/person/year. The increase in per capita consumption could have caused an increase in imports of catfish and other products that compare with catfish.

The reason for increases in per capita consumption of seafood over the last five years could have been due to an increase in nutritional awareness on the part of U.S. consumers. This increase caused a change from red meat to other protein sources like fish and seafood (Ligeon et al. 1996). In recent years, knowledge about fish's nutritional value has increased. The American Heart Association recommends the intake of omega-fatty acids, which can take place through diet or supplementation of fish oils (Oh et al. 2006). The consumption of fish oils (omega-fatty acids) has been shown to reduce deaths in patients with cardiovascular disease. The catfish industry is the largest aquaculture food industry in the U.S. Alabama, Arkansas, Louisiana, and Mississippi are the four leading states in catfish production. Alabama, Arkansas, Louisiana, and Mississippi economies exceed 4 billion dollars combined annually, due to the impact of catfish production in those states (Buguk et al. 2003). In Mississippi, catfish is vital to the state's economy, providing jobs and opportunity in the Mississippi Delta.

As Table 1.1 shows, according to the 2005 Census of Aquaculture, the catfish industry represents 51 percent of food sales of all U.S. aquaculture. By comparison, the second leader in sales of U.S. aquaculture product only represents 9 percent of all U.S. aquaculture food sales. Catfish is an extremely important component in U.S. aquaculture industries.

Table 1.1 U.S. Aquaculture Industries, 2005.

Industry	Sales Value ($1000)	% of Total Food Aquaculture
Food Fish		
Catfish	461,885	51.0
Trout	79,282	9.0
Salmon	41,164	5.0
Bass	31,472	4.0
Tilapia	31,334	4.0
Crustaceans		
Crawfish	21,148	2.5
Shrimp	20,724	2.5
Mollusks		
Oysters	102,896	12.0
Clams	84,874	10.0
Total	897,970	100.0

Catfish sales averaged nearly $600 million dollars annually from1996-2006 (USDA-NASS Catfish processing repots, various years). The amount of live catfish sold, in pounds, to U.S. wholesalers has been declining recently. In 2006, sales were around $700 million, which fell to $616 million in 2007 as shown in Figure 1.1. The decrease in amount sold to U.S. wholesalers may be at least partially attributable to the influx of imported catfish.

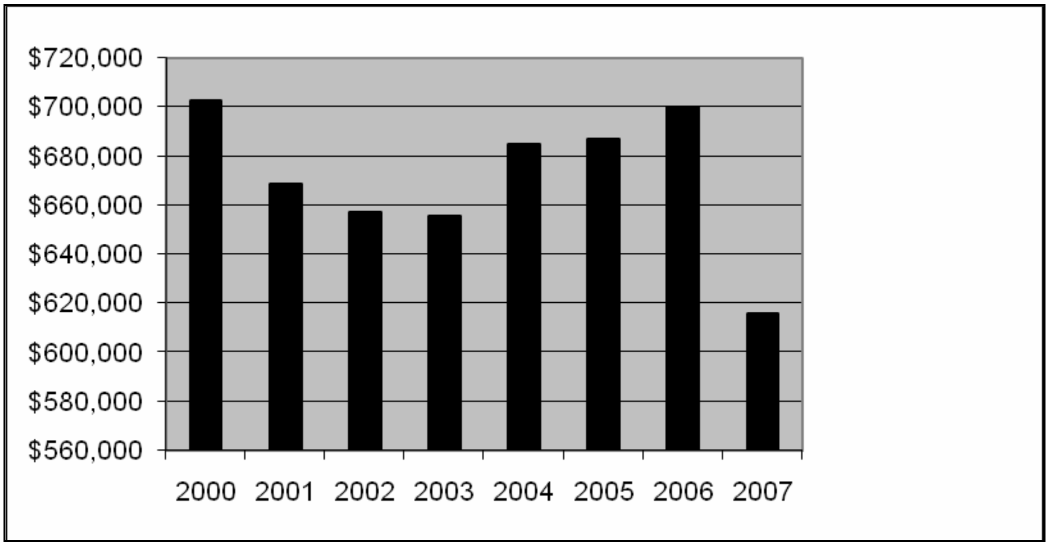

Figure 1.1 Total Processed Catfish Revenue ($1000) in U.S.
Source: USDA, NASS various years.

1.1 General Problem

In order to meet the increase in U.S. demand for fish products, fish imports have significantly increased. Imports of channel catfish and similar products have been of significant interest to U.S. processors and farmers. Catfish imports are coming into the U.S. primarily from the countries of China and Vietnam. Domestic production at the farm and processing level can be affected by these imports, and this study will attempt to provide a clear understanding of the effects of catfish imports on U.S. domestic production and processing.

The importing of tra, basa, and channel catfish at a relatively lower price could cause wholesalers to purchase more of that commodity, displacing catfish purchases from U.S. processors, ultimately reducing whole catfish purchases from farms. U.S. catfish processor prices could be considered high by some U.S. wholesalers. If catfish prices are high, U.S. wholesalers will look to alternative sources to provide the same or similar product at a lower price. U.S. catfish production costs could have an effect on catfish imports.

1.1.1 Imports of Tra, Basa, and Channel Catfish

Catfish imports have increased from 8,219 million pounds in 2000 to 84,429 million pounds in 2007. In 2000, imported catfish fillet sales represented 6 percent of total frozen catfish fillet sales in the U.S., and has increased in 2007 to 41 percent. As shown in Figure 1.2, frozen catfish fillets have increased over the past two years. In 2007, catfish fillet imports reached 84,429 million pounds while in 2006 that number was only 74,805 million pounds (NMFS, 2007). In 2006, the U.S. received approximately 6,200 million pounds of catfish, basa, and tra each month, an increase of 149 percent from 2005 levels (USDA-NASS Catfish processing repots, various years). Imports in 2007 surpassed 2006's total. Data from February 2002 to July 2004 do not include imports of Vietnamese basa and tra, due to legislation barring non-Ictaluraidae fish species from being called "catfish." Thus, catfish import numbers for those years are low. In August, 2004, all species were reported and aggregated.

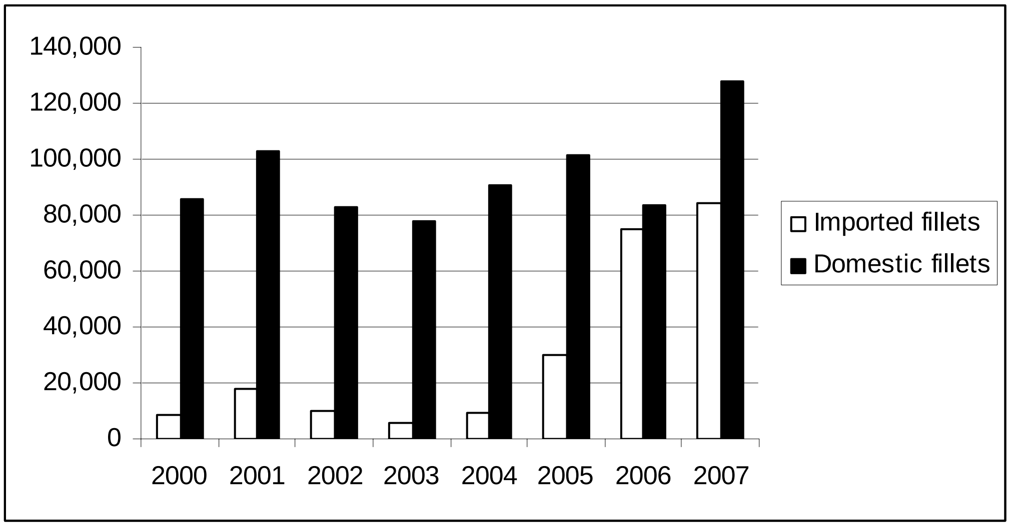

Figure 1.2 Frozen U.S. and Imported Catfish Fillet Sales (1000 lbs) in the U.S., 2000 -2007.
Source: USDA, NASS, Catfish Processing, June 2007; Hanson and Sites, 2007.

As shown in Figure 1.3, prices of imported catfish are substantially different from that of U.S. farm-raised catfish. In 2000, imported processed catfish frozen fillet prices averaged $1.50 per pound, while domestic processed catfish frozen fillets prices average $2.82 per pound. In 2007, imported processed frozen catfish fillet prices averaged $1.48 per pound, and domestic processed frozen catfish fillets prices averaged $2.92 per pound. From 2000 to 2007, catfish fillet import prices averaged $1.31 per pound; this gives importers an advantage when selling their product in the U.S. catfish market.

Catfish is mainly imported in the form of frozen boneless fillets (Quangranine and Engle, 2002, NMFS, 2007). Upon arrival it is sold to U.S. wholesalers and competes directly with domestic catfish products at the retail level (Kinnucan et al. 1988). Since 2003, the majority of catfish imports came from China and Vietnam. Prior to that date, Brazil was the leader in catfish exports to the U.S.; now it ranks near the bottom. Vietnam is currently the leading supplier to the U.S. of catfish-like products. In 2006, 19,843 tons of catfish-like products were imported into the U.S. from Vietnam, according to the National Marine Fisheries Service trade query (NMFS, 2007). The second leading supplier, China, exported 8,545 tons of catfish-like products and channel catfish to the U.S in 2006. Vietnam exported no channel catfish during this time period (NMFS, 2007). All of Vietnam's catfish was of the *Pangasius genus*, which is a non-*Ictaluridae genus*, and is known as either tra or basa.

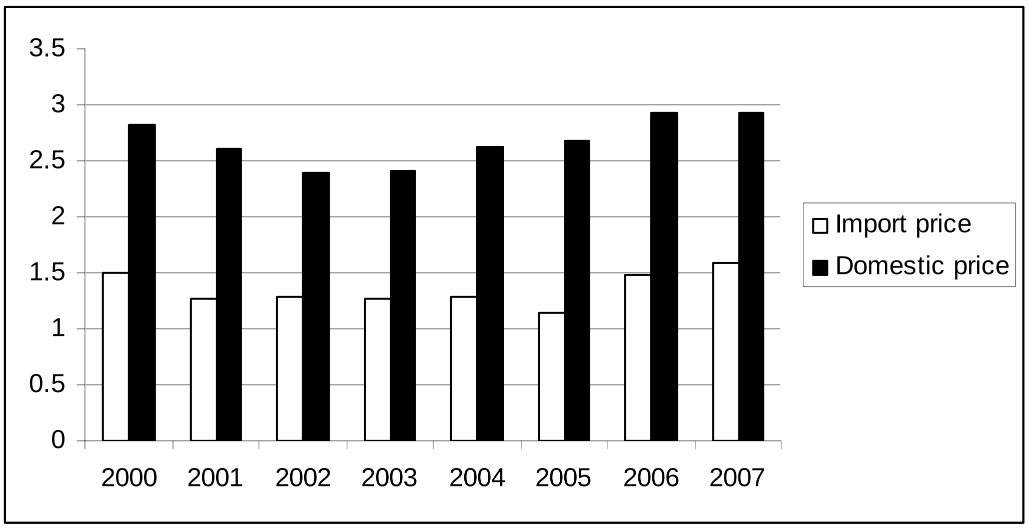

Figure 1.3 U.S. Domestic and Foreign Prices, ($/lb)
Source: (NMFS, various years)

1.1.2 U.S. Law About Naming Non-Ictaluridae Genus

Channel catfish is taxonomically known as the *Ictalurus punctatus*; it is known in the U.S. as catfish. Vietnam is a major importer of the *Pangasius* genus; as mentioned earlier they exported no channel catfish to the U.S. in 2006. The International Trade Commission of the U.S. Department of Commerce investigated the claims of Vietnam exporting a "catfish-like" product under the name catfish. As a result of that investigation, Congress implemented Section 10806 of the farm Security and Rural Investment Act of 2002, which required all "catfish-like" products being imported from Vietnam or any other country to be label as tra or basa. The term "catfish" could only be used for fish within the family *Ictaluridae* (US ITC, 2003).

1.1.3 Antidumping

The U.S. has anti-dumping laws to protect domestic businesses from products imported at less than fair market price. The Tariff Act of 1930 states that U.S. industries can seek relief from the U.S. government from imports, when countries are found to be dumping products (US ITC, 2003). The Catfish Farmers of America (CFA) filed a petition with the International Trade Commission of the Department of Commerce on behalf of the CFA, a trade association of U.S. catfish farmers and processors, and individual U.S. catfish processors on June 28, 2002 alleging that Vietnamese companies were dumping catfish into the U.S. (U.S. ITC, 2003). Vietnam was found by the International Trade Commission to be dumping. The U.S. Department of Commerce recommended imposing tariffs from 36.84 percent to 63.88 percent on imported basa and tra coming from specific Vietnamese companies (US.ITC, 2003). As shown in Figure 1.3, foreign prices are still relatively lower than domestic prices. Between 2000 and 2002, U.S. consumption of catfish increased, and there was a decrease in the value of whole form catfish from a $1.75 in 2000 to a $1.46 in 2002 (US ITC, 2003).

1.2 U.S. Catfish Industry

In the U.S., there are over 20 catfish processing plants. One of the largest of them all is ConFish, Inc. ConFish, Inc was established from a joint venture between

ConAgra and Fishco, Inc. Other processing companies include America's Catch, Carolina Classic Catfish, and Farm Breeders of Idaho. Processing companies are not just limited to the south, but are located all over the nation.

Recently, catfish processor prices have been increasing. In 2006, processed frozen catfish fillets averaged $2.91 per pound, and in 2007, processed frozen catfish fillet prices rose to $2.92 per pound, an increase of $0.01 per pound. In 2000, frozen catfish fillet prices averaged $2.82 per pound. The increase in price from 2000 to 2007 was only $0.10 per pound. From 2000 to 2007, catfish processor prices for fresh catfish fillets averaged $2.74 per pound (USDA-NASS Catfish processing reports, various years).

Catfish processor quantities for total fresh and frozen catfish fillets have been on a slight decline. In 2005, 91,869 tons of fresh and frozen processed catfish fillets were sold, and in 2006, 86,227 tons of fresh and frozen processed catfish fillets were sold. Comparing 2006 quantities to that of 2000, quantities in 2000 were 89,089 tons, which is a difference of 2,780 tons from 2006. The biggest change took place between 2005 and 2006, when quantities dropped by 2,890 tons. A total of 61,841 tons of frozen processed catfish fillets were sold in 2005, and that number fell in 2006 to 58,951 tons of frozen processed catfish fillets, with a drop of 2,890 tons in a year's time.

