COMPETITION BETWEEN DOMESTIC AND IMPORTED FARMED FISH –

A DEMAND SYSTEM ANALYSIS

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COMPETITION BETWEEN DOMESTIC AND IMPORTED FARMED FISH – A DEMAND SYSTEM ANALYSIS

To Thi Kim Hong

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THESIS ABSTRACT

COMPETITION BETWEEN DOMESTIC AND IMPORTED FARMED FISH -

A DEMAND SYSTEM ANALYIS

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Monthly data from 1999 through 2007 are used to estimate demand interrelationships between domestic and imported farmed fish. Specifically, a demand model is estimated for four products: imported frozen tilapia fillets, imported frozen salmon fillets, imported frozen catfish fillets, and US-produced frozen catfish fillets. The demand model used in this analysis is the Linear Approximate Almost Ideal Demand System (LA/AIDS), which is extended to include dummy variables to indicate the effect of a labeling law and US anti-dumping duties. The system is estimated with and without symmetry and homogeneity imposed to assess the sensitivity of results to restrictions implied by demand theory. In addition, the model is estimated by Seemingly Unrelated

Regression and by Three Stage Least Squares to assess the sensitivity of results to estimation procedure. Own-price elasticities estimated from the preferred models are significant and negative as expected. The demand for imported frozen catfish fillets is price elastic at -3.22 while the demand for domestic frozen catfish fillets is inelastic at -0.69. Opposite to tilapia imports, the demand for salmon imports is estimated to be price elastic at -1.51. The demand for imports of catfish, tilapia, and salmon are expenditure elastic at 2.90, 2.08, and 1.43 respectively while the demand for domestic frozen catfish fillets is expenditure inelastic at 0.38. Thus, the demand for imported farmed fish is more sensitive to changes in the US business cycle than demand for the domestic product.

Allen elasticities are calculated to determine the degree of substitutability among the four products. The closest substitute for domestic frozen catfish fillets is imported frozen catfish fillets (Allen elasticity = 5.11), followed by imported tilapia (1.09). Imported salmon is found to be a weak substitute (0.45) for domestic catfish. Imported salmon competes more closely with imported catfish (12.33) than with imported tilapia (2.80). Imported tilapia and imported catfish show a strong complementary relationship (-18.95), which means a rise in the price of either product causes the demand for the other product to fall. The US antidumping tariff against catfish imports from Vietnam is shown to positively affect the market shares of salmon and tilapia imports and to negatively the market shares of imported and domestic catfish. However, the effects are small in absolute value with the largest for imported catfish (-0.08) and the smallest for domestic catfish (-0.03). The labeling law, passed by the US Congress in 2001 to differentiate Vietnamese frozen catfish fillets from domestic frozen catfish fillets, has no significant effect on the demand curves for the two products based on the 3SLS estimates.

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I. INTRODUCTION

In the past, some nations operated a closed economy; however, this operation caused low economic growth. Trade has played an important role in the economic growth of many countries. In the United States, it has created more jobs and has raised standard of living as well as has kept the economy open, dynamic and competitive. So trade is necessary for national economic growth. So far, the United States has been the best place for doing business and the biggest trading country in the world. If export stimulates domestic production, import also has an essential role for consumers because it raises dietary variety, keeps retail prices low when domestic production declines, and makes food products available year-round (Kantor and Malanoski, 1997).

Fish is considered healthy for humans and an essential product for trade, “about 40% of all fish produced are traded internationally” (Josupeit, Lem and Lupin, 2001). Also fish plays an important role in the economics of many developing countries. The growth of aquaculture for high value species (shrimp, seabass, seabream, salmon) has had an important impact on international fish trade while species of lower value (tilapia and catfish) have successfully entered international trade in recent years (Globefish, 2005). The value of edible fishery products to the U.S. was 13.7 billion dollars in 2007, a 13% increase compared to 2006 and a 52% increase compared to 1999. The value of exported fish was $4.2 billion in 2007, a 50% increase compared to 1999, and re-export in 2007 was worth $256 million dollars (NMFS, 2007).

Salmon is a high value fish. Large increases in supplies, especially from Norway and Chile, have had a significant effect on world trade of salmon (Globefish, 2005). Between 1976 and 2003, salmon exports worldwide grew from 100,000 metric tons to over 1.7 million metric tons, and unit export value decreased from $6.20/kg in 1990 to $3.20/kg in 2005. Chile is the leading exporter of salmon to the U.S. with an import value of $863 million in 2007, which is twice the import value in 2000 (FAO, 2005).

Tilapia has become one of the most successful aquaculture products entering international trade after salmon and shrimp (Globefish, 2005). Between 1995 and 2005 production of tilapia from farms has tripled from 0.55 million to 1.67 million metric tons. Exports of tilapia have been growing and unit values have held steady or even increased in recent years. The United States is a major market for tilapia-exporting countries (Fitzsimmons, 2000), especially China (FAO, 2008).

Catfish raised on domestic farms is the fifth most consumed fish species in the United States (Josupeit *et al.*, 2001). The most popular product form is frozen fillets (Harvey, 2005). In 2005, 124 million pounds of frozen catfish fillets were sold by domestic processors, an increase of 1.5% over 2004 (Harvey, 2006). Although the U.S. is the biggest producer of catfish in the world, it imported 32 thousand tons in the first ten months of 2007, a 32% increase from 2006. Most of the imported catfish is from China, Vietnam, Thailand and Malaysia. While Ictalurus catfish imports are mostly from China, Pangasius catfish imports are from Vietnam. The price of Vietnamese catfish is $2.25-2.45/lb, $.10/lb higher than Chinese catfish imports (FAO, 2007). Previously, the low price of Vietnamese frozen catfish fillets during 1999 - 2002 has lowered the price of domestic frozen catfish fillets in the same period. Since 2003, Vietnamese catfish imports have been imposed with an antidumping tariff up to 64% and the Chinese catfish has taken advantage of this by offsetting the deficiency. The Chinese catfish has then become a main source of imported catfish in the U.S. market (FAO, 2008).

There are various studies discussing about the competitiveness between the U.S. domestic catfish and imported catfish with an estimation of demand price elasticities of the fish. In the circumstance of an increasingly important role of imported tilapia and salmon, none of these studies involves salmon, tilapia, and catfish in an estimation of the fish demand system. The objective of this research is to determine the effect of the above imported fish on the domestic catfish industry, especially the relationship between imported catfish price and domestic catfish demand. Using an Almost Ideal Demand system, this study also examines possible effects of the antidumping measures and labeling law on these goods. This research would give valuable information and insight to fish farmers, traders, and policy makers.

II. LITERATURES REVIEW

2.1. International trade for agricultural products

The role of trade is appreciated in numerous production industries worldwide. Agricultural products are essential for human existence. Many studies have discussed impacts of international trade on agricultural production for the past several years. Cramer et al. (1993), examining the effect of trade liberalization on the world rice market, predicted a large increase in both trade volumes and prices for rice products. Most rice exporters and importers would gain a significant welfare and trade liberalization which would increase the total welfare. For instance, total U.S. export revenue has grown up by 109% under trade liberalization impact.

Another study related to trade agricultural subject is of Wailes et al. (1998) with discussion on the constraints and potential of bilateral trade between the U.S. and China. They stated that China has become one of the most rapidly growing countries in the world after conducting open economy in the late 1970s. Its agricultural trade has expanded tremendously despite U.S. restrictions for competing with U.S. food and agricultural products. The authors also mentioned that China has been increasingly changing from raw agricultural production to valued-added processed and manufactured production. On the other hand, the U.S. has exported many agricultural products, especially soybean, cotton, wheat and poultry to China. Still while the China's share in U.S. farm exports is not big, it has high upward trend.

2.2 Previous studies related to US catfish industry and fish imports

Although the domestic production of catfish declined over 220 million pounds between 2003 and 2007 in the United States, it is still the most important producer of catfish in the world. Reasons for this decrease are a rising demand of agricultural crops for bio-fuels production, leading to rising costs of inputs and an improvement in catfish production of other countries (FAO, 2007). By the end of 2007, 252 million pounds of domestic catfish were sold by U.S. processors, an 11% decrease relative to the previous year. Average price received by processor was $2.44/lb, declining by 1% from 2006.

There are numerous studies discussing the U.S. catfish industry. One of these studies is of Quagrainie (2003) who uses a dynamic almost ideal demand system model to examine the U.S. catfish demand. As indicated, adjustment coefficients indicate how rapidly consumers of catfish adjust toward long-run equilibrium when real price and expenditure fluctuate. While full adjustment is finished within the subsequent two-month period, about 16% of the adjustment occurs instantaneously. With a low cost of adjustment, purchasers of catfish change quickly toward a new equilibrium after disequilibrium movements. Often, the market demand for catfish is in equilibrium. The dynamic AIDS model behaved well for catfish products. As reported, the uncompensated own-price elasticities are -0.86 for whole fish and -1.02 for fillets. Based on uncompensated form, whole fish is less own-price inelastic; fillets are own-price elastic. Expenditure elasticities are 0.486 for whole fish and 1.201 for fillets. This is different from the results Quagrainie (2006) obtained, which estimated coefficient of personal disposable income is -0.48. The result gives suggestions to processors. They need to more concerned with efficient production and marketing processes to make whole fish and fillets more price-competitive.