As of January 1, 2007, there were 1,023 catfish operations in the U.S. The number of catfish operations has been on a constant decline since January 1, 2002. Only in January 2004 to January 2005 did catfish operations increase, going from 1,147 to 1,158 in number of operations. Since January 2001, catfish operations have been declining on average by 42 operations per year. In January 2006, the number of catfish operations was 1,035, which declined to 1,023 in 2007. Alabama, Arkansas, and

Mississippi account for nearly 93 percent of all catfish production in the U.S. (USDA-NASS Catfish production repots, various years). Alabama accounts for nearly 21 percent of all catfish production in the U.S., Arkansas 17 percent, and Mississippi accounts for 55 percent (Hanson and Sites, 2007).

U.S. catfish farmers are price takers, meaning they have no power to set the price for their product. They can either accept or decline a price presented to them by processors. Prices being paid to producers were at an all-time high in the first six months of 2007. In 2006, farm prices were $0.796 per pound; in 2005, prices were $0.725 per pound. Before these high prices, catfish farmers went through a period of hardship. Prices reached their lowest level January 2003 when the price of catfish was $0.529 per pound (Hanson and Sites, 2007). In 2002, the average price of catfish for the year was $0.568 per pound which was the lowest annual average price for catfish in the last 20 years (USDA-NASS Catfish processing repots, various years).

Channel catfish is the primary species grown by farmers in the U.S. Channel catfish can live up to forty years, grow to a length of 40 inches and weigh nearly 44 pounds in body weight (Southworth et al. 2006). Gender of catfish can be determined at about six months of age, and they become sexually mature after two or three years, and can begin to breed. Growth of channel catfish depends on several factors. Water temperature, quality of diet, feeding rate, and age of fish are important components in developing healthy channel catfish stock (Hargreaves, 2002). Fish feed, labor, fingerlings, and electricity are some of the main components in a catfish farm operation. Fish feed is one of the most important components in producing healthy channel catfish. Corn is one of the most important ingredients in fish feed. Corn prices have been on the rise since late 2006, and with the increased attention to ethanol production as an alternative fuel source in the U.S., corn prices are expected to remain high (Informa Economics, 2007).

The U.S. catfish industry is seeing an influx of catfish imports, primarily from Asia, being purchased by U.S. wholesalers. Imports can displace domestic production, with less catfish purchased from U.S. processors, which leads to less catfish purchased at the farm level. This research will look at the impact of imports on the farm and processing sectors. The objective of this research is to determine the magnitude of that impacts by developing a model that can predict impacts of future imports.

1.3 U.S. Producer

The producer, processor, and wholesaler make up the U.S. catfish industry. Each level plays a major role in the industry. A schematic view of the catfish industry is presented in Figure 1.4. Catfish producers purchase fingerlings from farm suppliers. Growth of catfish to food size takes 18-24 months. At the farm level several factors go into producing live catfish. Resources such as farm machinery, labor, fuel, and several other factors are needed. Feed, a major component in U.S. catfish production, makes up 50 percent of the total production costs. Seining uses a net to harvest an entire pond without lowering water levels; this method is most commonly used among farmers today (Tucker and Robinson, 1990). After harvesting takes place, catfish are live-hauled to a processing plant.

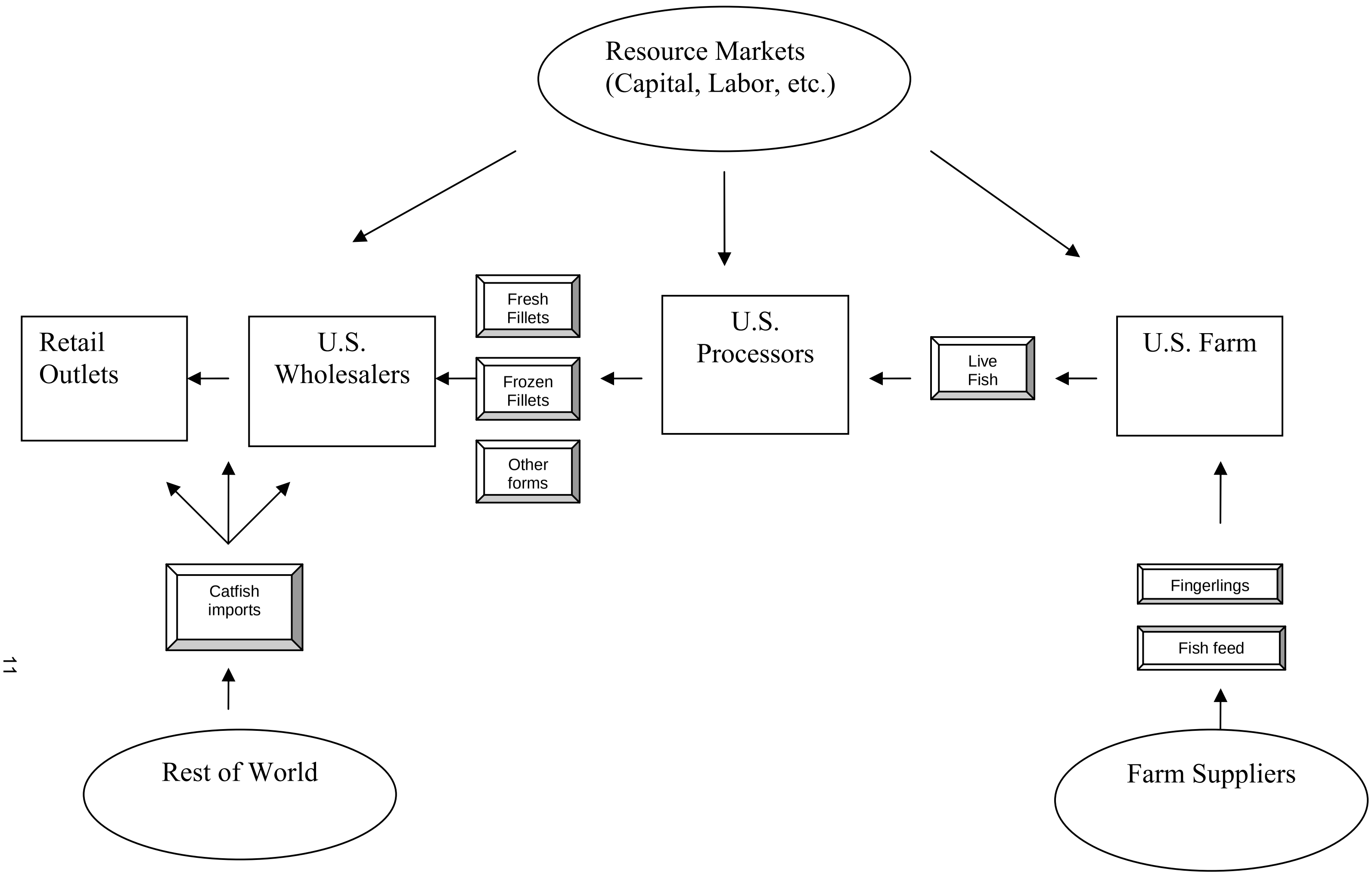

Figure 1.4 U.S. Catfish Industry- Overview of Catfish Supply and Distribution in the U.S. (schematic view)

A supply and demand graph is constructed in Figure 1.5 for the farm and processing levels. Quantity supplied is determined at the farm level by the producer marginal cost curve. Equilibrium between the supply and demand curves is achieved at their point of intersection. It is hypothesized that the increase in imported catfish has led to less live catfish being purchased by U.S. processors from U.S. farmers, caused by the producer demand curve shifting to the left. The result of this demand shift would be a decrease in price from P_{0f} to P_{1f}, and a decrease in the quantity purchased from Q_{0f} to Q_{1f}.

1.4 Catfish Processor

Farm raised catfish is typically sold to U.S. processors and is processed into several fresh and frozen forms, which include whole, dressed, steaks, shank fillets, regular fillets, nuggets, strips, fingers, breaded fillets, and marinated fillets. Several factors go into processing catfish. Resources such as processing machinery, labor, fuel, and electricity are the major components, but not the only ones used in the processing of catfish. Capital costs account for a large portion of total costs of processing catfish. Capital includes, but is not limited to, transportation and machinery costs. Labor accounts for a smaller portion of processing costs. Processed catfish is then sold to wholesalers who act as intermediaries between processors and retailers.

At the processor level, catfish is demanded by the wholesalers and sold to retailers. A supply and demand graph is constructed for the processing level in Figure 1.5. In theory, supply from the processor is based on the marginal cost curve above the shutdown point (average variable cost). Equilibrium price and quantity are determined where the supply and demand curves intersect. The impact of imported

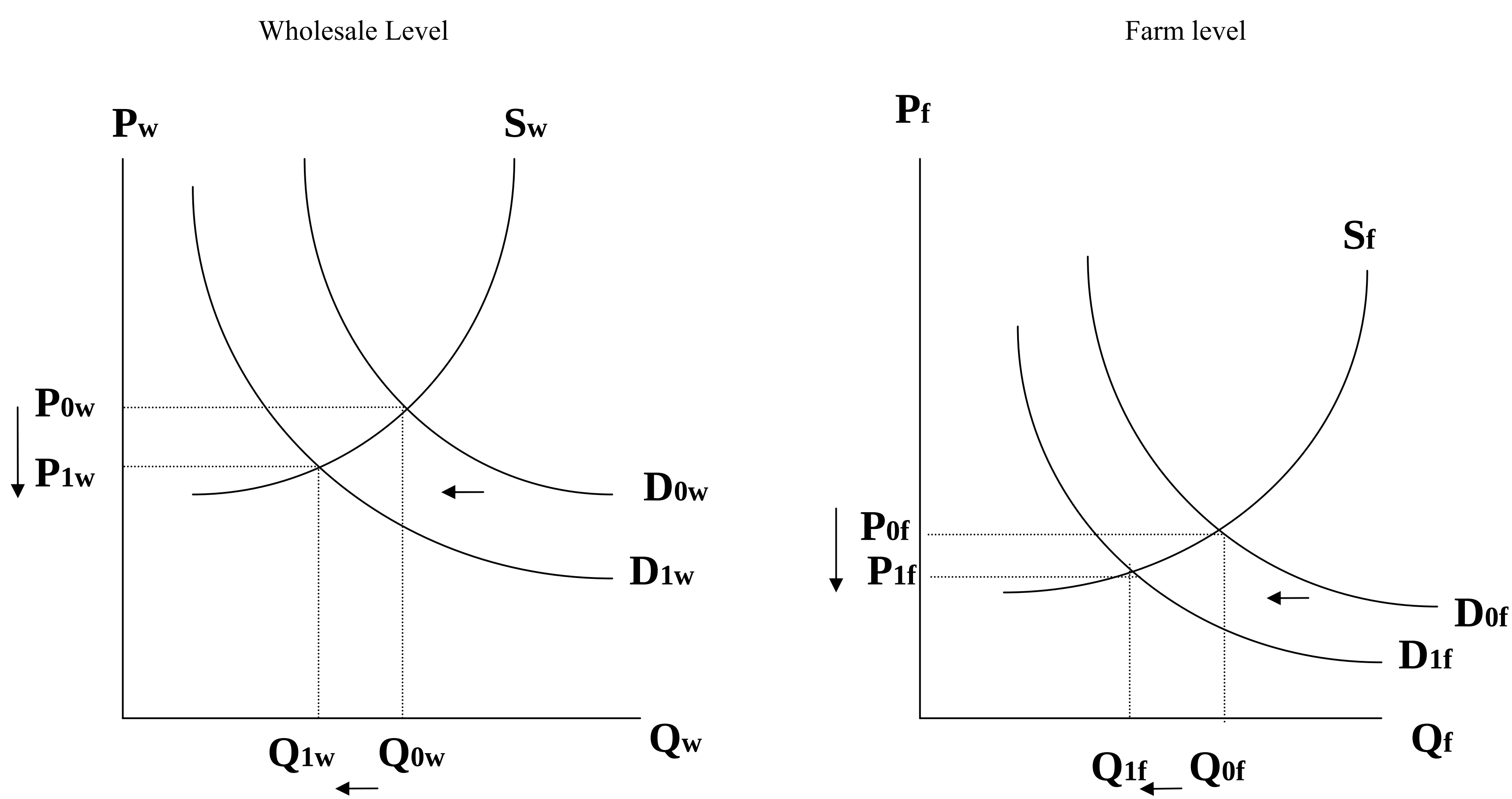

Figure 1.5 Supply and Demand for Wholesaler and Farm Level.

catfish leads to less domestic processed catfish being purchased by wholesalers, causing P_{0p} to decrease to P_{1p}, and Q_{0p} to decrease to Q_{1p}.

1.5 Wholesaler

U.S. wholesalers buy foreign catfish (channel catfish and catfish-like species) from abroad. In 2006, imported frozen catfish fillets made up 37.48 percent of the frozen fillet market; compared to 2000 when imported frozen catfish fillets accounted for only 6.42 percent of the market share. Frozen fillets account for the majority of all catfish imports (Quagrainie and Engle, 2002). Imports are relatively cheaper when compared to U.S. catfish. On average (2000-2006) domestic frozen catfish fillets were $2.63 per pound, while imported frozen catfish fillets are $1.31 per pound. Wholesalers are attracted to the lower priced product, which could increase profit margins for them. Wholesalers then take both products purchased, domestically and from foreign countries, and sell these products to retailers. As described above, the processor and wholesale levels were separated, but for our work they will be combined.

1.6 Imports by U.S Catfish Wholesaler

U.S. wholesalers buy imported and domestically processed catfish. Wholesalers act as intermediaries between U.S. retailers and domestic/foreign producers. Imported quantities have been increasing over the last three years. In 2006, imported catfish quantities were 37,436 tons; while in 2000, imported quantities only were 4,113 tons. Import quantities for 2007 look to surpass those of 2006 because as of July 2007, catfish imports were 23,864 tons (NMFS, 2007).

The majority of catfish imports arrive in the form of frozen fillets, and catfish and catfish-like products have been tabulated together since February of 2002. Domestic frozen catfish fillet sales have been declining lately; in 2006, the quantity sold was 58,951 tons compared to 2005 when quantity sold was 61,841 tons, and in 2004 when 60,900 tons were sold (Hanson and Sites, 2007).

1.7 Specific Problem

Increases in imports of channel catfish and catfish-like species into the U.S. may play a significant role in determining the price and quantity of U.S. processed catfish production. This, in turn, will impact domestic production, and the price received by farmers as well. Theory suggests that increased imports reduce the amount of fish demanded by U.S. wholesalers from U.S. catfish processors. This, in turn, leads to a lower price for processors from wholesalers. Theory also suggests that increased imports reduce the amount of catfish demanded at the farm level. This, in turn, leads to a lower price to the producer from the processor.

1.8 Objectives to Address Hypotheses Posed

A. Develop a supply and demand model for U.S. produced catfish at the U.S. farm level;

B. Develop a supply and demand model for U.S. produced catfish at the U.S. processor level;

C. Incorporate channel catfish and catfish-like species supplies from international sources into the supply and demand models; and

D. Estimate short-run and long-run effects of changes in imported catfish quantities on U.S farm and wholesale level equilibrium prices and quantities

CHAPTER II

LITERATURE REVIEW

The literature reviewed in this study is divided into two categories: an overview of previous supply and demand studies, and a review of previous seafood trade studies.

2.1 Overview of Previous Supply and Demand Studies

In order to have a better understanding of the catfish market, supply and demand models are needed. A supply and demand model gives policy makers a better understanding of supply and demand determinants in the catfish market. Work has been done for developing conceptual and empirical supply and demand models for agricultural commodities in many studies. Studies by Wohlgenant (1989), Lusk and Anderson (2004), Brester et al. (2004), Hudson and Ethridge (2000), Crutchfield (1985), Zidack (1992), and Marsh (2003, and 2007) are some examples that have been used to understand the details required to develop the catfish model here. There were several studies on price spreads and price volatility by Buguk et al. (2003) and Hudson and Hanson (1999) which were also helpful in this research. Also a study done by Kouka and Engle (1998) which estimated supply in the catfish industry was useful in determining how catfish supply at the farm level could be modeled.

At the farm level, Wohlgenant (1989) presented a model for estimating supply and demand interrelationships. Without direct information on retail quantities, Wohlgenant's model estimated the marketing sector's supply/demand structure. The results of this study are consistent with the theoretical specifications of a competitive marketing group.

In the livestock sector, Lusk and Anderson (2004) looked at the effects of Country-of-Origin Labeling (COOL) on the welfare of participants. Using an estimated supply-demand framework for livestock, they analyzed existing estimates of COOL costs and looked into their impact on consumer and producer surplus. The effect of incidences of costs on the welfare of market participants were shown by conducting sensitivity analyses. Looking at the effects of COOL costs on producer, processor, retailer and consumer demand were possible by horizontally linking beef, pork, and poultry demands at the retail level and vertically linking the farm, wholesale, and retail sectors. Lusk and Anderson (2004) showed that COOL costs could be offset by increases in demand, whether paid by producers or processors, and by the increases in welfare to producers and/or processors.

The effects of COOL costs were also investigated by Brester et al. (2004). The farm, wholesale, and retail markets for meat and livestock in the beef, pork, and poultry sectors were used to estimate short-run and long-run changes in equilibrium prices and quantities through an equilibrium displacement model or a modification of the Wohlgenant model (1989). Brester et al. (2004) was able to estimate changes in producer surplus at each level of the marketing chain and consumer surplus at the retail level to determine the welfare effects of the COOL implementation cost shock. The results show that an increase in COOL marketing cost for the beef and pork sector will cause consumers to substitute these products for poultry, whose cost structure is not affected by COOL legislation.

In the international trade sector Hudson and Ethridge (2000) looked at the income distributional impacts of Pakistan trade polices in a multi-market framework. Hudson and Ethridge (2000) looked at export taxes, using them as price controls in a multi-market framework. When an export tax was placed on cotton, results showed an increase in consumption domestically and a drop in exports of Pakistani cotton. This led to more government generated revenue, which was good in the short-run, but since cotton yarn is an intermediate good, their study suggested that wealth was transferred outside the domestic economy in the long-run. A system of simultaneous equations was estimated using the two-stage least squares and three-stage least squares procedures to estimate the distributional impacts associated with the export tax policy simulation.

Marsh (2003) looked at the impacts of declining U.S. retail beef demand on farm-level beef prices and production. A structural inverse-demand-and-supply equation was estimated to determine the effects on farm-level beef prices and production. The Marsh model consisted of six equations: three slaughter equations and three feeder equations. Both the slaughter and feeder equations contained one supply and one demand equation, and each contained a market clearing equation as well. In the estimation procedure, Marsh used an iterative three-stage least squares approach. Agricultural producers found that demand and supply cross effects are important, due to the dynamics of these industries. Instead of having slaughter and feeder equations, this research will contain processor- and farm-level equations, each containing a supply and demand equation, and both containing a market clearing equation. This would lead to a model having a total of four equations to be estimated using the three-stage least squares method.

Marsh (2007) also developed a model for cross-sector relationships between corn feed grain, livestock, and poultry economies. A structural inverse-demand-and-supply equation was estimated to determine the effects on farm-level corn, feeder calf, slaughter cattle, and slaughter hog prices and production. Each equation contained a market-clearing condition for price and quantity. Farm demand prices and production are affected by shifts in retail beef demand, which would cause prices and production at the farm to either increase or decrease depending on the shift of the demand curve. In the econometric estimation procedure Marsh used the three stage least squares regression estimation procedure, and estimated all equations using double-logs. Instead of having eight structural inverse-demand-and-supply equations as Marsh, this research contains only one inverse demand equation at the import level. Imported catfish prices will be the dependent variable, and both the farm- and processor- level will contain supply and demand equations estimated using the three stage least squares procedure.

Crutchfield (1985) developed a model of a multi-level market for U.S. groundfish. A groundfish is a species or group of fish that lives most of its life near or on the bottom of the sea. The U.S. groundfish market contains several different market sectors and a variety of groundfish product forms. The model included sixteen equations estimated simultaneously using the three-stage least squares procedure. The model included 17 exogenous variables, four lagged endogenous variables, and 16 endogenous variables. The model provided elasticities, and significant variable estimates for the interrelationships between domestic landings, foreign imports, and consumer preferences related to the determination of fish price and consumption. Such an econometric model could be used to analyze public policy issues as it relates to the groundfish industry. Crutchfield used disaggregated data, whereas this research contains aggregate data, and only six equations. Furthermore, this research looks at a multi-level market, and the complete model can be used to analyze public policy issues and determine catfish price and quantity changes under varying policy options.

Traesupap et al. (1999) developed a simultaneous-equation model of supply and demand for the Japanese shrimp import market. Their model contained two structural equations and four identities. The structural equations were supply and demand equations for Japanese shrimp imports. These two structural equations represented a simultaneous system of equations, which was used to determine the own- and income-price effect of import quantities. Their results showed that increases in imports of shrimp to Japan have not had a significant impact on Japan's domestically caught shrimp price and quantities. Their research did not contain a supply equation or identities at the import level. However, their research looked at the responsiveness of quantities when there was a change in price at the farm and processor levels. The import demand equation is a price transmission equation, which looks at the responsiveness of catfish import prices when there is a change in price at the import level.

Chavas and Johnson (1982) stated that in poultry markets, supply response was difficult to represent in forecasting and policy analysis models. Even with a quarterly time frame, supply response was difficult to model for poultry since the production was completed in one year. But by directly using the biological process in the supply response structure, market models for quarterly data have plausible dynamic properties, and development for adjustment characteristics can be foreseen. Within the poultry industry the results were of significance for forecasting and policy analysis, showing the stages in production at which economic stimuli will gather its greatest response.

Zidack et al. (1992) looked at a four-equation econometric model of the U.S. catfish industry. In their study they wanted to determine the impacts of advertising on the wholesale and farm levels of the market. In their results, quasi-rents to producers have increased, despite market power held by the wholesalers. The estimates are based on monthly data from 1980-1989. The Cobb-Douglas production function was used to determine the effects of wholesale- and farm-level impacts on generic advertising campaigns. Results showed that generic advertising increased producer returns at the farm-level and processor returns at the wholesale-level. Producer surplus will increase at the farm-level for promotional advertising aimed at shifting retail demand.

Kouka et al. stated that in an attempt to estimate supply in the catfish industry, supply does not adjust in the short-run to price-fluctuations, but rather in the long-run. So supply is inelastic in the short-run and supply of food-size fish will not adjust for increases in feed costs instantaneously. The supply of catfish will react to increases in feed costs indirectly, by decreasing the supply of fingerlings purchased at the farm level. The supply of catfish is difficult to model because the production cycle takes up to two years to complete and prices of catfish and feed can fluctuate during that time. Results show that catfish supply cannot react in the short-run, because once a commitment has been made to the production cycle it must be seen through to harvest for any revenue to be received.

Much work has been done with supply and demand models at the farm- and wholesale-level. The work by Wohlegnant (1989), Marsh (2003, 2007), Crutchfield (1985), and others mentioned here have been a tremendous asset to the completion of this study. The supply and demand model developed here for the U.S. catfish industry will provide a framework that can answer many questions that arise from producers, processors, and policy makers.

2.2 Review of Previous Seafood Trade Studies

In order to have an understanding on how trade can affect domestic industries, previous trade studies involving seafood were reviewed. U.S. wholesalers import seafood from a number of countries around the world. This is mainly due to the relatively lower price of the imported product, and in some cases, countries have a comparative advantage in production of the product. The wholesalers demand for seafood depends on several factors, notably, the cost of the product and its resale value. This literature review will look at several studies that examine the seafood trade issue from several different points of view. The first set of papers looks at imports of seafood products in general, specifically catfish. The second looks at tariffs, and why they are applied to a certain country's seafood products. Studies by Ligeon et al. (1996) and Quagrainie et al. (2002) looked at the role of imported catfish and how it affects producer, domestic, and import catfish price. Hudson et al. (2003) measured the effects of a potential ban on shrimp imports in the U.S., due to exporting countries not abiding by U.S. environmental regulations. Kinnucan (2003) examined the application of U.S. imported fish tariffs and whether they significantly benefited the domestic country.

Liegeon et al. (1996) examined the possible threat posed to the U.S. catfish industry by the North America Free Trade Agreement (NAFTA). The result of their study showed that if domestic prices fell relative to that of import prices, the quantity of catfish imported would decline. U.S. levels of imports from NAFTA members have never been great and have not been seen as a threat to the catfish industry. However, results from their model showed that an increase in imports from NAFTA member countries would not have an effect on the domestic catfish industry. This research is concerned with imports from Asian countries that export the most catfish and catfish-like fish to the U.S.

Quagrainie et al. (2002) suggested that the driving force behind the increase in imports is the high fillet price. As long as wholesalers and retailers do not see a reason for paying a higher premium for U.S. catfish, they will continue to purchase the lower-priced catfish import product. Their results showed that there is a positive price transmission between the price of domestic frozen fillets and the price of imported fillets. A one dollar increase in the price of domestic frozen fillets can lead to a one dollar increase in the price of imported fillets. As long as wholesalers see no benefit in purchasing domestic fillets, imports will continue to be purchased at an increasing rate.

Kinnucan (2003) applied a targeted tariff of $0.50 per pound to Vietnamese catfish imports to determine if there were benefits to the U.S. catfish industry. The benefit of the $0.50 per pound tariff on Vietnam catfish imports was a $0.17 per pound rise in U.S wholesale prices in the short-run and $0.11 per pound in the long-run. He suggests a better way of dealing with increased imports is through marketing promotion of U.S. catfish products. Countries can then invest in the domestic catfish market, which would lead to a "win-win" scenario for all involved.

Hudson et al. (2003) explored a proposed U.S. ban on foreign shrimp because of exporters' failure to comply with U.S. environmental regulations concerning commercial shrimping nets. Using simulated trade restrictions imposed by the U.S. government, Hudson solved a system of estimated equations for quantity levels. This resulted in set prices at each import level.

Much work has been done with seafood trade studies at the farm- and wholesale-level. The work by Liegeon et al. (1996), Quagrainie et al. (2002), Kinnucan (2003), and others mentioned here has been a tremendous asset to the completion of this study. The tariffs applied to the supply and demand model developed here for the U.S. catfish industry will provide a framework that can answer many questions that arise from policy makers on the effectiveness of tariffs on imported catfish.

CHAPTER III

CONCEPTUAL FRAMEWORK

3.1 Background

Chapter two introduced the concept of supply and demand models used in previous studies, while also identifying other seafood trade studies that looked at foreign imports and their affect on domestic markets. Although the U.S. catfish industry has been the subject of considerable research, there has been little research looking at the impact of imports on U.S. catfish and the impacts of tariffs placed on those exports from foreign countries, especially Vietnam.

The focus of this study is to develop a supply and demand model to investigate the impact that catfish, catfish-like products, tilapia, trout, and salmon imports have had on the U.S. catfish industry at the farm and wholesale levels. Following Kinnucan (2003), application of a fish tariff will be helpful in determining if present tariffs placed on catfish and catfish-like products from Vietnam are really effective in solving the problems faced by the domestic catfish industry. Following Crutchfield (1985) and Marsh's (2003) multi-level market models, a similar model was developed to assess the impact of imports on the supply and demand for catfish at the farm and wholesale levels. The three-stage least squares (3SLS) procedure was used to estimate the system of equations present at the farm and wholesale levels. Ordinary least squares (OLS) was used to estimate the equation at the import level, which provided a more accurate catfish import price for use in the wholesale demand equation. The stocker equation was also estimated using OLS, and this equation helped in determining the impact of feed at the farm supply level. Further detailed information will be provided in chapter four on why 3SLS was chosen over various other estimation possibilities. Elasticities and welfare effects were derived using the variable means for 2007 and the entire data set (1993-2007); further information will be given in chapter four on the calculation of these measures at the wholesale and farm levels.

3.2 Conceptual Framework Model

This section will discuss the conceptual framework and theory used as the foundation for the empirical model. It will begin with the conceptual framework used to model the U.S. catfish industry, followed by economic theory, which gives the basis for interpreting results. An example of how tariffs will be applied to the supply and demand model is also given.