Studying on the U.S. catfish industry in the period of 1986 - 2005, Kaliba *et al*. (2007) evaluated the efficiency of catfish processing plants. They found that new innovations were not adopted by processors. When plant managers changed resources, technical efficiency change was unstable. In the period of 1986 – 1996, technical efficiency change had a negative relation with the optimal fish size. Technical efficiency change had a positive sign from 1995 - 2005. Fillets price and inventory accumulation increased in relation to technical efficiency gains. Based on this, plant managers can make short-term decisions to get higher prices or get rid of inventories. Market competition increases and relates positively to technical efficiency change. The catfish processing sector should be concerned with the development of new technical innovations to increase both domestic and international competitiveness.

Another study of Quagrainie and Engle (2006) determined catfish preferences of Arkansas restaurateurs from stated choice data. With respect to different attributes and buyer preferences, the threat of import competition presents unique marketing challenges to the catfish industry. Restaurant managers were grouped into some latent class segments based on their preferences. The managers in both classes were concerned with the prices of catfish products and preferred mild flavor and soft texture catfish. In addition, the managers were grouped into other classes. One class segment was not concerned with color but was very sensitive to price. The second class segment was concerned not only with color but also with the price. They were assumed that selections for dryness, flavor and texture were equal for both classes. The study reveals that the percentage of catfish products purchased from food distributors increases with the likelihood of the class segment unconcerned about color of products.

One of the studies on the effects of imported catfish on domestic catfish is the study of Ligeon *et al*. (1996). With Ordinary Least Squares regression for double-log functions, they examined the effects of catfish imports from NAFTA member countries to the U.S. domestic catfish. They found that the quantity of imported catfish will decrease when the domestic price declines which is associated with a lower import price. Their regression indicated that imported catfish is an inferior good. When the real U.S. GDP increased by 1%, the ratio of imported to domestic catfish declined by 0.13%. They also estimated that imported catfish in the period from 1970 to 1991 did not predict imports in the year of 1996, and catfish imports did not affect U.S. catfish industry.

Quagrainie and Engle (2002) applied a co-integration procedure on domestic and imported catfish. The purpose was to estimate the long-run relationships and price transmission between these goods. As reported, producer price, frozen fillets and imports price were unified. Between pairs of these prices, there exists a long-run equilibrium relationship. The producer price and the price of domestic frozen fillets have a positive price transmission. This means an increase in the price of one product correlates with an increase in price of the other. Also there is a positive price transmission between the price of imported fillets and domestic frozen fillets. However, the producer and import prices have negative price transmission. Producer's long-run price transmission elasticity for frozen fillets is 0.16. Frozen fillets - imported fillets long-run price transmission elasticity is 3.56 and producer-frozen fillets short-run price transmission elasticity is 0.32. Moreover, the market for domestic frozen fillets has an important role in the price determination of imported catfish. The relationship between the import price and price of domestic frozen fillets is strong and the price transmission elasticity for frozen fillets to imported fillets is large. High levels of fillets price have affected the level of catfish imports. If restaurateurs and distributors purchase the lower price imported catfish, the consequence is an increase in catfish imports.

Quagrainne (2006) used alternative logit methods to predict market share of U.S frozen farm-raised catfish fillets. His study indicates that log inverse power transformation (IPT) formulation gives better results than simple logit and IPT logit models, when predicting market share of U.S. frozen, farm-raised catfish fillet. The log-IPT formulation shows that higher price premiums and market shares of U.S. catfish fillets have a negative relationship. Imported catfish is substituted for domestic since it is assumed to be an undifferentiated product. This means that when the price of domestic fillets wholesale increases relative to price of imported fillets, consumers would buy imported catfish. The market shares of catfish and income have negative relationship as consumer expenditure is stable. This study found that catfish is a necessary product. In addition, while the economy changes, total demand of catfish remains stable.

There also exist other studies considering changes in domestic catfish industry which has been impacted by other imported fish and meats. Such a study was conducted by Asche et al. (2001) which determined market interactions among three groups of fish: salmon, catfish, and sea bass/sea bream. The study found that if the price of new aquaculture species declined strongly, the relations between markets for these species and market for other products would be not strong. The relative price between farmed fish and most other goods changed substantially if any other goods changed similarly in price.

Moreover, close substitutes get a highly relative price and perfect substitutes get a constant correlated price. Therefore, farmed fish and other goods did not have a closely competitive relationship. The market interactions between farmed fish and other fish and meats were small, except for wild supplies of the species which are farm-raised. With an increasing demand for fish, these farmed species had gained substantial production and taken some market share.

Comparing OLS and SUR methods, Kennedy and Lee (2005) also concerned with effects of imports of catfish, crawfish, and shrimp on domestic prices. They found that imports of catfish and shrimp had a negative effect on domestic prices. However, imported crawfish and domestic price were positively related. Their study indicated that consumption of catfish and shrimp declined as their price increased. Income and consumption of catfish, crawfish, and shrimp had a positive relationship. Therefore catfish and shrimp are normal products. This result is opposite to the previous study of Ligeon et al. (1996) which concluded that imported catfish is an inferior good. An increase in income corresponded with decrease domestic crawfish prices. Their findings also confirm that trout, clam, chicken, and pork impacted domestic prices of catfish, crawfish and shrimp. The decrease of catfish price was affected by increase of trout, clam, and chicken supplies. The result reveals that direct price flexibilities of catfish range from -0.020 to 0.006 based on five models.

As mentioned, salmon is a high value fish. A previous study working on this kind of product is the one of Kinnucan and Myrland (2005) who applied an equilibrium displacement model for the world salmon market to estimate effects of tariffs and income growth on salmon prices, production, and trade flows. They estimated that the average of long-run total income elasticity for U.S salmon imports is 1.06 with the partial elasticity is 1.17. The total income elasticity in world trade for salmon was estimated at 1.02, implying that imports worldwide grow at about the same rate as world income. In addition, domestic production is less sensitive to price change than import supply. Fixing supply affects total income elasticity for the U.S, which decreases from 1.06 to 0.98. The study also suggested that US tariffs on imports from Norway and Chile are ineffective.

2.3 The Almost Ideal Demand System (AIDS)

Methods and models used in estimation are important issues in empirical research. An inappropriate model can give biased results. Some of recent studies use equation systems to estimate demand for food. One of these is the study by Eales *et al*. (1997) that estimated Japanese demand for fish and concluded that the ordinary demand system is dominated by the inverse demand system in non-nested tests and forecasting performance. Another study is by Alston and Chalfant (1993) that compares two versions of the Linear Approximate Almost Ideal Demand System (LA/AIDS) with the Rotterdam model. They found that LA/AIDS is dominant when it is applied to meats.

The Almost Ideal Demand System (AIDS) had its origins in early work by Richard Stone (Deaton and Muellbauer, 1980). The AIDS has proved popularly in empirical word due to several advantages. It gives an arbitrary first-order approximation to any demand system and a second-order local approximation to any cost function, permits exact aggregation over consumers with different incomes, satisfies restrictions imposed by the consumer allocation problem, and permits testing of the general restrictions of homogeneity and symmetry. Applications of the AIDS to studies on food and agricultural products include Lee and Pitt (1986), Green and Alston (1990), Kinnucan *et al*., (1997), and Fousekis and Revell (2000). Applications of the AIDS to studies on fishery products can be seen in those of Wellman (1992), Ligeon, Jolly and Jackson (1996), Eales, Durham and Wessells (1997), Salvanes and Devoretz (1997), and Holt and Bishop (2002). Green and Alston (1991) also discussed formulas and corrected formulas used to calculate price and expenditure elasticities for the LA/AIDS.

Given the foregoing advantages, in this study the LA/AIDS model was selected to estimate the demand for U.S. fish imports.

2.4. Labeling Law

Labeling was considered a technical barrier to restrict imports. In July 1991, the U.S. passed a law to restrict fish imports from countries that permitted "large-scale driftnet fishing" because the driftnet fishing system for tuna also leads to killing of dolphins. This law also banned imported tuna from third-world countries that purchase the fished tuna. As this case was taken to GATT, eco-labeling is approved by GATT and named a better program to solve the problem than trade restrictions. This is good because the consumer can have some choice and may be happy to pay a premium. Labeling has been preferred to use as a trade barrier. After "Dolphin-safe" was labeled, the "unsafe" tuna is difficult to be sold in the U.S. market (Hogendorn, 1996).