The structural model, expressed in general notation, for the U.S. catfish industry is as follows:

Wholesale Level

(1A) $QD_W = f(P_W, \hat{P}_{MC}, P_{MT}, P_{MS}, P_{MTR}, P_R, P_{FUEL}, QD_{W(-1)}, q1, q2, q3)$

(1B) $QS_W = f(P_W, P_F, P_{FUEL}, TREND, QS_{W(-1)}, q1, q2, q3)$

Farm Level

(2A) $QD_F = f(P_F, P_W, P_{FUEL}, QD_{F(-1)}, q1, q2, q3)$

(2B) $QS_F = f(P_F, P_{FUEL}, FS_{(-7)}, TREND, QS_{F(-1)}, q1, q2, q3)$

Market Clearing

(3A) $QD_W = QS_W$ (Wholesale)

(3B) $QD_F = QS_F$ (Farm)

Table 3.1 Variable Symbols and Descriptions

QD_W	Quantity of wholesale-level U.S. catfish demanded by wholesalers
P_W	Price of processed catfish
$\hat{P}_{MC}$	Predicted imported catfish prices
P_{MS}	Imported salmon prices
P_{MTR}	Imported trout prices
P_R	Retail price index for all fish
$QD_{W(-1)}$	Lag quantity of wholesale-level catfish demanded by wholesalers
$q1,q2,q3$	Dummy variables to account for seasonality
P_{Fuel}	Price of fuel
QS_W	Quantity of wholesale-level catfish supplied by U.S. processors
P_F	Price of farm raised catfish
$TREND$	Accounts for technological changes or time
$QS_{W(-1)}$	Lag quantity of wholesale-catfish supplied by processors
QD_F	Quantity of U.S. farm-level catfish demanded by processors
$QD_{F(-1)}$	Lag quantity of farm-level demanded by processors
QS_F	Quantity of the U.S. farm-level catfish supplied by producers
$\hat{FS}_{(-7)}$	Lagged predicted fingerling supply (number of fish)
$QS_{F(-1)}$	Lag quantity of farm-level supplied by farmers

Equation (1A) represents the wholesale demand for processed catfish. Domestic processed catfish prices and fuel prices should all have a negative sign to be in line with theory. Retail fish prices, imported catfish prices, imported trout prices, imported salmon prices, and imported tilapia prices should have a positive impact because they are substitutes. Dummy variables will account for seasonality within the production cycle at the farm level. Equation (1B) is the amount of catfish supplied by U.S. processors to U.S. wholesalers. The processor will supply the wholesaler with a given amount of U.S. catfish at a given price level. U.S. wholesalers have three options, buy the U.S. processed catfish, purchase imports at a relatively lower price, or a combination of the two. In equation (1B), domestic processed catfish prices, dummy variables, trend term, and lagged quantity supplied at the wholesale supply level will all have positive signs. Farm catfish prices and fuel prices will both have negative signs. National Marine Fishery Service data show the imported frozen catfish fillet prices tend to be lower than domestically processed catfish.

Equation (2A) represents the amount of farm raised catfish demanded by the processor. The impact of farm prices and fuel prices should be negative. The impact of domestic processed catfish prices should be positive. Equation (2B) is the amount supplied by the U.S. catfish farmer. The farmer will supply the processor with a given amount of catfish at a given price offered by the processor. The farmer in this case is considered a price-taker, and has no control over determining price for their catfish. Farm catfish prices, lagged fingerling quantity (predicted) from the stocker equation, and the lagged dependent variable should all be positive. Fuel prices should be negative. Equations (3A) and (3B) are market clearing conditions, which lead to the determination of equilibrium prices and quantities at both the farm and wholesale-levels. All variables and their signs mentioned in this section will be explained in greater detail in chapter four.

Figure 3.1 shows the supply and demand for catfish at the farm and wholesale levels before and after the tariff. P_{W0} and Q_{W0} are the wholesale price and quantity at the initial equilibrium. Producer surplus at the wholesale level is represented by area E, and buyer surplus at the wholesale level is represented by areas B and C. At the farm level, P_{F0} and Q_{F0} are the price and quantity at the initial equilibrium. Producer surplus at the farm level is represented by area E', and buyer's surplus at the farm level is represented by areas B' and C'.

The application of a tariff to catfish imports causes wholesale demand to shift to the right, leading to an increase in price and quantity at the wholesale level. Producer surplus at the wholesale level increases to areas E, C, and D. Buyer surplus at the wholesale level changes from areas B and C to areas A and B. Because of the increase in price at the wholesale level, farm demand shifts to the right. The increase in farm demand causes an increase in farm price and quantity. Producer surplus at the farm level increases to areas E', C', and D', and buyer surplus changes from areas B' and C' to areas A' and B'. In the following chapter specific equations to calculate buyer and producer surplus before and after the tariff are presented.

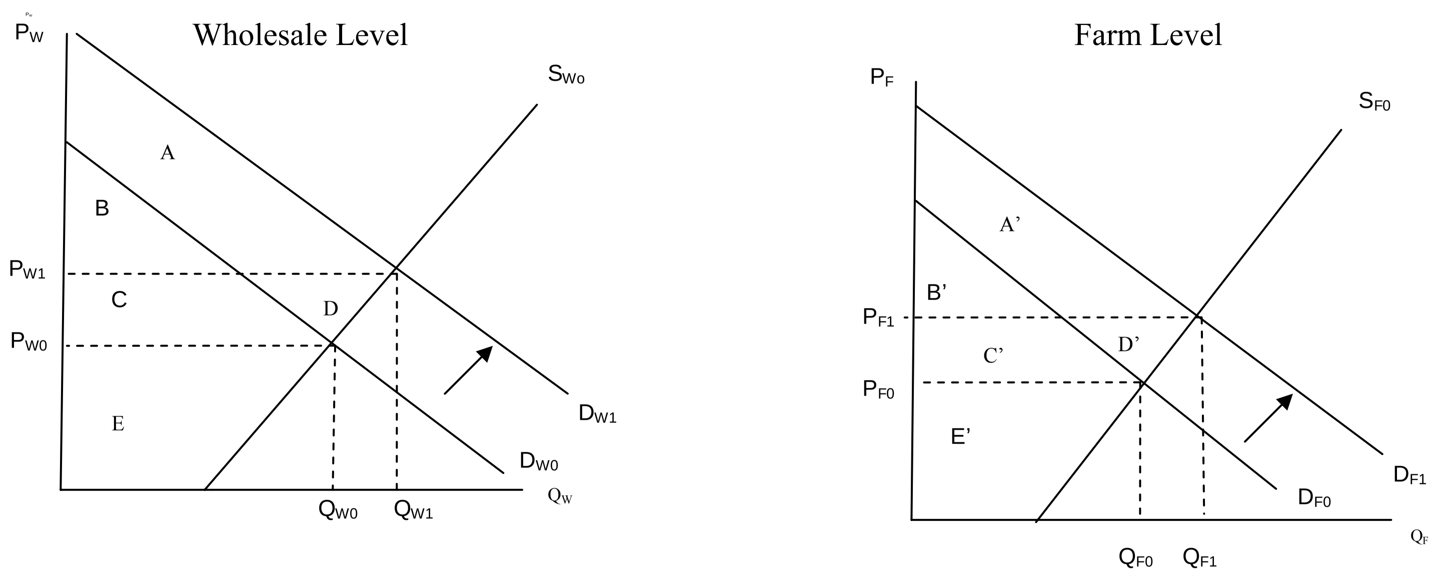

Figure 3.1 Supply and Demand at the Wholesale and Farm Level (Before and After the Tariff is Applied)

CHAPTER IV

METHODOLOGY

4.1 Econometric Model of U.S. Catfish Industry

Following Crutchfield (1985), the following six linear equations (4.1A-4.1F) are used to model the U.S. catfish industry. Variable descriptions are given in Table 4.1. The *a*', *b*'s, *c*'s, *d*'s, *α*'s, and *β*'s are parameters to be estimated. Equations 4.1A and 4.1B are the demand and supply, respectively, at the wholesale level. Equations 4.1C and 4.1D are the demand and supply, respectively, at the farm level. Equation 4.1E and 4.1F are added to the system presented in the previous chapter. Equation 4.1E is an import price transmission equation that links other import prices to the price of imported catfish. Equation 4.1F is the stocker equation that links expected price and soybean prices to fingerling supply. In equation 4.1A through 4.1F, all 1-period lagged terms are used to account for dynamic adjustments at each level. The quarterly dummy variables (q_1, q_2, and q_3) account for seasonality and the trend terms (*TREND*) account for changes in technology.

(4.1A)
$$QD_W = a_0 + a_1 P_W + a_2 P_{MC} + a_3 P_{MT} + a_4 P_{MS} + a_5 P_{MTR} + a_6 P_R + a_7 P_{FUEL} + a_8 QD_{(-1)} + a_9 q1 + a_{10} q2 + a_{11} q3 + e_{DW}$$

(4.1B)
$$QS_W = b_0 + b_1 P_W + b_2 P_F + b_3 P_{FUEL} + b_4 TREND + b_5 QS_{(-1)} + b_6 q1 + b_7 q2 + b_8 q3 + e_{SW}$$

(4.1C) $$QD_F = c_0 + c_1 P_F + c_2 P_W + c_3 P_{FUEL} + c_4 QD_{(-1)} + c_5 q1 + c_6 q2 + c_7 q3 + e_{dF}$$

(4.1D) $$QS_F = d_0 + d_1 P_F + d_2 P_{FUEL} + d_3 FS_{(-7)} + d_4 TREND + d_5 QS_{(-1)} + d_6 q1 + d_7 q2 + d_8 q3 + e_{SF}$$

(4.1E) $$P_{MC} = \alpha_0 + \alpha_1 P_W + \alpha_2 P_{MT} + \alpha_3 P_{MS} + \alpha_4 P_{MTR} + \alpha_5 P_R + \alpha_6 TREND + e_{P_{MC}}$$

(4.1F) $$FS = \beta_0 + \beta_1 P_{FE} + \beta_2 SP + \beta_3 TREND + \beta_4 FS_{(-1)} + \beta_5 q1 + \beta_6 q2 + \beta_7 q3 + e_{FS}$$

Variables descriptions are in Table 4.1, along with their units of measure. Domestic catfish quantities and prices were provided by the National Agricultural Statistic Service. Import prices were provided by the National Marine Fisheries Service. The fuel and retail price indexes were provided by the Bureau of Labor Statistics. Soybean prices were provided by the Chicago Board of Trade. The data used to estimate the model was quarterly. The time period for the data was from 1993:1-2007:4 (60 observations).

In equation 4.1A, if a_1 is negative, the law of demand holds true, as quantity demanded would increase as price decreases. If imported catfish, tilapia, salmon, and trout are substitutes for domestic catfish, then the expected signs of a_2 through a_5 should be positive. Likewise, the retail fish index price is expected to be positive as well. A unit increase in retail fish prices leads to an increase in wholesale demand by a_6 units. The expected sign of parameter a_7 should be negative because fuel is an input for wholesalers. In equation 4.1B, if b_1 is positive, then the law of supply holds, quantity supplied would increase as price increases. The expected sign of parameters b_2 and b_3 should be negative, because both are inputs for processors. In equation 4.1C, if c_1 is negative, then the law of demand holds, as the price of farm catfish increases, less would be demanded by

Table 4.1. Variable Symbols and Descriptions

QD_W	Quantity of wholesale-level catfish demanded by U.S. wholesalers (000 lbs)
P_W	Price of domestically processed catfish ($/lb)
$\hat{P}_{MC}$	Predicted imported catfish prices ($/lb)
P_{MT}	Imported tilapia prices ($/lb)
P_{MS}	Imported salmon prices ($/lb)
P_{MTR}	Imported trout prices ($/lb)
P_R	Retail price index for all processed fish and seafood (=100, 2002)
P_{FUEL}	Fuel price index throughout all levels (=100, 2002)
$QD_{W\,(-1)}$	Lag quantity of wholesale-level catfish demanded by wholesalers (000 lbs)
$q1,\ q2,\ q3$	Quarterly dummy variables to account for seasonality (1993:1, 1993:2,……..,2007:4)
QS_W	Quantity of the wholesale-level catfish supplied by U.S. processors (000 lbs)
P_F	Price of farm raised catfish ($/lb)
$TREND$	Accounts for technological changes or time
$QS_{W\,(-1)}$	Lag quantity of wholesale-catfish supplied by processors (000 lbs)
QD_F	Quantity of farm-level catfish demanded by processors (000 lbs)
$QD_{F\,(-1)}$	Lag quantity of farm-level demanded by processors (000 lbs)
QS_F	Quantity of the farm-level catfish supplied by producers (000 lbs)
$\hat{FS}_{(-7)}$	Lagged predicted fingerling supply (number of fish)
$QS_{F\,(-1)}$	Lag quantity of farm-level supplied by farmers (000 lbs)
P_{MC}	Imported catfish prices ($/lb)
FS	Fingerling supply (1,000 number of fish)
P_{FE}	Expected price of farm raised catfish ($/lb)
SP	Soybean futures price (cents/bu)
$FS_{(-1)}$	Lag fingerling supply (1,000 number of fish)

processors. The expected sign of c_2 should be positive because if processed catfish prices go up, then more catfish would be demanded from farmers. The expected sign of c_3 should be negative, due to fuel being an input for processors. In equation 4.1D, if d_1 is positive, then the law of supply holds, quantity supplied would increase as price increases. Since fuel is also an input for farmers, the expected sign of d_2 should be negative. The parameter d_3 should have a positive expected sign. If fingerling supply increases by one unit, then quantity supplied increases by d_3 pounds. Equation 4.1E, is the import price transmission equation. If parameters α_1 through α_4 are positive, then imported catfish and other products are substitutes; if not, they are complements. The retail fish price should have a positive impact, because if retail prices increase then more will be demanded from aboard which should increase imported prices.

Equation 4.1F is the stocker equation. P_{FE} is the expected price of farm-raised catfish. It is the average quarterly price of the previous year. For example, in 2000:2, P_{FE} is the average of farm prices in 1999:2, 1999:1, 1998:4, and 1998:3. A one dollar increase in P_{FE} leads to an increase in FS by β_1 units. The expected sign of β_2 is negative; soybean prices should have a negative impact on fingerling supply.