In the U.S., seafood imports, recently gain 50%-70% of total seafood supply; imported catfish is named a new phenomenon to the catfish industry (Hanson, 2005). Catfish raised popularly in U.S. Southern states are from the Ictaluridae family, mostly channel catfish (*Ictalurus punctatus*) and blue catfish (*Ictalurus furcatus*) farmed in closed ponds, while Vietnamese catfishes are basa (*Pangasius bocourti*) and tra (*Pangasius pangasius*) belonging to Pangasius family and cultured popularly in cages and pens along the Mekong River. Imports of frozen catfish fillets from Vietnam had increased strongly during 1999-2002, and the country was the largest exporter of frozen fillets to the U.S. catfish market (Quagrainie and Engle, 2006). To protect domestic catfish industry, the US Congress passed a law in December 2001 restricting the use of the word "catfish" for labeling to only those Ictaluridae varieties farmed in US (Narog, 2003). According to Duval-Diop et al. (2005), the labeling law is an effectively technical trade barrier which is supported by the farm lobby and other interests.

For some agro-products, exporters are more successful when labeling favorite products and marketing them to the world such as French champagne, Florida oranges, or Kobe beef. These products are labeled by a geographical location because they have different qualities from the others (Duval-Diop and Grimes, 2005). However, it is difficult to distinguish between U.S. and Vietnamese catfish. The texture and taste of the products are similar, but the price of Vietnamese catfish is lower (ITC, 2002). This is consistent with a statement of Kinnucan (2003) that import and domestic catfish fillets are not totally differentiable. In addition, decision of consumer is mediate factor which affects the competition between these catfish products. If so, consumer must adjoin labels and other product information beside background about the products. It is confusing to U.S. consumers to see the label "basa" on imported catfish from Vietnam at the first time they purchase it (Duval-Diop and Grimes, 2005). Yet, as quoted by Nalley (2007), basa imported from Vietnam and domestic frozen catfish fillet are differentiable products based on texture, color, taste, and name recognition. After the label law has been imposed on Vietnamese catfish, it creates new market, which has favorable difference that increases demand for Vietnamese catfish and reduces demand for the US catfish.

2.5 Antidumping Tariff

While many countries try to liberalize their economy toward a free trade, less competitive domestic industries often seek protection in the form of import restrictions. Antidumping duties is one of the more popular tools allowed by the GATT/WTO to assure trade principles and to protect domestic industry from a dumping of low-price imports.

According to Prusa (2005), antidumping has been increasingly used by more countries and on more products. Traditionally, high-income countries, such as the United States and EU nations, have been the dominant users of antidumping provisions. In recent years, the trade tool has used by more and more middle- and lower-income countries. However, because antidumping measures typically are not imposed on all exporters (Asche, 2001, and Prusa, 1996), their ability to benefit domestic producers is problematic. The reason is that declines in imports from the targeted countries are often offset by increases in imports from non-targeted countries. In addition, import demand tends to more elastic than export supply, which means most the tariff is borne by foreign producers rather than domestic consumers (Kinnucan 2003).

A number of studies have invested the effect of antidumping duties on domestic prices and trade flows. One of these is by Asche (2001) who examined changes in price and market shares when an antidumping duty was imposed on Norwegian salmon imports in 1996. Another is study of Kinnucan and Myrland (2005), which examined effects of the U.S. antidumping tariff on Norwegian and Chilean salmon imports. In both of these studies the tariffs were found to have little impact on prices in the U.S. market.

In the case of catfish, the United States have imposed an antidumping tariff on Vietnamese frozen catfish fillets since 2003 with ranges between 37 and 64% of import values. The expectation of this antidumping tariff is to protect domestic catfish industry by increasing domestic price and domestic sell. Several studies have examined the effect of this antidumping tariff on domestic and imported catfish. According to Kinnucan (2003), the tariff punishes Vietnamese exporters but does not give a significant benefit to U.S. catfish producers. Moreover, the tariff motives an increase in catfish imports from non-taxed countries. The conclusion is affirmed by Duval-Diop (2005) who found that although catfish imports from Vietnam declined 70% in the two years following the duty (from 2001 to 2003) U.S. farm prices did not strengthen appreciably. However, Nalley (2007) stated that the tariff initially had an impact on the budget share of domestic frozen catfish fillets in the month after the imposition and then decreased to no more effect.

III. MODEL SPECIFICATION

3.1 Model specification

Assuming frozen fillets imports of salmon, tilapia, and catfish constitute a separable group, this study uses the Linear Approximate Almost Ideal Demand System of Deaton and Muellbauer (1980) to estimate import curves for these products. Frozen catfish fillets produced in the United States were added to the system to explore the possible effects of imports on the demand for the domestic product.

The Linear Approximate Almost Ideal Demand System (LA-AIDS) model has the following basic form:

$$(1) \qquad R_{it} = \alpha_i + \sum_{j=1}^{4} \theta_{ij} \ln P_{jt} + \beta_i \ln(Y_t / P_t^*) + \varepsilon_{it}$$

where $i = 1, \ldots, 4$ index the product (1 = salmon, 2 = tilapia, 3 = catfish imports, and 4 = domestic catfish); R_{it} is the expenditure share for the i^{th} product at time t: P_{jt} is the price of the j^{th} product at time t; Y_t is total US consumer expenditure on the four products at time t; P_t^* is the Stone price index at time t calculated as $\ln P_t^* = \sum_{i=1}^{4} R_{it} \ln P_{it}$, and ε_{it} is a random disturbance term.

Previous research indicates the demand for catfish is seasonal with demand peaks occurring during the Lenten season and late summer or early fall (see, e.g., Kinnucan and

Miao, 1999). Therefore, dummy variables were added to the model to account for seasonal shifts in preferences:

$$(2) \qquad R_{it} = \alpha_i + \sum_{j=1}^{4} \theta_{ij} \ln P_{jt} + \beta_i \ln(Y_t / P_t^*) + \sum_{q=1}^{3} \phi_{iq} QRT_{qt} + \varepsilon_{it}$$

where QRT_{qt} equals one in calendar quarter q and zero otherwise.

Since 2003 the United States has imposed anti-dumping duties on imports of frozen catfish fillets from Vietnam (Kinnucan, 2003; Zanardi, 2004; Prusa, 2005). The duties ranged between 37 and 64% of import value (Duc and Kinnucan, 2007). To determine the effect of the tariff a dummy variable was added to the model as follows:

$$(3) \qquad R_{it} = \alpha_i + \sum_{j=1}^{4} \beta_{ij} \ln P_{jt} + \lambda_i \ln(Y_t / P_t^*) + \sum_{q=1}^{3} \phi_{iq} QRT_{qt} + \delta_i TARIFF_{it} + \varepsilon_{it}$$

where $TARIFF_t$ equals one for the tariff period (January 2003 through December 2007) and zero otherwise.

Another tool used to restrict catfish imports is labeling (for a general discussion, see Duval-Diop and Grimes (2005)). Specifically, in 2001 the U.S. Congress passed a law that does not allow catfish imported from Vietnam to be labeled "catfish" like the channel catfish produced in the United States (Narog, 2003). To determine whether the labeling law had the intended effect, an interaction term was added to the model as follows:

$$(4) \qquad \begin{aligned} R_{it} = {} & \alpha_i + \sum_{j=1}^{4} \theta_{ij} \ln P_{jt} + \beta_i \ln(Y_t / P_t^*) + \sum_{q=1}^{3} \phi_{iq} QRT_{qt} + \delta_i TARIFF_t \\ & + \varphi_i (\ln P_3 \cdot LABEL_t) + \varepsilon_{it} \end{aligned}$$

where $LABEL_t$ equals one during the label period (December 2001 through December 2007) and zero otherwise. The coefficient of the interaction term, φ_i, reflects the effect of the labeling strategy on the sensitivity of budget share to changes in the price of imported catfish. Thus, for example, if $\varphi_3 > 0$, the labeling strategy has made the budget share for imported catfish less sensitive to changes in the price of imported catfish. In general, one would expect the labeling to make demand for imported catfish less elastic, and to reduce the substitutability between domestic and imported catfish. These hypotheses are tested later in the study.

To satisfy theory the coefficients in equation (4) must satisfy the following restrictions:

(5a) $$\sum_{j=1}^{4} \theta_{ij} = 0 \quad \text{for all } i$$ (homogeneity)

(5b) $$\theta_{ij} = \theta_{ji} \quad \text{for all } i \text{ and } j$$ (symmetry)

(5c) $$\sum_{i=1}^{4} \alpha_i = 1; \sum_{i=1}^{4} \theta_{ij} = \sum_{i=1}^{4} \beta_i = \sum_{i=1}^{4} \phi_i = \sum_{i=1}^{4} \delta_i = \sum_{i=1}^{4} \varphi_i = 0$$ (adding up).

In estimation, adding up is treated as a maintained hypothesis; homogeneity and symmetry can be tested for their compatibility with the data.

Conditional elasticities are computed from the estimated coefficients as follows:

(6a) $$e_{ii} = -1 + \frac{\theta_{ii}}{R_i} - \beta_i$$ (Marshallian own price)

(6b) $$e_{ij} = \frac{(\theta_{ij} - R_j \beta_i)}{R_i}$$ (Marshallian cross-price)

(6c) $$e_i = 1 + \frac{\beta_i}{R_i}$$ (expenditure)

(6d) $$e^*_{ij} = e_{ij} + R_j e_i$$ (Hicksian own and cross price)

(6e) $$a_{ij} = \frac{e^*_{ij}}{R_i}$$ (Allen substitution)

After the labeling law goes into effect, the Marshallian price elasticities are calculated as follows in (6f) and (6g). The detail formulas are indicated in appendix A.

(6f) $$e_{i3} = \frac{(\gamma_{i3} - R_3\beta_i + \varphi_i)}{R_i}$$ $i \neq 3$ (Marshallian cross-price)

(6g) $$e_{33} = \frac{(\gamma_{33} - R_3\beta_3 + \varphi_3 - R_3)}{R_3}$$ $i = 3$ (Marshallian own-price)

Following Irwin (2003), standard errors for elasticities were computed by dividing the standard error of estimated coefficients by their respective budget shares.

(7) $$se^*_{ij} = \frac{se_{ij}}{R_i}$$

Where se^* is new standard errors of elasticities; se is standard error of estimated coefficients.

3.2 Data Description

Monthly import data in the period from January 1999 to December 2007 of salmon, tilapia, and catfish are obtained from National Marine Fisheries Service, while domestic catfish quantity is obtained from the Department of Economics, Mississippi State University. All four products are in frozen fillet forms. The quantities of the four products are converted into units of pounds. Prices are represented in dollars per pound. Figure 1 shows quantities of frozen salmon, tilapia and catfish fillets imported into the United States and domestic frozen catfish fillets. Figure 2 shows the changes in budget shares while figure 3 and 4 exhibit the price fluctuation of the products.

Overall, import products have many changes especially in the period from 2001-2007, such as salmon which has deep fall points and sharp rises in 2003 (65%), 2005 (64%) and 2007 (48%); tilapia, which fluctuates much in the period 2005-2007. Although labeling law and antidumping tariff went into effect on imported catfish in December 2001 and January 2003 respectively, the quantity of import catfish has not been affected immediately at that time. Three years after the tariff imposition, catfish imports increased to over 7 million pounds (from July – October 2006). Then it experienced a deep decline in 2007. As can be seen, domestic catfish varies less than the others; it fell off about 19% after 9 years (1999-2007). In contrast to imported catfish, tilapia has had an upward trend. By the end of 2007, tilapia was imported in over 22 million pounds into the Unites States; it was 4 times higher than imported catfish.

3.3 Estimation Strategy

To determine the sensitivity of results to estimation procedure the model was estimated by seemingly unrelated regression (SUR) with NLOGIT (LIMDEP 2003) and, alternatively, by three-stage least squares (3SLS) with the Statistical Analysis Software (SAS). In 3SLS estimation, instrument variables used are TARIFF, $\ln P_3$.LABEL, QRT_1, QRT_2, QRT_3 and the first lags of endogenous variables of $\ln P_i$ and $\ln(Y/P^*)$. The endogenous variables are R_i, $\ln P_j$, and $\ln(Y/P^*)$. Additionally, the model was estimated with and without the theoretical restrictions of homogeneity and symmetry imposed. Altogether five models were estimated:

Model A: SUR without theoretical restrictions

Model B: SUR with theoretical restrictions

Model C: SUR with theoretical restrictions and correction for serial correlation

Model D: 3SLS without theoretical restrictions

Model E: 3SLS with theoretical restrictions.

IV. RESULTS

Estimation results based on January 1999 through December 2007 data are reported in Table 2. For brevity, only the results for models C and E are presented as these are indicative. The results suggest the LA/AIDS provides a good fit to the data as R^2s range from 0.80 in the salmon equation to 0.98 in the domestic catfish equation in model C, from 0.69 in the imported catfish equation to 0.98 in the domestic catfish equation in model E. Most of the estimated coefficients are significant at conventional probability levels. Prior to discussing results with respect to the policy variables, we present own-price and expenditure elasticities estimated from the five models. These are at average budget shares (0.56, 0.25, 0.15, and 0.04 respectively for salmon, domestic catfish, imported salmon, imported tilapia, and imported catfish).

4.1 Own Price and Expenditure Elasticities from the Five Models

The Marshallian own-price elasticities are listed in Table 3. All are significant, all of the own price elasticities are negative as expected. This result is consistent with the demand theory, which states that demand for a product declines with its higher own price. While imported catfish has the biggest own price elasticities (3.22) in absolute value, domestic catfish has the smallest own price elasticities (0.69) in absolute value. The imported catfish demand is confirmed to be price elastic as the one way *t*-test rejects the null hypothesis of unique price elasticity at 95% significant level. In other words, if imported catfish price increases by 1%, its demand declines by 3.22%, *ceteris paribus*.

The demand for domestic catfish is shown to be price inelastic at -0.69 as the one way *t*-test rejects the null hypothesis of unique price elasticity at 95% significant level. The result somehow is similar to the result of Zidack, Kinnucan and Hatch (1992) which stated catfish supply is price inelastic in the short run.

The demand of salmon imports is also estimated to be price elastic ($P<0.05$) as it decreases by 1.51% for a 1% increase in its price. The remaining fish product, tilapia imports, seems to be price inelastic with calculated own price elasticity of -0.86. However the t-test can not reject the null hypothesis of its unique price elastic at 95% significant level.

As shown in Table 3, expenditure elasticities of imports of catfish, tilapia, and salmon, and domestic catfish are 2.90, 2.08, 1.43, and 0.38, respectively. It means the demand for the products increases by 29.0%, 20.8%, 14.3%, and 3.9%, respectively, if expenditure for one of them grows by 10%, controlling the others factors. Expenditure elasticities of the fish imports and domestic catfish are positive at the 95% level of statistical significance. So all of goods are normal goods which is relevant to previous conclusions such as Zidack and Hatch (1991). However, it is opposite to study of Ligeon et al. (1996), which found that imported catfish is an inferior good. Furthermore, imports of salmon, tilapia, and catfish are income elastic which the elasticities are bigger than one; especially demand of imported catfish has a big change with respect to a change in its expenditure. One of these results (for salmon) is not opposite to the conclusion of Kinnucan and Myrland (2005) that total income elasticity for U.S salmon imports is positive and just above one unit. Unlike fish imports, domestic catfish is shown expenditure inelastic because the size of impact is small, less than one unit.

4.2 Elasticity Estimates from Models C and E

There are some weak impacts of catfish and tilapia imports price on salmon imports demand, but the effect of tilapia imports price is not significant at 95% level (Table 4). The calculated Marshallian elasticities in this table seem to be problematic because the same two goods get different signs in the elasticity matrix. So Allen elasticities are calculated to indicate relationships between demand of the products and price of the other substitutes and how strong they are (Table 6). Generally, Allen elasticities of Model E give interesting results and all cross price elasticities are symmetrical as expected.

There are substitution relationships between goods such as imported catfish and domestic catfish; domestic catfish and tilapia; domestic catfish and salmon; tilapia and salmon; salmon and imported catfish. Moreover, Allen elasticity of domestic catfish and imported catfish is 5.11; they are the closest substitutes which would make obvious sense. On the other hand, tilapia and imported catfish are complements. Although, this finding is different from assumption, it is more reasonable if it is in the case the traders import these 2 goods together.

4.3 Seasonal Effect

Dummy variables represent for the first three quarters of the year and the last quarter is used as the base. Overall, the biggest decrease takes place in the budget share of imported salmon and tilapia in the first quarter. The budget share of imported salmon decreases at 5% level of statistical significance in the first and second quarters (Table 2), while the shares of tilapia and catfish imports decline in the months from January to March. On the other hand, the share of domestic catfish increases in the first three quarters relative to the fourth quarter with the biggest peak happening in the first quarter. This result is relevant to the previous finding of Zidack, Kinnucan and Hatch (1992).

4.4. Tariff Effect

The United States has imposed an antidumping tariff on imported catfish from Vietnam since January 2003. The dummy variable for the tariff represents a single shift on shares of products after the tariff imposition. As shown in Table 2, the tariff positively affected shares of salmon and tilapia imports but negatively affected imported and domestic catfish. Before tariff went into effect, share of frozen Vietnamese catfish fillets was large above 95% (2002). After the tariff went into effect, the share of Vietnamese catfish has been declining (figure 5). It decreased to 65% (2004) and 43% (2007). However shares of catfish imports from other countries as China and Thailand are increasing, and share of domestic catfish has not increased (figure 5). Moreover, although the effects of the tariff are statistically significant (*t*-ratios exceed 2.5), they are small in absolute values with the larger for catfish imports (-0.068) and the smaller for domestic catfish (-0.03). Consequently, these numbers do not seem to be economically significant. The result is consistent with conclusions of Kinnucan (2003), Duc and Kinnucan (2007), and Nalley (2007). It is reasonable as domestic catfish and imported catfish are differentiable because Vietnamese catfish (basa or tra) are not perfect substitutes for domestic catfish (Nalley, 2007).