4.2 Estimation Method

4.2.1 Three-Stage Least Squares Procedure

The three-stage least squares (3SLS) estimation procedure is used to jointly estimate equations 4.1A through 4.1D. The 3SLS method accounts for P_W and P_F being endogenous in the system. If the equations are specified correctly, 3SLS yields more accurate results than the ordinary least squares (OLS) procedure (Kennedy, 2003).

Before estimating equations 4.1A-4.1D, equations 4.1E and 4.1F are estimated by OLS. The predicted values from these equations are used as instruments in equations 4.1A and 4.1D where the predicted catfish import price from equation 4.1E is used in equation 4.1A instead of the actual catfish import price, and the predicted fingerling supply from equation 4.1F is used in equation 4.1 D instead of the actual fingerling supply. This is done because the variables P_{MC} and FS may be correlated with there error terms in equations 4.1A and 4.1D, respectively.

4.2.2 Testing for First-order Autocorrelation

When a lagged dependent variable is present in an equation, the Durbin-Watson test cannot be used to test for first-order autocorrelation (AR1). Equations 4.1A through 4.1D have lagged dependent variables as explanatory variables. Therefore, the Durbin-H test must be used to determine if AR1 is present. The basic result under the null is that h is equal to:

$$(4.2) \qquad h = r\sqrt{\frac{n}{1 - n\,\mathrm{var}(b)}}$$

In equation 4.2, n is the sample size, var (b) is the sample variance of the coefficient of the lagged dependent variable, and $r \cong 1 - d/2$ where d is the Durbin-Watson statistic. If the absolute value of h is less than 1.645, then there is no AR1. If h is greater than 1.645, AR1 is present (Johnston, 1984). In equations 4.1B, 4.1C, and 4.1D the Prais-Winsten Method is used to correct for AR1, and in equations 4.1E and 4.1F the Yule-Walker method was employed to corrected for AR1 (Kennedy, 2003).

4.3 Calculating Supply and Demand Elasticities

In this section, elasticities are calculated from equations 4.1A through 4.1D.

(4.3) $$\eta_{P_w}^{sr} = \frac{\Delta QD_w}{\Delta P_w}\frac{\overline{P}_w}{\overline{Q}_w} = a_1 \frac{\overline{P}_w}{\overline{Q}_w}$$

(4.4) $$\eta_{P_W}^{lr} = \frac{\Delta QD_w}{\Delta P_W}\frac{\overline{P}_W}{\overline{Q}_w} = \left(\frac{a_1}{1-a_8}\right)\frac{\overline{P}_W}{\overline{Q}_w}$$

(4.5) $$\eta_{P_{m\hat{c}}}^{sr} = \frac{\Delta QD_w}{\Delta P_{MC}}\frac{\overline{P}_{MC}}{\overline{Q}_w} = a_2 \frac{\overline{P}_{MC}}{\overline{Q}_w}$$

(4.6) $$\eta_{P_{M\hat{C}}}^{lr} = \frac{\Delta QD_w}{\Delta P_{MC}}\frac{\overline{P}_{MC}}{\overline{Q}_w} = \left(\frac{a_2}{1-a_8}\right)\frac{\overline{P}_{MC}}{\overline{Q}_w}$$

Equations 4.3 through 4.6 are demand elasticities for the variables P_W and P_{MC} and are two of the most important elasticities derived from Equation 4.1A. These two variables are endogenous to the system of equations, and have the greatest impact on quantity demanded at the wholesale level. In equation 4.3, the short-run elasticity is calculated from parameter a_1 of Equation 4.1A. The parameter is multiplied by $\overline{P}_W$ (mean processor price of catfish) divided by $\overline{Q}_W$ (mean wholesale quantity of catfish). In equation 4.4, the long-run elasticity is calculated from parameter a_1 divided by one minus parameter a_8, (i.e. the coefficient on the lagged dependent variable in equation 4.1A). It is then multiplied by $\overline{P}_W$ divided by $\overline{Q}_W$. Equations 4.3 and 4.4 should be negative. That is, if $\overline{P}_W$ increases by one percent, then $\overline{Q}_W$ should decrease by the percent indicated by the elasticity. Equations 4.5 and 4.6 should be positive. That is, if $\overline{P}_{MC}$ (mean import catfish price) increase by one percent, then $\overline{Q}_W$ should increase by the percentage indicated by the elasticity. Short and long-run elasticities are calculated in the same manner for all other exogenous variables in equation 4.1A.

Elasticities for variables P_W and P_F from equations 4.7 through 4.10 are.

$$(4.7) \quad \varepsilon_{P_w}^{sr} = \frac{\Delta QS_w}{\Delta P_w}\frac{\overline{P}_w}{\overline{Q}_w} = b_1 \frac{\overline{P}_w}{\overline{Q}_w}$$

$$(4.8) \quad \varepsilon_{P_W}^{lr} = \frac{\Delta QS_w}{\Delta P_w}\frac{\overline{P}_w}{\overline{Q}_w} = \left(\frac{b_1}{1-b_5}\right)\frac{\overline{P}_w}{\overline{Q}_w}$$

$$(4.9) \quad \varepsilon_{P_F}^{sr} = \frac{\Delta QS_w}{\Delta P_F}\frac{\overline{P}_F}{\overline{Q}_w} = b_2 \frac{\overline{P}_F}{\overline{Q}_w}$$

$$(4.10) \quad \varepsilon_{P_F}^{lr} = \frac{\Delta QS_w}{\Delta P_F}\frac{\overline{P}_F}{\overline{Q}_w} = \left(\frac{b_2}{1-b_5}\right)\frac{\overline{P}_F}{\overline{Q}_w}$$

These represent the most important elasticities derived from Equation 4.1B. These two variables are endogenous to the system of equations and have the greatest impact on quantity supplied at the wholesale level. Equations 4.7 and 4.8 should be positive. That is, if $\overline{P}_W$ increases by one percent, then $\overline{Q}_W$ should increase by the percentage indicated by the elasticity. Equations 4.9 and 4.10 should be negative. That is, if $\overline{P}_F$ (mean domestic farm catfish price) increases by one percent, then $\overline{Q}_W$ should decrease by the percentage indicated by the elasticity. All other exogenous variables in equation 4.1B are used in the same manner for both the short and long-run elasticities.

Elasticities for variables P_F and P_W from equations 4.11 through 4.14 are.

$$(4.11) \quad \eta_{P_F}^{sr} = \frac{\Delta QD_F}{\Delta P_F}\frac{\overline{P}_F}{\overline{Q}_F} = c_1 \frac{\overline{P}_F}{\overline{Q}_F}$$

(4.12) $$\eta_{P_F}^{lr} = \frac{\Delta QD_F}{\Delta P_F}\frac{\overline{P}_F}{\overline{Q}_F} = \left(\frac{c_1}{1-c_4}\right)\frac{\overline{P}_F}{\overline{Q}_F}$$

(4.13) $$\eta_{P_W}^{sr} = \frac{\Delta QD_F}{\Delta P_w}\frac{\overline{P}_W}{\overline{Q}_F} = c_2\frac{\overline{P}_W}{\overline{Q}_F}$$

(4.14) $$\eta_{P_W}^{lr} = \frac{\Delta QD_F}{\Delta P_w}\frac{\overline{P}_W}{\overline{Q}_F} = \left(\frac{c_2}{1-c_4}\right)\frac{\overline{P}_W}{\overline{Q}_F}$$

These represent the most important elasticities derived from Equation 4.1C. These two variables are endogenous to the system of equations and have the greatest impact on quantity demanded at the farm level. Equations 4.11 and 4.12 should have negative signs. That is, if $\overline{P}_F$ increase by one percent, then $\overline{Q}_F$ (mean farm quantity of catfish) should decrease by the percentage indicated by the elasticity. Equation 4.13 and 4.14 should have positive signs, if $\overline{P}_W$ increase by one percent, then $\overline{Q}_F$ should increase by the percentage indicated by the elasticity. All other exogenous variables in equation 4.1C are used in the same manner for both short and long-run elasticities.

Elasticities for variable P_F from equation 4.15 and 4.16 are.

(4.15) $$\varepsilon_{P_F}^{sr} = \frac{\Delta QS_F}{\Delta P_F}\frac{\overline{P}_F}{\overline{Q}_F} = d_1\frac{\overline{P}_F}{\overline{Q}_F}$$

(4.16) $$\varepsilon_{P_F}^{lr} = \frac{\Delta QS_F}{\Delta P_F}\frac{\overline{P}_F}{\overline{Q}_F} = \left(\frac{d_1}{1-d_5}\right)\frac{\overline{P}_F}{\overline{Q}_F}$$

These represent the most important elasticities derived from Equation 4.1D. This variable is endogenous to the system of equations and has the greatest impact on quantity supplied at the farm level. Equation 4.15 and 4.16 should be positive. That is, if $\overline{P}_F$ increase by one percent, then $\overline{Q}_F$ should increase by the percentage indicated by the elasticity. All other exogenous variables in equation 4.1D are used in the same manner for both short and long-run elasticities.

$$(4.17)\quad \varepsilon_{SP}^{sr} = \left(\frac{\Delta QS_F}{\Delta FS} * \frac{\Delta FS}{\Delta SP} \right) = \beta_2 * d_3 \frac{\overline{SP}}{\overline{Q}_F}$$

$$(4.18)\quad \varepsilon_{SP}^{lr} = \left(\frac{\Delta QS_F}{\Delta FS} * \frac{\Delta FS}{\Delta SP} \right) = \left(\frac{\beta_2}{1-\beta_4} \right) \left(\frac{d_3}{1-d_5} \right) \frac{\overline{SP}}{\overline{Q}_F}$$

Equations 4.17 and 4.18 are how the elasticities for the SP (mean soybean future price) variable are calculated from Equation 4.1F. In order to account for feed cost, $\overline{SP}$ is used to determine the impact of feed price on $\overline{Q}_F$. Equations 4.17 and 4.18 should have negative signs. That is, if $\overline{SP}$ increases by one percent, $\overline{Q}_F$ should decrease by the percentage indicated by the elasticity.

4.4 Equilibrium Price and Quantity Analysis

The following is based on the four equations 4.1A through 4.1D in section 4.1. Equations 4.4A through 4.4D are used to calculate the equilibrium price and quantity at the wholesale and farm levels. The intercept values are calculated by taking all exogenous mean values and adding them to the original intercept.

$$(4.4A)\qquad QD_W = a_0' + a_1 P_w$$

$$(4.4B)\qquad QS_W = b_0' + b_1 P_W + b_2 P_F$$

$$(4.4C)\qquad QD_F = c_0' + c_1 P_F + c_2 P_W$$

$$(4.4D)\qquad QS_F = d_0' + d_1 P_F$$

where

$$a_0' = a_0 + a_2\overline{P}_{MC} + a_3\overline{P}_{MT} + a_4\overline{P}_{MS} + a_5\overline{P}_{TR} + a_6\overline{P}_R +$$
$$a_7\overline{P}_{FUEL} + a_8\overline{Q}D(-1) + a_9\overline{q}1 + a_{10}\overline{q}2 + a_{11}\overline{q}3,$$

$$b_0' = b_0 + b_3\overline{P}_{FUEL} + b_4\overline{T}REND + b_5\overline{Q}S(-1)$$
$$+ b_6\overline{q}1 + b_7\overline{q}2 + b_8\overline{q}3,$$

$$c_0' = c_0 + c_3\overline{P}_{FUEL} + c_4\overline{Q}D(-1)$$
$$+ c_5\overline{q}1 + c_6\overline{q}2 + c_7\overline{q}3,$$

and

$$d_0' = d_0 + d_2\overline{P}_{FUEL} + d_3\overline{F}S(-7) + d_4\overline{T}REND$$
$$+ d_5\overline{Q}S(-1) + d_6\overline{q}1 + d_7\overline{q}2 + d_8\overline{q}3$$

Setting equations 4.4A and 4.4B equal, results in the following:

$$(4.19) \quad P_W = \frac{b_0' - a_0'}{a_1 - b_1} + \frac{b_2}{a_1 - b_1} \times P_F$$

Setting equations 4.4C and 4.4D equal, results in the following:

$$(4.20) \quad P_F = \frac{d_0' - c_0'}{c_1 - d_1} - \frac{c_2}{c_1 - d_1} \times P_W$$

In equation 4.19, we insert farm price from equation 4.20 to solve for equilibrium P_W^* as follows:

$$(4.21) \quad P_W^* = \frac{\dfrac{b_0' - a_0'}{a_1 - b_1} + \dfrac{b_2}{a_1 - b_1}\left(\dfrac{d_0' - c_0'}{c_1 - d_1}\right)}{1 + \dfrac{b_2}{a_1 - b_1}\left(\dfrac{c_2}{c_1 - d_1}\right)}$$

We can use equilibrium P_W^* to solve for equilibrium P_F^* from equation 4.20 as follows:

$$(4.22) \quad P_F^* = \frac{d_0' - c_0'}{c_1 - d_1} - \frac{c_2}{c_1 - d_1} \times P_W^*$$

Solving for equilibrium Q_W^* and Q_F^* is done by substituting P_W^* and P_F^* into equations 4.23 and 4.24, respectively.

(4.23) $$Q_W^* = a_0^{'} + a_1 P_W^*$$

(4.24) $$Q_F^* = d_0^{'} + d_1 P_F^*$$

4.5 Welfare Analysis

The buyer surplus (consumer surplus) is the amount that buyers benefit by being able to purchase a product for a price that is less than what they would be willing to pay. The producer surplus is the amount that producers benefit by selling at a market price that is higher than marginal cost (Nicholson, 2005). From equations 4.4A through 4.4D, we can calculate buyer and producer surplus at the wholesale and farm levels. Buyer and producer surpluses are calculated for both wholesale and farm levels as shown below:

(4.25) $$BS_W = \left(\tfrac{1}{2}\right) * \left(Q_W^*\right) * \left(P_W^0 - P_W^*\right) * (1000)$$

(4.26) $$PS_W = \left[\left(P_W^* \times Q_W^*\right) - \left(\tfrac{1}{2}\right) * \left(Q_W^* - QS_W^0\right) * \left(P_W^*\right)\right] * (1000)$$

(4.27) $$BS_F = \left(\tfrac{1}{2}\right) * \left(Q_F^*\right) * \left(P_F^0 - P_F^*\right) * (1000)$$

(4.28) $$PS_F = \left[\left(P_F^* \times Q_F^*\right) - \left(\tfrac{1}{2}\right) * \left(Q_F^* - QS_F^0\right) * \left(P_F^*\right)\right] * (1000)$$

All surpluses are multiplied by one thousand to account for scaling. In equation 4.25, BS_W is the buyer surplus at the wholesale level, Q_W^* is the equilibrium quantity, P_W^0 is the wholesale price when quantity is set to zero, and P_W^* is the equilibrium price at the wholesale level. PS_W is the producer surplus at the wholesale level, and all other variables are the same as previously defined, except for QS_W^0, which is the supply of processed catfish when prices are set to zero.