4.5 Labeling Law Effect

From December 2001, the United States Senate has not allowed imported catfish from Vietnam to get the brand name of “catfish” of the competitive catfish raised in the

Mississippi Delta. In this study, the label is considered as a cause of a structural change in demand of catfish imports. As reported in Table 4, the labeling law increases the substitute effect of catfish imports price on the demand of salmon imports but decreases the effects of catfish imports price on demands for tilapia imports, catfish imports and domestic catfish. Furthermore, the labeling law changes the relationship of domestic catfish and imported catfish as substitutes before the law went into effect but became complements after it was instituted. However, the labeling effects are not significant statistically because their t-ratios are small.

V. CONCLUSION

The LA/AIDS models give price elasticities and expenditure elasticities relevant to theory with signs as expected. While imported catfish has the biggest own price elasticity (-3.22), domestic catfish has the smallest own price elasticity (-0.69) in absolute values. Opposite to the demand for tilapia imports, the demand of salmon imports is estimated to be price elastic at -1.51. Expenditure elasticities of imports of catfish, tilapia, salmon, and domestic catfish are estimated to be 2.90, 2.08, 1.43, and 0.39, respectively. It indicates that the fish imports are income elastic while domestic catfish is income inelastic. With Allen elasticities calculated, the study estimates a substitution between imported catfish and domestic catfish. Substitutions are also shown between domestic catfish and tilapia imports, between domestic catfish and salmon imports, between tilapia imports and salmon imports, and between salmon imports and catfish imports. While domestic frozen catfish fillets and imported frozen catfish fillets are estimated to be close substitutes (Allen elasticity = 5.11), frozen fillets imports of tilapia and catfish are likely to be complements (-18.95). Although this finding is different from the assumptions made in the model, it is more reasonable if traders do import these two products together.

The U.S. antidumping tariff is shown to positively affect the market shares of salmon and tilapia imports, but to negatively impact the shares of imported and domestic catfish. However, these are very small in their magnitudes and therefore, have insignificant economic implications. The 3SLS regression estimates that the 2001 labeling law on catfish brand name had no statistically significant effect on the demand for the two products of catfish. The antidumping measures and labeling law appear not to be efficient policies to support domestic catfish industry as expected because they do not increase the market share or demand for domestic frozen catfish fillets. To enhance the competitiveness for domestic catfish, market promotion might be considered as an alternative tool to support the domestic catfish industry.

REFERENCES

Alston, J. M. and J. A. Chalfant, 1993. The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models. *American Journal of Agricultural Economics*. 75(2): 304-13.

Asche, F. (2001). Testing the Effect of an Anti-Dumping Duty: The US Salmon Market. *Empirical Economics* (2001) 26:343-355.

Asche, F., T. Bjorndal and J. A. Young, 2001. Market Interactions for Aquaculture Products. *Aquaculture Economics and Management*. 5(5-6): 303-18.

Buguk, C., D. Hudson and T. Hanson, 2003. Price Volatility Spillover in Agricultural Market: An Examination of US Catfish Markets. *Journal of Agricultural and Resource Economics*. 28(1): 86-99

Cramer, G. L., E. J. Wailes and S. Shui, 1993. Impacts of Liberalizing Trade in the World Rice Market. *American Journal of Agricultural Economics*. 75(1): 219-26.

Deaton, A. S. and J. Muellbauer, 1980. An Almost Ideal Demand System. *American Economic Review*. 70(3): 312-26.

Duc, N.M. and H. W. Kinnucan, 2007. Effects of Antidumping Duties with Bertrand Competition: Some Evidence for Frozen Catfish Fillets. Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007

Duval-Diop, D. M. and J. R. Grimes, 2005. Tales from Two Deltas: Catfish Fillets, High-Value Foods, and Globalization. *Economic Geography*. 81(2): 177-200.

Eales, J., C. Durham and C. R. Wessells, 1997. Generalized Models of Japanese Demand for Fish. *American Journal of Agricultural Economics*. 79(4): 1153-63.

Fitzsimmons, K., 2000. Future Trends of Tilapia Aquaculture in the Americas. In B.A. Costa-Pierce and J. E. Rakocy (eds.) *Tilapia Aquaculture in the Americas*, Vol. 2. The World Aquaculture Society, Baton Rouge, Louisiana, United States, pages 252-264.

Fousekis, P. and B. J. Revell, 2000. Meat Demand in the UK: a Differential Approach. *Journal of Agricultural and Applied Economics*. 32(1): 11-19.

GLOBEFISH, 2007. Catfish Market Report – January 2008. Available online: http://www.globefish.org/index.php?id=4383

GLOBEFISH, 2008. Salmon and Trout – April 2008 – Chile. Available online: http://www.globefish.org/index.php?id=4443

GLOBEFISH, 2008. Tilapia Market Report – April 2008. Available online: http://www.globefish.org/index.php?id=4456

Green, R. and J. M. Alston, 1991. Elasticities in AIDS Models: A Clarification and Extension. *American Agricultural Economics Association*. Vol. 73. pp. 874-75

Hanson, T., 2005. U.S. Farm-Raised Catfish Industry 2004 Review and 2005 Outlook. Available online: http://www.agecon.msstate.edu/Research/catfishdb/2004catfishdatabase_002.pdf.

Harvey, D.J., 2005. *Aquaculture Outlook*. LDP-AQS-21. Mar 2005. Electric Outlook Report from the Economic Research Service. Available URL: www.ers.usda.gov

Harvey, D.J., 2006. *Aquaculture Outlook*. LDP-AQS-21. Mar 2006. Electric Outlook Report from the Economic Research Service. Available URL: www.ers.usda.gov

Hogendorn, J. S., 1996. Economic Development. Third Edition. HarperCollins College Publishers

Holt, M. T., and R. C. Bishop, 2002. A Semiflexible Normalized Quadratic Inverse Demand System: An Application to the Price Formation of Fish. *Empirical Economics.* 27(1): 23-47.

Irwin, D. A. (2003). The Optimal Tax on Antebellum US Cotton Exports. *Journal of International Economics*. Vol. 60, pp. 275-291

Josupeit, H.' A. Lem' and H. Lupin, (2001). Aquaculture Products: Quality, Safety, Marketing and Trade. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp. 249-257. NACA, Bangkok and FAO, Rome.

Kaliba A. R., C. R. Engle and L. Dorman, 2007. Efficiency Change and Technological Progress in the U.S. Catfish-Processing Sector, 1986 to 2005. *Aquaculture Economics and Management*. 11: 53-72

Kantor, L. S. and M. Malanoski, 1997. Imports play a growing role in the American diet. *Foodreview*. 20(3): 13-17.

Kennedy, P.L and C. Lee (2005). Effects of Catfish, Crawfish, and Shrimp Imports on U.S. Domestic Prices. Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meetings. February, 2005.

Kinnucan, H.W. 2003. Futility of Targeted Fish Tariffs and an Alternative. *Marine Resource Economics*. 18: 211-224.

Kinnucan H.W. and Y. Miao, 1999, Media-Specific Returns to Generic Advertising: The Case of Catfish, *Agribusiness*, 15 (1): 81–99

Kinnucan, H.W., O. Myrland, 2005. Effects of Income Growth and Tariff on the World Salmon Market. *Applied economics*. 37(17): 1967-78.

Kinnucan, H.W., H. Xiao, C.J. Hsia, and J. D. Jackson, 1997. Effects of health information and generic advertising on U.S. meat demand. *American Journal of Agricultural Economics*. 79(1): 13-23.

Lee, L.-F., and M. M. Pitt, 1986. Microeconometric Demand System with Binding Nonnegativity Constraints: The Dual Approach. *The Econometric Society.* 54(5): 1237-1242.

Ligeon, C., C.M. Jolly and J. D. Jackson, 1996. Evaluation of Possible Threat of NAFTA on U.S. Catfish Industry Using a Traditional Import Demand Function. *Journal of Food Distribution Research*. July 1996.

Nalley, L. L., 2007. Modeling the Structural Change in American Frozen Catfish Fillet Demand: An Analysis of Country of Origin Labeling and the Implementation of an Import Tariff. Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meetings. February, 2005.

Narog, B.J., 2003. Past – Present – Future Catfish in Vietnam and the US. *Aquaculture Magazine*. May/June 2003.

Pollak, A. Robert and T. J. Wales, 2000. Demand System Specification and Estimation. *Journal of Agricultural and Applied Economics*. 32(1): 11-19.

Prusa, T. J., 1996. The Trade Effects of U.S. Antidumping Actions. NBER Working Paper No. W5440. Available at SSRN: http://ssrn.com/abstract=225497

Prusa, T. J. (2005). Anti-Dumping: A Growing Problem in International Trade. *The World Economy*. 28(5): 683-700

Quagrainie, K. K. 2003. A Dynamic Almost Ideal Demand Model for US Catfish. *Aquaculture Economics and Management*. 7: 167-178

Quagraine, K.K., 2006. Analysis of U.S. Catfish Fillet Market Share Using a Flexible Logistic Model. *Marine Resource Economics.* 21: 33-44.

Quagrainie, K. K. and C. R. Engle, 2002. Analysis of Catfish Pricing and Market Dynamics: the Role of Imported Catfish. *Journal of the World Aquaculture Society*. 33(4).

Quagrainie, K. K. and C. R. Engle, 2006. A Latent Class Model for Analyzing Preferences for Catfish. *Aquaculture Economics and Management*. 10: 1-14

Salvances, K. G., and D. J. DeVoretz, 1997. Household Demand for Fish and Meat Products: Separability and Demographic Effects. *Marine Resource Economics.* 12(1): 37-55.

Wailes, E. J., C. Fang and F. C. Tuan, 1998. U.S.-China Agricultural Trade: Constraints and Potential. *Journal of Agricultural and Applied Economics*. 30(1): 113-26

Wellman, K. F., 1992. The U.S. Retail Demand for Fish Products: An Application of the Almost Ideal Demand System. *Applied Economics.* 24(4): 445-57.

Zanardi, M., 2004. Anti-Dumping: What Are the Numbers to Discuss at Doha? *World Economy*. 27(3): 403-33.

Zidack, W. and U. Hatch, 1991. An Econometric estimatIon of Market Growth for the U.S. Processed Catfish Industry. *Journal of the World Aquaculture Society.* 22:10–23.

Zidack, W. H. Kinnucan and U. Hatch, 1992. Wholesale- and Farm-Level Impacts of Generic Advertising: The Case of Catfish. *Applied Economics.* 24(10): 959-968.

APPENDIX: FORMULAS FOR CROSS AND OWN PRICE ELASTICITY AFTER LABELING EFFECT

I/ Cross-price elasticities

System equations:

$$R_{it} = \alpha_i + \sum_{j=1}^{4}\theta_{ij} LnP_{jt} + \beta_i Ln(Y_t / P_t^*) + \sum_{q=1}^{3}\phi_{iq} QRT_{qt} + \delta_i TARIFF_t \quad (1)$$
$$+ \varphi_i (LnP_3 \cdot LABEL_t) + \varepsilon_{it}$$

$$\leftrightarrow \quad \frac{\partial R_i}{\partial LnP_3} = \theta_{i3} + \varphi_i + \beta_i \times \frac{\partial Ln\left(Y / P^*\right)}{\partial LnP_3}$$

$$\leftrightarrow \quad \frac{\partial R_i}{\partial LnP_3} = \theta_{i3} + \varphi_i - \beta_i \times R_3 \quad (2)$$

Stone price index:

$$LnP^* = \sum_{i=1}^{4} R_i LnP_i \quad (3)$$

Derivative of real expenditure with respect to LnP_3:

$$\frac{\partial Ln\left(Y / P^*\right)}{\partial LnP_3} = \frac{\partial LnY}{\partial LnP_3} - \frac{\partial LnP^*}{\partial LnP_3}$$

$$\leftrightarrow \quad \frac{\partial Ln\left(Y / P^*\right)}{\partial LnP_3} = -\beta_3 \times R_3 \quad (4)$$

Share of products:

$$R_i = P_i Q_i / Y \qquad \text{with } i \neq 3 \quad (5)$$

Take logarithm both sides of (5)

$LnR_i = LnP_i + LnQ_i - LnY$ (6)

Take first differences both sides of (6), we have:

$dLn\ R_i = dLn\ P_i + dLn\ Q_i - dLn\ Y$ (7)

Divide both sides of (7) by $dlnP_3$,

$$\frac{dLnR_i}{dLnP_3} = \frac{dLnP_i}{dLnP_3} + \frac{dLnQ_i}{dLnP_3} - \frac{dLnY}{dLnP_3}$$

For i ≠ 3, the first and the last terms of the right hand side should be nullified, or

$$\frac{dLnR_i}{dLnP_3} = \frac{dLnQ_i}{dLnP_3} \quad (8)$$

From (8) and (4) we have:

$$\frac{\partial LnQ_i}{\partial LnP_3} = \frac{\partial R_i}{\partial LnP_3} \times \frac{1}{R_1} = \frac{\theta_{i3} + \varphi_i - \beta_i \times R_3}{R_i}$$

The cross-price elasticities of products with respect to price of catfish imports:

$$e_{i3} = \frac{\theta_{i3} + \varphi_i - \beta_i \times R_3}{R_i}$$

II/ Own-price elasticity after labeling effect

Share of product 3 (catfish imports):

$$R_3 = \frac{P_3 Q_3}{Y} \quad (9)$$

Take logarithm of (9):

$LnR_3 = LnP_3 + LnQ_3 - LnY$ (10)

Derivative of (10):

$$\frac{\partial LnR_3}{\partial LnP_3} = \frac{\partial LnP_3}{\partial LnP_3} + \frac{\partial LnQ_3}{\partial LnP_3} - \frac{\partial LnY}{\partial LnP_3}$$

$$\frac{\partial LnR_3}{\partial LnP_3} = 1 + \frac{\partial LnQ_3}{\partial LnP_3}$$

$$\frac{\partial LnQ_3}{\partial LnP_3} = \frac{\partial LnR_3}{\partial LnP_3} - 1 = \frac{\partial R_3}{\partial LnP_3} \times \frac{1}{R_3} - 1 \tag{11}$$

Take derivative of (3) with respect to LnP_3 :

$$\frac{\partial R_3}{\partial LnP_3} = \theta_{33} - \beta_3 \times R_3 + \varphi_3$$

$$\leftrightarrow \qquad \frac{\partial R_3}{\partial LnP_3} \times \frac{1}{R_3} = \frac{\theta_{33} - \beta_3 \times R_3 + \varphi_3}{R_3} \tag{12}$$

From (11) and (12):

$$\frac{\partial LnQ_3}{\partial LnP_3} = \frac{\theta_{33} - \beta_3 \times R_3 + \varphi_3}{R_3} - 1$$

The own-price elasticity of catfish imports:

$$e_{33} = \frac{\theta_{33} - \beta_3 \times R_3 + \varphi_3}{R_3} - 1$$

Table 1: Variable description

Variable	Description	Unit	Source of data
Q_i	Quantities of US imported frozen fillets of salmon, tilapia and catfish, i =1,2,3	Lb	NMFS
Q_4	Quantity of US domestic frozen catfish fillets	Lb	Mississippi State University
P_i	Price of US imported frozen fillets of salmon, tilapia and catfish, i =1,2,3	\$/lb	NMFS
P_4	Price of US domestic frozen catfish fillets	\$/lb	Mississippi State University
Y	Total US consumer expenditure in dollar, $Y = \sum_{i=1}^{4} P_i Q_i$ where i = 1,2,3,4 represent imported frozen fillets of salmon, tilapia, catfish and domestic frozen catfish fillets		
R_i	Share of the four products; $R_i = P_i Q_i / Y$ where i =1,2,3,4 represent imported frozen fillets of salmon, tilapia, catfish and domestic frozen catfish fillets		
P^*	Stone Price Index with $\ln P^* = \sum_{i=1}^{4} R_i \ln P_i$		
TARIFF	zero-one dummy variable for antidumping tariff imposition, get value one for the period after January 2003		
LABEL	zero-one dummy variable for the US 2001' labeling law, get value one for the period after November 2001		
QRT_q	zero-one dummy variables representing the first three quarters of a year, q = 1,2,3		

Table 2: Coefficient Estimates of Linear Approximate Almost Ideal Demand System for Domestic and Imported Farmed Fish