(4.29) $P_W^0 = \frac{-a_0^{'}}{a_1}$

(4.30) $QS_W^0 = b_0^{'} + b_1(0) + b_2(P_F^*)$

BS_F is the buyer surplus at the farm level, Q_F^* is the equilibrium quantity, P_F^0 is the farm price when quantity is set to zero, and P_F^* is the equilibrium price at the farm level. PS_F is the producer surplus at the farm level, and all other variables are as previously defined, except for QS_F^0, which is the supply of farm-raised catfish when prices are set to zero.

(4.31) $P_F^0 = \frac{-c_0^{'} - c_2(P_w^*)}{c_1}$

(4.32) $QS_F^0 = d_0^{'} + d_1(0)$

An example of how equations 4.25 through 4.28 are depicted in a supply and demand graph shown in Figure 4.1.

In Figure 4.1, producer surplus is determined by calculating $P^* \times Q^*$ and subtracting out $\frac{1}{2}\left[P^* \times (Q^* - Q^0)\right]$. This is due to the supply curve in both market levels running through the horizontal axis.

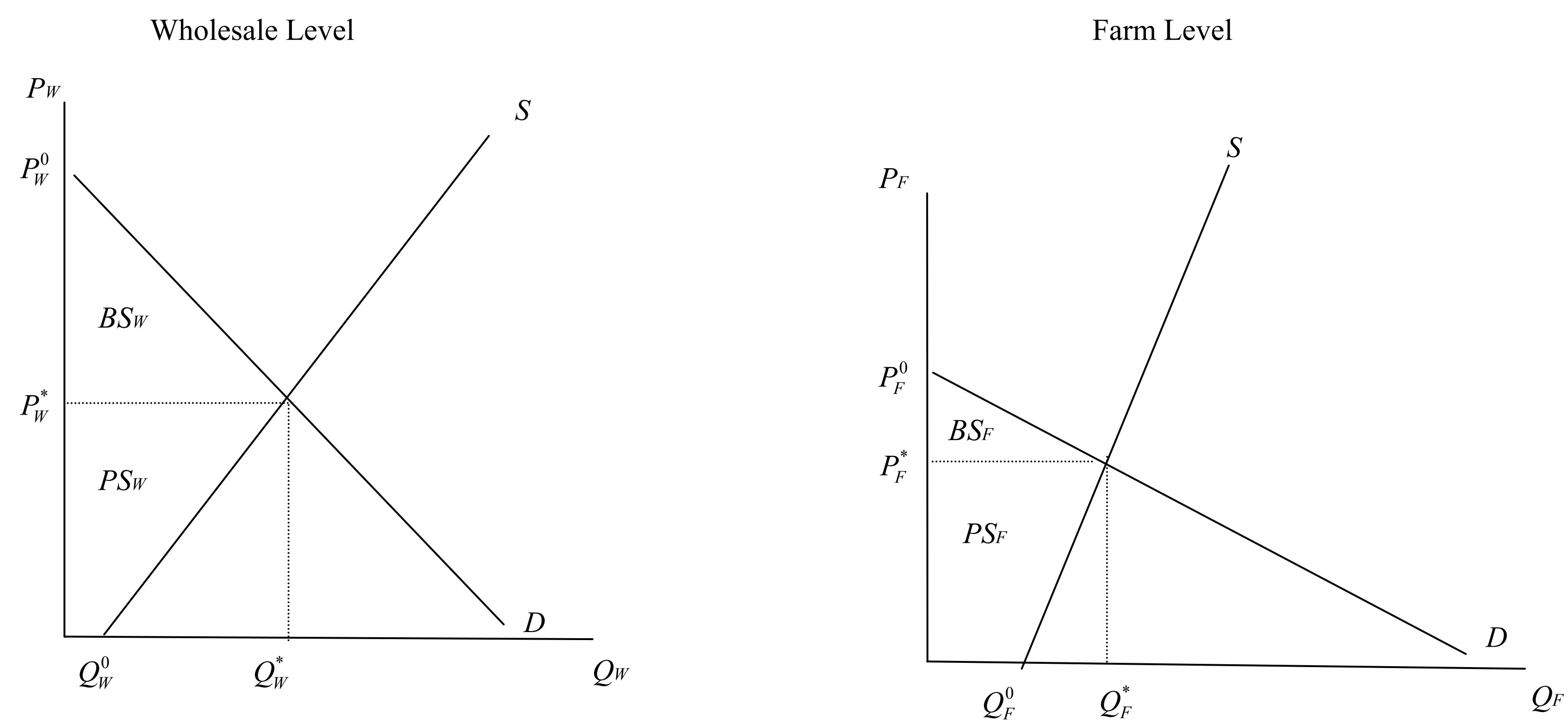

Figure 4.1. Supply and Demand: At the Wholesale and Farm Level

4.6 Trade Policy Analysis

On June 17, 2003, it was determined that Vietnamese producers and exporters made sales to the U.S. market at less than fair market value. There were four mandatory respondents to the questionnaire in this investigation, Agifish, Cataco, Nam Viet, and Vinh Hoan. Using these four companies, a final tariff margin was determined ranging from 36.84 to 52.9 percent. Any Vietnamese companies who voluntarily responded to the questionnaire received a tariff margin of 44.66 percent, based on a weighted average margin of the mandatory respondents. Imports from all other Vietnamese producers and exporters were subject to the highest tariffs margin of 63.88 percent (US D.O.C., 2003).

In order to determine a tariff margin for this trade analysis, a range of margins are used, from 36.84 to 63.88 percent. A third tariff margin for analysis comes from the average of the lowest and highest tariff, 50.36 percent. These are the three tariffs that are used in the trade policy analysis for this work. We can determine the impact of these tariffs on the U.S. catfish industry by using the share of import from Vietnam multiplied by each tariff level.

4.7 Data and Data Sources

Quarterly data from 1993 to 2007 is used to estimate the parameters in the supply and demand model. There are a total of 60 observations. All data are obtained from the National Marine Fisheries Service (NMFS), the USDA/NASS, or Bureau of Labor Statistics.

Data obtained from NMFS include all fish import prices and quantities, including imported tilapia, salmon, trout, and catfish. Import data were in metric units and were converted to English units. By taking the dollar value of monthly imports and dividing it by the monthly quantity of imports, a monthly dollar per kilogram value was calculated. The dollar per kilogram value was converted into a dollar per pound value.

All import data were aggregated, meaning all countries who exported catfish to the U.S. during January 1993-December 2007 were added together for each month. After all countries were aggregated for each month, the monthly import level data were aggregated into quarterly data. Wholesale and farm level prices and quantities came from the USDA/NASS website, specifically their catfish processing and catfish production reports. Wholesale prices were aggregate prices, which include frozen and fresh fillets and frozen and fresh other catfish. Other catfish forms include whole catfish, nuggets, and steaks. These prices and quantities were aggregated into one weighted wholesale price.

Farm prices and quantities are reported as one product, so no aggregation is needed. Also, fingerling supply is reported as quarterly data until 1998, and every six months thereafter. In the January *Catfish Production* report, information from all catfish producing states is included, but in the July report only the four largest producing states (AL, AR, LA, MS) are included. To get quarterly data for the time after 1998, a weighted average was used for quarter two and quarter four. Soybean futures prices came from the Chicago Board of Trade, price series for the months of March, June, September, and December. Soybeans futures prices are used to model stocking decisions. The fuel and retail fish price index both came from the Bureau of Labor Statistics (BLS) (BLS, 2007).

CHAPTER V

RESULTS

5.1 Model Results

The wholesale demand and supply estimation results for equations 4.1A and 4.1 B are presented in Table 5.1. The dependent variable is the wholesale quantity in 1,000 of pounds. Significant demand variables include: wholesale catfish price (P_W), imported salmon price (P_{MS}), retail fish price (P_R), fuel price (P_{FUEL}), quantity demand from the previous quarter ($QD_{W\,(-1)}$), quarterly dummy variable one ($q1$) and three ($q3$). Significant supply variables include: farm price (P_F), quantity supplied from the previous quarter ($QS_{W\,(-1)}$), and the fuel price (P_{FUEL}). The Durbin *h* statistic was calculated to test for autocorrelation. The Durbin *h* value for the wholesale demand is -0.630 and for the wholesale supply is 0.424, indicating no significant first order autocorrelation.

The price of wholesale catfish has a negative impact on quantity demanded at the wholesale level. Wholesale catfish price is significant at the 1% level. The price of imported catfish, tilapia and salmon have positive impacts on the quantity demanded, indicating that the three products are substitutes for domestically processed catfish. However, the price of imported catfish and tilapia are not significant. The price of imported salmon is significant at the 10% level. Imported trout prices have a negative impact on the quantity demanded by wholesalers, indicating that it

Table 5.1 Wholesale Level Estimates: Three Stage Least Squares Results

Demand Equation			Supply Equation		
Variable	Estimate [a]		Variable	Estimate [a]	
Constant	42,313	(3.34)***	*Constant*	6,214	(0.41)
P_W	-18,718	(-2.82)***	P_W	21,229	(1.61)
$\hat{P}_{MC}$	3,179	(0.85)	P_F	-49,588	(-2.23)**
P_{MT}	643	(0.31)	P_{FUEL}	-25	(-1.41)**
P_{MTR}	-572	(-0.49)	$QS_{W\,(-1)}$	0.68	(9.80)***
P_{MS}	2,801	(1.67)*	*TREND*	41	(0.76)
P_R	80	(2.19)**	*q1*	15,593	(15.36)***
P_{FUEL}	-23	(-1.74)**	*q2*	217	(0.19)
$QD_{W\,(-1)}$	0.65	(10.84)***	*q3*	5,272	(5.53)***
q1	15,027	(16.49)***			
q2	853	(0.79)			
q3	5,965	(6.60)***			
R^2=0.943 Durbin $\lvert h \rvert = \lvert -0.630 \rvert$			R^2 = 0.918 Durbin $\lvert h \rvert$ = 0.424		

[a] t-values are in parentheses.
*** indicates 1% significance.
** indicates 5% significance.
* indicates 10% significance.

is a complementary good. However, the price of imported trout is not significant. The retail fish index has a positive impact on quantity demanded indicating that if the index increases by one unit, quantity demanded would increase by 80 thousand pounds. The retail price index is significant at the 5% level. Fuel prices have a negative impact on quantity demanded due to the influence of fuel prices on transportation cost. Fuel price is significant at the 5% level. Given the estimate for $QD_{W\,(-1)}$ (0.65), the previous period quantity explains 65 percent of the present quarter quantity demand. This estimate is significant at the 1% level. The large coefficient on the *q1* (15,027) could be due to Lent, which takes place in February. Lent is a Catholic religion tradition that encourages the consumption of more fish products that could lead to an increase in demand during this quarter. Quarter three includes the months of July through September. More fish consumption takes place in the third quarter relative to quarter four, during which the Thanksgiving, Christmas, and New Year holidays lead to greater turkey and ham consumption. Both *q1* and *q3* are significant at the 1% level. The R^2 of 0.94 indicates that the included variables explain wholesale demand reasonably well.

In the supply equation, the wholesale catfish price has a positive impact on quantity supplied at the wholesale level. However, this relationship was not significant. Both farm price and fuel price have a negative impact on wholesale supply. This is expected from economic theory because fuel and farm-raised catfish are inputs for processors, and a price increase would raise production cost. Both farm price and fuel price are significant at the 5% level. Given the estimate for $QS_{W(-1)}$ (0.68), the quantity from the previous quarter explains 68 percent of the quantity supplied in the present quarter. This estimate was significant at the 1% level. The trend term (*TREND*) accounts for technological changes over time and was not significant. The *q1* and *q3* dummy variables in the supply equation are consistent with those in the wholesale demand equation. Given the R^2 of 0.91, the included variables explain wholesale supply very well.

The farm-level demand and supply estimation results for equations 4.1C and 4.1D are presented in Table 5.2. The dependent variable is quantity in 1,000 pounds at the farm level. Significant demand variables include: farm price (P_F), wholesale catfish price (P_W), fuel price (P_{FUEL}), quantity demanded from the previous quarter ($QD_{P(-1)}$), and quarterly dummy variable one (*q1*). Significant supply variables include: farm price (P_F), fingerling supply ($FS_{(-7)}$), quantity supply from previous quarter ($QS_{P(-1)}$), and quarterly dummy variable *q1*, *q2*, and *q3*.

Table 5.2 Farm Level Estimates: Three Stage Least Squares Results

Demand Equation			Supply Equation		
Variable	Estimate [a]		Variable	Estimate [a]	
Constant	-30,479	(-0.75)			
P_F	-422,393	(-2.71)***	P_F	40,691	(2.65)**
P_W	211,187	(2.47)**	P_{FUEL}	-92	(-1.26)
P_{FUEL}	-111	(-2.51)**	$\hat{FS}_{(-7)}$	0.07	(5.55)***
$QD_{F\,(-1)}$	0.27	(1.78)*	*TREND*	-379	(-1.46)
q1	21,333	(4.95)***	$QS_{F\,(-1)}$	0.52	(4.43)***
q2	15,301	(1.09)	*q1*	23,599	(6.37)***
q3	-1,690	(-0.38)	*q2*	-50,508	(-4.28)***
			q3	-379	(-5.88)***
R^2=0.743	Durbin $\lvert h \rvert$ = .809		Durbin $\lvert h \rvert$ =10.963	R^2 = 0.997	

[a] t-values are in parentheses.
*** indicates 1% significance.
** indicates 5% significance.
* indicates 10% significance.

As shown in Table 5.2, farm price has a negative impact on quantity demanded at the farm level. A one dollar increase in the farm price would lead to a 422.4 million pound decrease in the quantity demanded for farm-raised catfish. Farm price is significant at the 1% level. Wholesale catfish prices have a positive impact on quantity demanded at the farm level, indicating that an increase in the wholesale price of catfish will lead to more fish being demanded by processors from farmers. Since domestic processors will be able to sell their fish at a higher price, they will demand more from the farm. The price of processed catfish is significant at the 5% level. Fuel prices have a negative impact on quantity demanded. Fuel price is significant at the 5% level. Given the estimate for $QD_{F\,(-1)}$ (0.27), the quantity demanded from the previous quarter explains 27 percent of quantity demand in the present quarter. This estimate is significant at the 10

% level. Given the R^2 value of 0.74, the variables in the farm demand equation explains farm level demand well.

The farm supply equation was estimated without a constant term. Estimating the farm supply equation with a constant term caused the farm price to have a negative impact on farm supply which is counter to economic theory. Without the constant term, the farm price had a positive impact on farm supply, which is consistent with economic theory. The impact of the price of farm-raised catfish on farm supply is positive indicating that a one dollar increase in farm prices will lead to a 40.6 million pound increase in production at farm level. Farm price is significant at the 5% level. Fuel prices did not have a statistically significant impact on quantity supplied at the farm level. The fingerling supply (lagged seven quarters) has a positive impact on the current quantity supplied. The estimate for *FS* is significant at the 1% level. This variable can be interpreted as an increase in 1,000 fingerlings will result in a 70 pound increase in catfish production. The direct relationship between fingerlings and catfish production is plausible, however the size of the estimate is not. Fingerlings produce seven quarters ago does not translated into exact production seven quarters later. Given the estimate $QS_{F\,(-1)}$ (0.52), the quantity supplied of farm-raised catfish explains 52 percent of the quantity supply in the present quarter. This estimate is significant at the 10% level. Given the R^2 value of 0.99, the supply variables explain most of the variation in farm supply. Autocorrelation was present in these two equations and was corrected for using methods described in Chapter Four.

Table 5.3 reports the regression results for the stocker equation estimated using OLS. The dependent variable (*FS*) is measured in number of fingerlings per quarter. Statistically significant variables are the expected farm catfish price (P_{FE}), soybean price (*SP*), lagged quantity supply of fingerlings ($QS_{FS\ (-1)}$), and quarterly dummy variable two (*q2*), and *TREND*.

As shown in Table 5.3, expected farm catfish prices have a positive impact on fingerling supply. The estimate is significant at the 5% level. Soybean prices have a negative impact on fingerling supply. Soybean price is significant at the 5% level. The trend term accounts for technological changes in the fingerling supply. The trend term is significant at the 1% level. The lagged fingerling supply explains ten percent of the present quarter's supply. This estimate is not significant. The *q1* and *q2* variables are significant at the 1% level. Given the R^2 value of 0.74, the variables explain fingerling supply reasonably well. The predicted value *FS* is used to estimate the farm supply equation at the farm level.

The estimates of the import price transmission equation are in Table 5.4. The variables were estimated using AR1 in SAS. No variables were statistically significant in this equation. The purpose of the import price transmission equation is to link domestic prices and other import prices to the price of imported catfish for use in the wholesale demand equation. The predicted value P_{MC} is used to estimate the wholesale demand equation at the wholesale level.

Table 5.3 Stocker Equation Estimates: Ordinary Least Squares Results

Supply Equation		
Variable	Estimate [a]	
Constant	630,691	(1.34)
P_{FE}	1,409,632	(2.36)**
SP	-805	(-2.40)**
TREND	7,464	(2.69)***
$QS_{FS(-1)}$	0.099	(0.68)
q1	-624,495	(-6.94)***
q2	-788,558	(-6.12)***
q3	98,819	(0.63)
R^2=0.743	Durbin $\lvert h \rvert$ = 0.506	

[a] t-values are in parentheses.
*** indicates 1% significance.
** indicates 5% significance.
* indicates 10% significance.

Table 5.4 Import Price Transmission Equation

Variable	Estimate [a]	
Constant	-0.4390	(-0.48)
P_W	0.1791	(0.53)
P_R	0.005810	(0.90)
P_{MS}	0.1208	(0.76)
P_{MTR}	0.0502	(0.32)
P_{MT}	0.0994	(0.36)
TREND	-0.001179	(-0.19)
R^2=0.460	Durbin-Watson = 1.93	

[a] t-values are in parentheses.
*** indicates 1% significance.
** indicates 5% significance.
* indicates 10% significance.

Table 5.5 Descriptive Statistics for all variables (2007 only)

Variable Symbol	Unit	Mean	Standard deviation	Minimum	Maximum
Q_F	1,000 lbs	124,130	9,056	114,096	135,793
P_{FE}	$/lb	0.76	0.03	0.73	0.80
P_{FUEL}	Index	237	21	213	264
P_F	$/lb	0.77	0.084	0.67	0.84
P_W	$/lb	2.45	0.13	2.29	2.55
$FS_{(-7)}$	1,000 fish	1,270,979	427,924	720,871	1,732,777
Q_W	1,000 lbs	63,712	3,935	60,705	69,495
P_R	Index	182	2.06	179	184
$P_{MC\^}$	$/lb	1.55	0.09	1.44	1.66
P_{MC}	$/lb	1.59	0.02	1.56	1.61
P_{MT}	$/lb	1.48	0.02	1.45	1.50
P_{MTR}	$/lb	2.37	0.18	2.22	2.62
SP	cent/bu	891	98	795	1014
P_{MS}	$/lb	3.04	0.10	2.94	3.14
TREND		58.50	1.29	57	60
q1		0.25	0.50	0	1
q2		0.25	0.50	0	1
q3		0.25	0.50	0	1
$Q_{F(-1)}$	1,000 lbs	142,465	11,950	127,205	156,163
$Q_{W(-1)}$	1,000 lbs	63,566	3,424	60,705	69,495
FS	1,000 fish	1,152,887	422,594	720,871	1,732,047

5.2 Elasticities

Elasticities are calculated using the means from Table 5.5, which are 2007 mean values. Tables 5.6 and 5.7 report the wholesale and the farm-level elasticities calculated using the formulas from section 4.3. The *ε's* denote the supply elasticities and the *η's* denote the demand elasticities.

The own-price demand elasticity indicates the negative impact of price on the quantity demanded at the wholesale level, which is consistent with economic theory. In the short-run, a percentage increase in the wholesale price leads to a 0.718 percent decrease in the quantity demanded at the wholesale level. In the long run, the quantity demanded would decrease by 0.981 percent. A percentage increase in the retail fish price leads to an increase in wholesale quantity demanded of 0.228 and 0.312 percent in the short-run and long-run, respectively. Imported catfish, salmon, and tilapia price elasticities all show a positive impact of these prices on the quantity demanded at the wholesale level. These products are substitutes for domestic processed catfish, meaning that a one percent increase in the price of these products will lead to an increase in quantity demanded by wholesalers. Imported trout prices have a negative impact on quantity demanded by the wholesalers, and are considered to be a complementary good to domestic processed catfish. Fuel prices also have a negative impact on quantity demanded by wholesalers, which is due to fuel being an input for wholesalers.

The own price supply elasticity indicates a positive impact of the wholesale price on the quantity supplied at the wholesale level, which is consistent with economic theory. In the short-run, a percentage increase in price leads to a 0.815 percent increase in the quantity supplied at the wholesale level. In the long-run, the quantity supplied would increase by 2.95 percent. A one-percent increase in the farm price leads to a decrease of 1.9 percent in the quantity supplied at the wholesale level in the short-run and a 2.16 percent decrease in the long-run. The fuel price index has a negative impact on quantity supplied at the wholesale level. The quantity supplied decreases by 0.092 and 0.332 percent in the short-run and long-run, respectively, given a one percent increase in the fuel price.

Table 5.6 Wholesale Level Price Elasticities

Variable Name	Name	Short-run	Long-run
η_{P_W}	Own-price	-0.718	-0.981
η_{P_R}	Retail fish index price	0.228	0.312
$\eta_{P_{MC}}$	Imported catfish price	0.077	0.106
$\eta_{P_{MS}}$	Imported salmon price	0.134	0.183
$\eta_{P_{MT}}$	Imported tilapia price	0.014	0.02
$\eta_{P_{MTR}}$	Imported trout price	-0.021	-0.03
$\eta_{P_{FUEL}}$	Fuel price index	-0.085	-0.001
ε_{P_W}	Own-price	0.815	2.95
ε_{P_F}	Farm price	-1.90	-2.16
$\varepsilon_{P_{Fuel}}$	Fuel price index	-0.092	-0.332

Farm level elasticities are in Table 5.7. The own-price demand elasticity indicates a negative impact of price on the quantity demanded at the farm level. A one-percent increase in the farm price leads to a 2.61 percent decrease in the quantity demanded at the farm level in the short-run. In the long-run, the quantity demand would decrease by 3.56 percent. The wholesale price has a positive impact on the quantity demanded at the farm level. In the short-run, a percentage increase in price leads to a 4.16 percent increase in quantity demanded. In the long-run, the quantity demanded would increase by 5.68

percent. The fuel price index has a negative impact on the quantity demanded. In the short-run, a percentage increase in price would lead to a 0.21 percent decrease in quantity demanded. In the long-run, the quantity demanded would decrease by 0.29 percent.

The own-price supply elasticity indicates a positive impact of price on the quantity supplied at the farm level. In the short-run, a percentage increase in price leads a 0.25 percent increase in quantity supplied at the farm level. In the long-run, the quantity supplied would increase by 0.52 percent. The fuel price index has a negative impact on the quantity supplied. In the short-run, a percentage increase in price leads to a 0.66 percent decrease in the quantity supplied. In the long-run, the quantity supplied would decrease by 1.39 percent. Fingerling supply has a positive impact on the quantity supplied. A one-percent increase in the fingerling supply will lead to a 0.71 and 1.50 percent increase in the short-run and long-run, respectively. In order to determine the impact of feed cost at the farm level, we used the soybean price as a proxy for actual feed cost. Soybean is a major ingredient in catfish feed. If soybean prices increase by one percent, the quantity supplied at the farm-level will decrease by 5.78 and 12.12 percent in the short-run and long-run, respectively.

Table 5.7 Farm Level Price Elasticities

Variable Name	Name	Short-run	Long-run
η_{P_F}	Own-price	-2.61	-3.56
η_{P_W}	Wholesale price	4.16	5.68
$\eta_{P_{FUEL}}$	Fuel price index	-0.21	-0.29
ε_{P_F}	Own-price	0.25	0.52
$\varepsilon_{P_{FUEL}}$	Fuel price index	-0.66	-1.39
ε_{FS}	Fingerling supply	0.71	1.50
ε_{SP}	Soybean price	-5.78	-12.12

5.3 Equilibrium and Welfare

There are three tariff rates (20.35%, 28.05%, and 35.20%) that are used in the trade policy analysis in this study. These tariff rates were determined according to the discussion in Chapter Four. The results of the impact of the tariffs on the farm and wholesale level are reported in Table 5.8. Without any tariff being applied, the equilibrium price and quantity at the wholesale level are $2.74 per pound and approximately 60 million pounds, respectively. At the farm level, equilibrium price is $1.00 per pound and the equilibrium quantity is approximately 145 million pounds. Buyer and producer surpluses at the wholesale level are $96 and $84 million, respectively. Wholesale revenue is $164 million. At the farm level, buyer and producer surplus are $24 and $124 million, respectively. Farm revenue is $145 million. These results are based on 2007 mean values for the exogenous variables.

Table 5.8 General Equilibrium Price and Quantity and Changes from the Impacts of Tariffs at the Wholesale (Domestic) and Farm (Domestic) Level, 2007 mean values.

Wholesale					
Tariff (%)	Equilibrium Price ($/lbs)	Equilibrium Quantity (1000 lbs)	Buyer Surplus ($1000)	Producer Surplus ($1000)	Revenue ($millions)
	$2.74	60,026	$96,250	$84,774	$164
20.35%	+$0.05	-81	-$258	+$148	+$3
28.05%	+$0.08	-111	-$356	+$225	+$4
35.20%	+$0.10	-139	-$445	+$306	+$4
Farm					
	$1.00	145,285	$24,985	$124,994	$145
20.35%	+$0.02	+1,073	+$371	+$3,849	+$5
28.05%	+$0.04	+1,482	+$513	+$5,320	+$7
35.20%	+$0.05	+1,856	+$643	+$6,672	+$9

Table 5.8 shows the changes in price, quantity, welfare (surplus), and revenue for each applied tariff. Given the maximum tariff rate of 35.20%, the wholesale price increased by $0.10 per pound and the wholesale quantity decreased by 139 thousand pounds. Buyer surplus at the wholesale level decreased by $445 thousand and producer surplus at this level increased by $306 thousand. Wholesale revenue increased by $4 million. Given the maximum tariff rate at the farm-level, the farm price increased by $0.05 per pound, and farm quantity increased by 1.8 million pounds. Buyer surplus at the farm level increased by $643 thousand, and producer surplus at this level increased by $6.6 million. Farm revenue increased by $9 million.

The decrease in the wholesale quantity is inconsistent with economic theory and makes little sense given the increase in farm quantity. If a tariff is imposed on imports, theory suggests that quantity should increase at both levels. The decrease in the wholesale quantity is due to simultaneously solving the model at the farm and wholesale levels. Given the tariff on catfish imports, wholesale demand increases causing an increase in the wholesale price. This leads to an increase in farm demand causing an increase in the farm price. Given that wholesale supply is a function of the farm price, the increase in the farm price causes wholesale supply to shift left which causes the wholesale quantity to decrease. In theory, a farm price increase should decrease the wholesale supply only if it is caused by a decrease in farm supply. However, if the farm price increase is due to an increase in farm demand, then wholesale supply should remain unchanged. This model only gives the relationship between wholesale supply and the farm price; it can not distinguish between increases in farm price due to shifts in farm demand or farm supply. Thus, wholesale supply decreases in this analysis when in theory it should not.