	Imported Salmon		Imported Tilapia		Imported Catfish		Domestic Catfish	
	Est.	t-value	Est.	t-value	Est.	t-value	Est.	t-value
Model C								
μ_{i1}	0.15	*(5.33)*	-0.013	*(0.61)*	-0.025	*(1.78)*	-0.117	*(5.08)*
μ_{i2}	-0.008	*(0.38)*	0.044	*(1.50)*	-0.034	*(1.85)*	0.065	*(1.99)*
μ_{i3}	-0.025	*(1.78)*	-0.032	*(1.72)*	-0.033	*(1.60)*	0.093	*(3.89)*
μ_{i4}	-0.117	*(5.08)*	0.001	*(0.02)*	0.093	*(3.89)*	-0.041	*(0.83)*
Expend	0.086	*(3.94)*	0.141	*(7.35)*	0.08	*(6.45)*	-0.312	*(16.70)*
Int.	-1.242	*(3.45)*	-2.255	*(7.25)*	-1.322	*(6.60)*	5.926	*(19.87)*
Tariff	0.036	*(2.37)*	0.053	*(3.83)*	-0.038	*(3.82)*	-0.032	*(2.93)*
Label.P_3	0.07	*(2.02)*	0.046	*(1.47)*	0.014	*(0.58)*	-0.126	*(4.07)*
QRT_1	-0.018	*(1.82)*	-0.019	*(2.41)*	-0.011	*(2.30)*	0.052	*(6.88)*
QRT_2	-0.006	*(0.51)*	0.001	*(0.16)*	-0.004	*(0.74)*	0.015	*(1.86)*
QRT_3	-0.004	*(0.42)*	-0.003	*(0.41)*	-0.005	*(1.01)*	0.021	*(2.78)*
R^2	0.8		0.92		0.85		0.98	
D.W	1.51		1.9		1.61		1.83	
Model E								
μ_{i1}	-0.1	*(1.88)*	0.068	*(1.83)*	0.113	*(2.34)*	-0.08	*(1.86)*
μ_{i2}			0.045	*(1.00)*	-0.12	*(2.92)*	0.007	*(0.13)*
μ_{i3}					-0.086	*(1.09)*	0.092	*(1.39)*
μ_{i4}							-0.019	*(0.21)*
Expend	0.108	*(3.09)*	0.162	*(5.62)*	0.076	*(2.05)*	-0.346	*(8.97)*
Int.	-1.51	*(2.69)*	-2.658	*(5.81)*	-1.305	*(2.29)*	6.473	*(10.88)*
Tariff	0.076	*(4.74)*	0.031	*(2.62)*	-0.078	*(8.04)*	-0.029	*(2.79)*
Label.P_3	0	*(0.00)*	0.062	*(1.33)*	0.05	*(0.68)*	-0.112	*(1.71)*
QRT_1	-0.03	*(2.53)*	-0.019	*(2.09)*	-0.006	*(0.85)*	0.056	*(7.14)*
QRT_2	-0.04	*(3.07)*	0.005	*(0.54)*	0.011	*(1.35)*	0.024	*(2.73)*
QRT_3	-0.015	*(1.29)*	-0.012	*(1.38)*	-0.001	*(0.11)*	0.028	*(3.76)*
R^2	0.72		0.89		0.69		0.98	
D.W	1.42		1.16		1.07		1.45	

Table 3: Comparison of Marshallian Own-price and Expenditure Elasticities Estimated from Five Alternative Demand Models

	Own Price Elasticity				
Product	Model A	Model B	Model C	Model D	Model E
Salmon	-0.29	-0.83	-0.48	-0.29	-1.51
	(2.22)[a]	*(8.12)*	*(4.29)*	*(2.22)*	*(7.07)*
Tilapia	-1.27	-1.13	-0.84	-1.27	-0.86
	(3.94)	*(5.97)*	*(4.28)*	*(3.94)*	*(2.90)*
Imported Catfish (before Label)	-2.11	-1.81	-1.91	-2.11	-3.22
	(3.61)	*(3.27)*	*(3.68)*	*(3.61)*	*(1.65)*
Imported Catfish (after Label)	-1.28	-1.67	-1.55	-1.28	-3.07
	(1.04)	*(1.43)*	*(1.37)*	*(1.04)*	*(1.16)*
Domestic Catfish	-0.63	-0.79	-0.76	-0.63	-0.69
	(5.23)	*(9.53)*	*(8.72)*	*(5.23)*	*(4.28)*
	Expenditure Elasticity				
Product	Model A	Model B	Model C	Model D	Model E
Salmon	1.2	1.29	1.35	1.2	1.43
	(11.96)	*(16.31)*	*(15.32)*	*(11.96)*	*(10.26)*
Tilapia	2.08	1.91	1.94	2.08	2.08
	(14.71)	*(16.12)*	*(15.19)*	*(14.71)*	*(10.83)*
Imported Catfish (before Label)	3.28	3.48	2.99	3.28	2.9
	(9.02)	*(10.59)*	*(9.69)*	*(9.02)*	*(3.14)*
Domestic Catfish	0.46	0.45	0.44	0.46	0.38
	(13.60)	*(14.02)*	*(13.26)*	*(13.60)*	*(5.49)*

[a]Absolute value of *t*- ratio is in parenthesis

Table 4: Marshallian Price Elasticities

Quantity	Salmon price	Tilapia price	Imported catfish price Before Label	Imported catfish price After Label	Domestic Catfish
Model C:					
Salmon	-0.48	-0.08	-0.12	0.16	-0.66
	(4.29)[a]	*(0.99)*	*(2.02)*	*(0.83)*	*(7.18)*
Tilapia	-0.32	-0.84	-0.25	0.05	-0.52
	(2.29)	*(4.28)*	*(2.02)*	*(0.15)*	*(2.41)*
Imported catfish	-1.14	-1.14	-1.91	-1.55	1.20
	(3.17)	*(2.51)*	*(3.68)*	*(1.37)*	*(2.01)*
Domestic catfish	-0.07	0.20	0.19	-0.04	-0.76
	(1.69)	*(3.43)*	*(4.42)*	*(0.38)*	*(8.72)*
Model E:					
Salmon	-1.51	0.21	0.44	0.73	-0.564
	(7.07)	*(1.39)*	*(2.25)*	*(0.19)*	*(3.262)*
Tilapia	0.18	-0.86	-0.84	-0.44	-0.557
	(0.73)	*(2.90)*	*(3.08)*	*(0.31)*	*(1.547)*
Imported catfish	2.36	-3.28	-3.22	-3.07	1.236
	(1.93)	*(3.20)*	*(1.650)*	*(1.17)*	*(0.749)*
Domestic catfish	0.01	0.11	0.19	-0.06	-0.688
	(0.14)	*(1.10)*	*(1.60)*	*(0.10)*	*(-4.278)*

[a] Absolute value of *t*- ratio is in parenthesis

Table 5: Hicksian Price Elasticities

Quantity	Salmon price	Tilapia price	Imported catfish price: Before Label	Imported catfish price: After Label	Domestic Catfish Price
Model C :					
Salmon	-0.15	0.12	-0.06	0.22	0.09
Tilapia	0.17	-0.55	-0.18	0.13	0.56
Imported catfish	-0.39	-0.70	-1.79	-1.42	2.87
Domestic catfish	0.04	0.27	0.21	-0.02	-0.51
Model E:					
Salmon	-1.15	0.42	0.49	0.79	0.24
Tilapia	0.70	-0.55	-0.76	-0.36	0.61
Imported catfish	3.08	-2.84	-3.10	-2.96	2.86
Domestic catfish	0.11	0.16	0.20	-0.04	-0.47

Table 6: Allen Elasticities

Quantity	Salmon price	Tilapia price	Imported catfish price (Before Label)	Domestic Catfish
Model C:				
Salmon	-0.59	0.78	-1.55	0.16
Tilapia	0.66	-3.69	-4.40	1.01
Imported catfish	-1.55	-4.64	-44.79	5.13
Domestic catfish	0.16	1.77	5.13	-0.91
Model E:				
Salmon	-4.61	--	--	--
Tilapia	2.80	-3.67	--	--
Imported catfish	12.33	-18.95	-77.53	--
Domestic catfish	0.43	1.09	5.11	-0.85

Average expenditure shares for salmon, tilapia, imported catfish, and domestic catfish respectively are 0.25, 0.15, 0.04, and 0.56

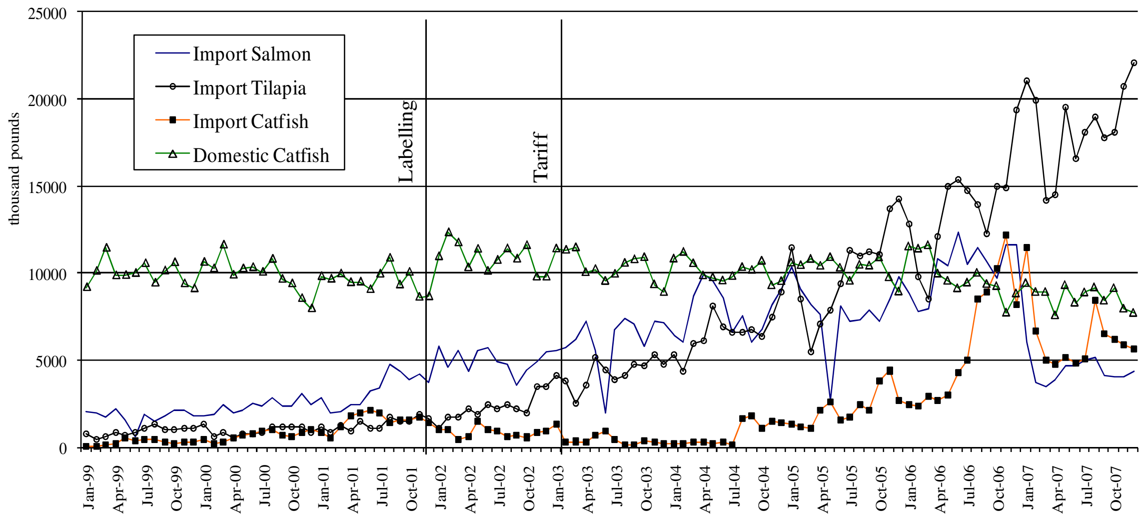

Figure 1: Quantisties of U.S import fish and domestic Catfish (Jan 1999 - Dec 2007)
Source: National Marine Fisheries Service and Department of Economics Mississippi State University