Additionally, the impact of farm prices on the wholesale supply (-49,588) was relatively large. This could be due to other inputs such as labor and capital not being included the model resulting in a relatively large estimate for the farm price. Thus, not only does wholesale supply decrease given an increase in the farm price, but the decrease is quite large.

The impact of the tariffs on the wholesale and farm-level was recalculated using 1993-2007 mean values (see Table 5.10). The results based on 1993-2007 mean values are reported in Table 5.9. Without any tariff being applied, the equilibrium price and quantity at the wholesale level are $2.52 per pound and approximately 65 million pounds, respectively. At the farm level, equilibrium price is $0.90 per pound and the equilibrium quantity is approximately 153 million pounds. Buyer and producer surpluses at the wholesale level are $114 and $97 million, respectively. Wholesale revenue is $165 million. At the farm level, buyer and producer surplus are $27 and $121 million, respectively. Farm revenue is $138 million.

Given the maximum tariff rate of 35.20 %, the wholesale price increased by $0.08 per pound and the wholesale quantity decreased by 120 thousand pounds. Buyer surplus at the wholesale level decreased by $417 thousand and producer surplus at this level increased by $642 thousand. Wholesale revenue increased by $5 million.

Table 5.9 General Equilibrium Price and Quantity and Changes from the Impacts of Tariffs at the Wholesale (Domestic) and Farm (Domestic) Level, 1993-2007 mean values.

Tariff (%)	Equilibrium Price ($/lbs)	Equilibrium Quantity (1000 lbs)	Buyer Surplus ($1000)	Producer Surplus ($1000)	Revenue ($millions)
Wholesale					
	$2.52	65,427	$114,348	$97,449	$165
20.35%	+$0.05	-69	-$240	+$391	+$3
28.05%	+$0.07	-95	-$348	+$520	+$4
35.20%	+$0.08	-120	-$417	+$642	+$5
Farm					
	$0.90	153,276	$27,810	$121,190	$138
20.35%	+$0.02	+919	+$335	+$3,472	+$4
28.05%	+$0.03	+1,260	+$459	+$4,763	+$5
35.20%	+$0.04	+1,599	+$584	+$6,058	+$7

Given the maximum tariff rate at the farm-level, the farm price increased by $0.04 per pound, and the farm quantity increased by 1.6 million pounds. Buyer surplus at the farm level increased by $584 thousand and producer surplus at this level increased by $6.1 million. Farm revenue increased by $7 million. Note that wholesale quantity decreased in this case as well, which is due to reasons that were previously explained.

Table 5.10 Descriptive Statistics for all variables (1993-2007)

Variable Symbol	Unit	Mean	Standard deviation	Minimum	Maximum
Q_F	1,000 lbs	137,9883	18,934	103,252	175,991
P_{FE}	$/lb	0.76	0.03	0.73	0.80
P_{FUEL}	Index	237	21	213	264
P_F	$/lb	0.72	0.07	0.56	0.84
P_W	$/lb	2.29	0.13	2.03	2.56
$FS_{(-7)}$	1,000 fish	1,183,009	410,056	498,165	1,771,653
Q_W	1,000 lbs	68,725	9,276	51,039	85,6550
P_R	Index	157	14	133	184
$P_{MC\^}$	$/lb	1.33	0.17	0.91	1.71
P_{MC}	$/lb	1.33	0.23	0.81	1.91
P_{MT}	$/lb	1.09	0.22	0.67	1.50
P_{MTR}	$/lb	2.37	0.18	2.22	2.62
SP	cent/bu	619	109	456	1,015
P_{MS}	$/lb	2.38	0.31	1.80	3.14
$TREND$		58.50	1.29	57	60
$q1$		0.25	0.50	0	1
$q2$		0.25	0.50	0	1
$q3$		0.25	0.50	0	1
$Q_{F\ (-1)}$	1,000 lbs	138,203	19,023	103,252	175,991
$Q_{W\ (-1)}$	1,000 lbs	68,725	9,276	51,039	85,655
FS	1,000 fish	1,183,010	410,057	498,166	1,771,653

CHAPTER VI

CONCLUSION

The goal of this research was to determine how the U.S. catfish industry was affected by the tariffs on catfish and catfish-like species from Vietnam. The tariff rates were calculated by multiplying the share of U.S. catfish imports from Vietnam by each tariff rate determined by the U.S. Department of Commerce. The range of the tariff used for analysis were from 36.84% to 63.88%. In order to determine the impact of these tariffs on the U.S. catfish industry, a supply and demand model was developed. The model was used to determine equilibrium price and quantity, buyer and producer welfare, and revenue at the wholesale and farm levels. The supply and demand model included input, farm, wholesale, and import prices. Given the model estimates, the equilibrium price and quantity were determined at the wholesale and farm level using the average catfish import price. A tariff was then applied to the price of imported catfish and new equilibrium prices and quantities were determined. A comparison was then made between the equilibrium before and after the application of the tariff.

Using the 2007 mean values as a point of reference, the maximum tariff on catfish imports caused the U.S. price of wholesale catfish to increase by $0.10 per pound. The wholesale quantity decreased by 139,000 pounds. Buyer surplus at the wholesale level decreased by $445 thousand, producer surplus increased by $306 thousand, and wholesale revenue increased by $4 million. The maximum tariff on catfish imports caused the U.S. price of catfish at the farm level, to increase by $0.05 per pound and the farm quantity to increase by 1.8 million pounds. Buyer surplus at the farm level increased by $643 thousand, producer surplus increased by $6.6 million, and farm revenue increased by $9 million.

As noted in the study, the decrease in the wholesale quantity is inconsistent with economic theory. If a tariff is imposed on imports, theory suggests that quantity should increase at both levels. The decrease in the wholesale quantity is due to simultaneously solving the model at the farm and wholesale levels. The tariff on catfish imports caused wholesale demand to increase resulting in an increase in the wholesale price. Farm demand increased, due to the increase in the wholesale price which resulted in an increase in the farm price. In theory, changes in the farm price affect the wholesale supply only if it was caused by changes in farm supply.
However, if the farm price changes due to changes in farm demand, then wholesale supply should remain unchanged. The wholesale supply decreased in this analysis when in theory it should not.

For the most part, all wholesale and farm-level elasticities were consistent with economic theory. In the short- and long-run, the own-price elasticity of demand at the wholesale level was inelastic with values of -0.718 and -0.981, respectively. The own-price elasticity of supply at the wholesale level was inelastic in the short-run and elastic in the long-run with values of 0.815 and 2.95, respectively. At the wholesale level, the impact of farm price on wholesale supply was inelastic and significant.

In the short-run and the long-run, the own-price elasticity of demand at the farm level was elastic with values of -2.61 and -3.56, respectively. In the short-run and the long-run, the own-price elasticity of supply was inelastic with values of 0.25 and 0.52, respectively. At the farm level, the impact of wholesale price on farm demand was elastic and significant. At the farm level, the impact of soybean price on farm supply was elastic and significant.

The results of this research will benefit aquaculture producers, catfish processors, policy makers, and economists. The supply and demand model can provide them with information on factors affecting the catfish industry, and ways to improve the industry as a whole through analysis of policy options. It can also benefit aquaculture producers by providing supplemental information about imports and how they affect the aquaculture industry. The supply and demand model benefits the Catfish Farmers of America association, who can use such information and analyses to better inform its members about what is affecting prices at the wholesale level and the limits of policy on the catfish farming industry in the U.S.

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APPENDIX

SAS CODE

```
data sam2;
set sam2.sam8;
if Month in(1,2,3) then  quarter=1;
if Month in(4,5,6) then  quarter=2;
if Month in(7,8,9) then  quarter=3;
if Month in(10,11,12) then quarter=4;
if year=. then delete;
run;
proc sort data=sam2;
by year quarter;
run;
proc means data=sam2 noprint;
by year quarter;
var  pf qfs t p p2feed pmtr pmsal pmtil qmc pmc wf wp ww qq1 qq2 pri
gat ene ;
output out=sam6 mean=;
data sam6;
set sam6;
if quarter=1 then q1=1; else q1=0;
if quarter=2 then q2=1; else q2=0;
if quarter=3 then q3=1; else q3=0;
if quarter=4 then q4=1; else q4=0;
qfs1 = qfs * 3;
qq=(qq1+qq2)*3;
drop _type_ _freq_;
t = _n_ ;
lgat6=lag6(gat);
lgat=(gat+lgat6)/2;
lpf4=lag4(pf);
lpf5=lag5(pf);
lpf6=lag6(pf);
lpf7=lag7(pf);
lagdep=lag6(qfs1);
pfe2=(lpf4+lpf5+lpf6+lpf7)/4;
lf4=lag4(p2feed);
lf5=lag5(p2feed);
lf6=lag6(p2feed);
lf7=lag7(p2feed);
lf8=lag8(p2feed);
ffe=(lf4+lf5+lf6+lf7)/4;
lpmc=lag(pmc);
run;
data sam2;
set sam2.sam9;
if year=. then delete;
if year>2000 then dy=1; else dy=0;
lagdep1=lag(fiq);
run;
proc sort data=sam2;
by  year quarter;
run;
data sam2;
merge sam6 sam2;
proc reg data=sam2;
model fiq = pfe2 sp q1 q2 q3 t lagdep1/ dw;
```

```
output out=sam5 p=fiq_hat;
run;
proc autoreg data=sam2;
import_demand: model pmc = p pri pmsal pmtr pmtil t/nlag=1;
output out=import1 p=pmc_hat;
run;
data sam8;
merge sam2 sam5 import1;
lfn=lag7(fiq_hat);
lagdep2=lag(qq);
pmm=pmc_hat;

proc syslin data=sam8  3sls;
endogenous  pf p;
instruments pmm pri pmsal pmtr gat wf wp q1 q2 q3 lfn;
processor_demand: model qq = p pri pmm pmsal pmtr pmtil gat q1 q2 q3
lagdep2/ dw;
processor_supply: model qq = p pf gat q1 q2 q3 t lagdep2/ dw;
farm_demand: model qfs1 = pf p gat q1 q2 q3 lagdep / dw;
farm_supply: model qfs1 = pf gat lfn q1 q2 q3 t lagdep /noint dw;
run;
quit;
data sam8;
set sam8;
rho1 =   0.2999;
rho2 =   0.514;
rho3 =   0.379;
lqq=lag(qq);      qqt = qq - rho1*lqq;
lp=lag(p);        pt = p - rho1*lp;
lpf = lag(pf);    pft = pf - rho1*lpf;
lgat=lag(gat);    gatt = gat - rho1*lgat;
lq1=lag(q1);      q1t = q1 - rho1*lq1;
lq2 = lag(q2);    q2t = q2 - rho1* lq2;
lq3 = lag(q3);    q3t = q3 - rho1*lq3;
llagdep2 = lag(lagdep2);      lagdep2t = lagdep2 - rho1*llagdep2;

lqfs1=lag(qfs1);  qfs1t = qfs1 - rho2*lqfs1;
lpf = lag(pf);          pftt = pf - rho2*lpf;
lp = lag(p);            ptt = p - rho2*lp;
lgat = lag(gat);  gattt = gat - rho2*lgat;
lq1 = lag(q1);          q1tt = q1 - rho2*lq1;
lq2 = lag(q2);          q2tt = q2 - rho2*lq1;
lq3 = lag(q3);          q3tt = q3 - rho2*lq1;
llagdep = lag(lagdep);        lagdept = lagdep - rho2*llagdep;

lqfs1=lag(qfs1);  qfs1tt = qfs1 - rho3*lqfs1;
lpf = lag(pf);          pfttt = pf - rho3*lpf;
lgat = lag(gat);  gatttt = gat - rho3*lgat;
llfn = lag(lfn);  lfnt = lfn - rho3*lfn;
lq1 = lag(q1);          q1ttt = q1 - rho3*lq1;
lq2 = lag(q2);          q2ttt = q2 - rho3*lq1;
lq3 = lag(q3);          q3ttt = q3 - rho3*lq1;
llagdep = lag(lagdep);        lagdeptt = lagdep - rho3*llagdep;
lt = lag(t);            tt = t - rho3*lt;
if _n_ = 1 then do;
```

```
      q1t = q1*sqrt(1-rho1**2);
      q2t = q2*sqrt(1-rho1**2);
      q3t = q3*sqrt(1-rho1**2);
      lagdep2t = lagdep2*sqrt(1-rho1**2);
      q1tt = q1*sqrt(1-rho2**2);
      q2tt = q2*sqrt(1-rho2**2);
      q3tt = q3*sqrt(1-rho2**2);
      lagdept = lagdep*sqrt(1-rho2**2);
      tt = t*sqrt(1-rho3**2);

      pft = pf*sqrt(1-rho1**2);
      pt  = p*sqrt(1-rho1**2);
      qqt= qq*sqrt(1-rho1**2);
      qfs1t = qfs1*sqrt(1-rho2**2);
      pftt = pf*sqrt(1-rho2**2);
      ptt = p*sqrt(1-rho2**2);
      gatt = gat*sqrt(1-rho2**2);

      qfs1tt = qfs1*sqrt(1-rho3**2);
      pfttt = pf*sqrt(1-rho3**2);
      gattt = gat*sqrt(1-rho3**2);
      lfnt = lfn*sqrt(1-rho3**2);
    lagdeptt = lagdep*sqrt(1-rho3**2);
      end;
proc syslin data=sam8  3sls;
endogenous  p pf pftt ptt pfttt ptt;
instruments pmm pri pmsal pmtr gat wf wp q1 q2 q3 lfn;
processor_demand: model qq = p pri pmm pmsal pmtr pmtil gat q1 q2 q3
lagdep2/ dw;
processor_supply: model qq = p pf gat q1 q2 q3 t lagdep2/ dw;
farm_demand: model qfs1t = pftt ptt gatt q1tt q2tt q3tt lagdept / dw;
farm_supply: model qfs1tt = pfttt gattt lfnt q1ttt q2ttt q3ttt tt
lagdeptt /noint dw;
run;
quit;
data sam11;
set sam8;
proc sort data=sam11;
by quarter;
run;
proc means data=sam11 print;
var  p   pf lagdep1 lfn fiq t pfe2 pmc pmsal pmtr sp q1 q2 q3  gat
lagdep
 qfs1 pri pmtil lagdep2 lagdep1 qq ;
output out=sam11 mean=;
run;
quit;*/
```