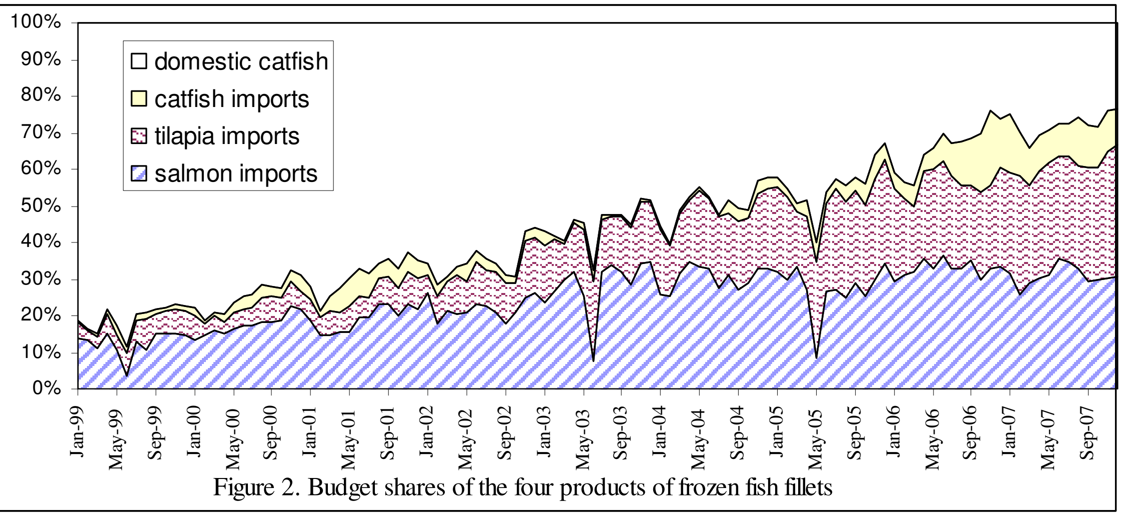

Figure 2. Budget shares of the four products of frozen fish fillets

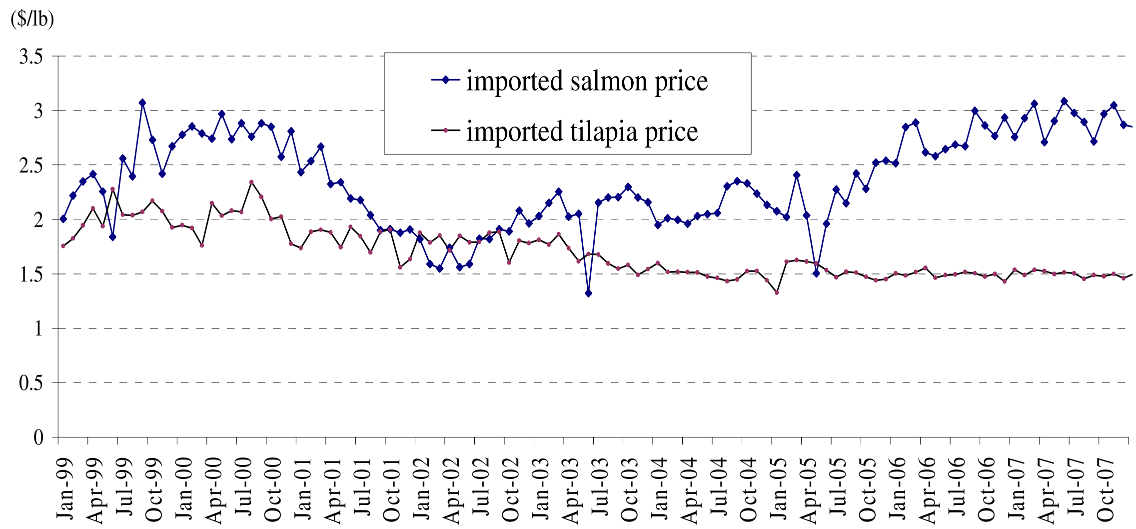

Figure 3. Prices of imported salmon and tilapia

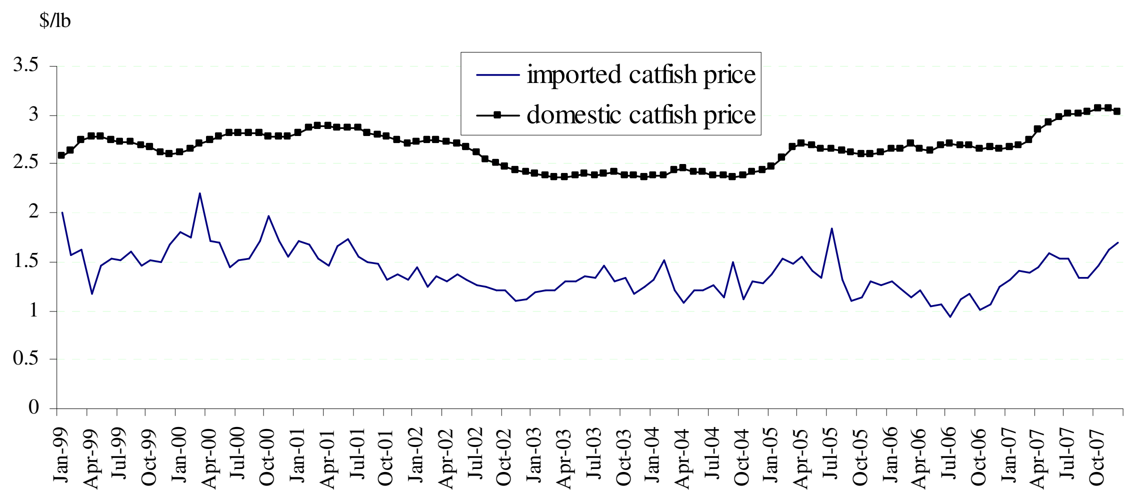

Figure 4: Prices of imported and domestic catfish

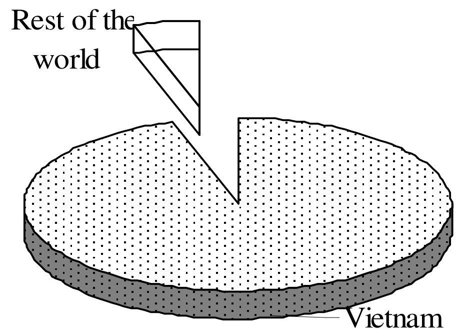

Chart 1. Shares of frozen catfish fillets imports to the US in 2002
(before antidumping tariff imposition)

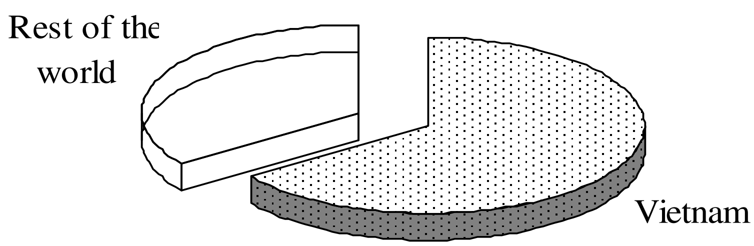

Chart 2. Shares of frozen catfish fillets imports to the US in 2004
(after antidumping tariff imposition)

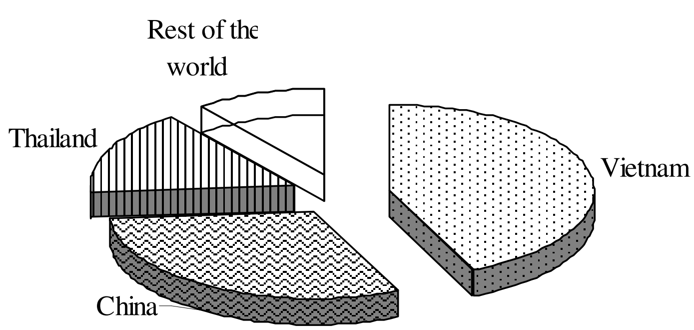

Chart 3. Shares of frozen catfish fillets imports to the US in 2007

Figure 5. Changes in import structure of frozen catfish fillets imports to the US