Three Essays on Fish Demand Analysis

by

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Abstract

The first chapter is themed around the catfish dispute between Vietnamese pangasius and U.S catfish. Vietnamese pangasius frozen fillets were accused of having depressing effect on U.S catfish prices, which in turn leads to significant material injuries to the respective industry. In this paper, it is evident that, among important whitefish imports, Vietnamese pangasius have the least depressing effect on U.S catfish prices. Thus, any protective measures that are aimed to curb Vietnamese pangasius imports would be unlikely to fruitfully benefit the U.S catfish industry.

Turning to chapter 2, the tests for separability are performed to understand US consumer preferences for fish. Fish included constitute the top most consumed products in the U.S. Separability is investigate within the quantity-dependent demand system in which the generalized demand model is specified and used. Test results indicate that shellfish (shrimp and crab) are symmetrically separable from finfish (salmon, tuna and whitefish). Moreover, within the finfish group, whitefish can be treated as separable from salmon and tuna, and vice versa.

The last chapter is aimed at investigating the effects of exchange rate effects on export prices of Vietnamese pangasius. Understanding behavior of export prices relative to exchange rates is important to the exporting sector because such an elasticity underlies price competitiveness and reaction of export volumes to exchange rates. With respect to Vietnamese pangasius, such knowledge is particularly essential as the industry makes up a significant source of export earnings. Results show that exchange rate pass-through to export prices, although incomplete, is as sizeable as 50%. Incomplete pass-through to export prices implies that part of the incidence of exchange rate realignments is passed into import prices (denominated in foreign currencies). In this way, Vietnamese exporters can widen their profit margins, while improving competitiveness in the foreign markets. Implication to the antidumping duty is discussed.

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Chapter 1

The Catfish War: Is It Fair to Blame Vietnamese Pangasius?

Introduction

Vietnamese pangasius debuted in the U.S market in 1996 following the normalization in trade relation between the two countries. Being marketed as catfish, coupled with low-price strategy, eased the species into the market. While imports of Vietnamese pangasius were largely absent from channels of distribution prior to 1999, they subsequently became an increasingly significant source of supply afterwards. Unhappy with this, the U.S catfish industry proactively spurred to adopt protective measures. In late 2001 Congressional legislation prohibited the practice of labeling or promoting pangasius as catfish. Shortly later in late 2003, following the affirmative determination of the U.S International Trade Commission (Commission, thereafter), the antidumping duty was imposed on Vietnamese pangasius frozen fillets. The first and second administrative reviews (in 2009 and 2014) resulted in the continuation of the antidumping[1].

The material injuries endured by the US catfish industry are predicated upon price effects caused by Vietnamese pangasius imports. In the original investigation as well as in the two administrative reviews, imports of Vietnamese pangasius frozen fillets was accused

[1] More recently, the catfish inspection program was initiated in December 2015 which transfers the inspection responsibilities from the FDA to the Food Safety and Inspection Service (FSIS) within USDA. The program is controversial, however. Advocates cite the program as a measure to protect U.S consumers from contaminated fish products from Asia including Vietnamese pangasius. Opponents view the program as a waste and a shortsighted practice of anti-free market protectionism.

of significantly depressing U.S catfish prices. As noted by the Commission, "subject imports from Vietnam suppressed prices of the domestic like product to a significant degree", and therefore the domestic industry was unable to pass "cost increases to purchasers by way of higher prices" (U.S ITC, 2009). By definition of domestic like product, the Commission's scrutiny confined itself to the competition between U.S catfish and Vietnamese pangasius. At issue is whether it is Vietnamese pangasius that most depresses U.S catfish prices. Put in other words, the validity of the Commission's argument hinges on the degrees of substitution between catfish and other whitefish including Vietnamese pangasius. Previous research on the catfish dispute includes papers by Kinnucan (2003), Muhammad et al. (2010), Nguyen (2010), Brambilla et al. (2012), and Kinnucan et al. (2017). These studies have been useful detailing different aspects of the antidumping duty. However, whether Vietnamese pangasius are the cause of material losses endured by U.S catfish industry is not addressed.

With that in mind, we aimed to analyze the competition between U.S catfish and Vietnamese pangasius before and after the advent of the catfish regulations in the context of the U.S whitefish market. We specifically estimated a demand structure that includes U.S catfish, Vietnamese pangasius, tilapia, cod, Alaskan pollock, and haddock, with the last two species being grouped and named *otherwhite*. These species are chosen because they are the most popular whitefish in the U.S market. A transition function was incorporated into the demand system to allow for a potential structural change caused by the catfish regulations. This study is policy relevant in the sense that knowledge of demand interrelations is crucial to antidumping policy (Asche et al., 1999).

We begin the next section with a brief overview of the U.S whitefish market and data description. Next, the analytical framework is presented, followed by the empirical results. The paper concludes with a summary of major findings.

The U.S Whitefish Market

U.S consumers are exposed to a wide range of edible seafood choices that are either locally sourced or imported. U.S consumption of seafood, however, centers on 10 species that represent about 90% of seafood consumed. Five out of the 10 species are whitefish, namely tilapia, Alaskan pollock, pangasius, cod and catfish, named in descending order of consumption. Cod, haddock and pollock were traditionally the primary whitefish species in the U.S market. Catfish is the first farmed fish to enter the whitefish market in the early 1990s. Because there are no large supplies of wild or commercially harvested catfish, farmed catfish has to establish its market at the expense of other fish (Asche et al., 2001). Similarly, pangasius is comparable to other whitefish due to its mild flavored white flesh. It is however far from obvious which species of whitefish pangasius is competing against (Asche et al., 2009).

Data for imported frozen fillets of Vietnamese pangasius, tilapia, cod, Alaskan pollock, and haddock were retrieved from the National Marine Fisheries Services. We restricted our focus to frozen fillets because Vietnamese pangasius enters the U.S market mostly as frozen fillets, and because the antidumping is imposed on this product form. The data are available in imported quantities (kilogram) and import values (USD) which result in import prices of USD per kilogram. For *otherwhite* (pollock and haddock), we use the

Stone price index to create a representative import price for the group. Data for U.S catfish at wholesale level are extracted from the 2013 U.S catfish database (Hanson and Sites, 2014). The data used range from January 1998 till December 2013 which consist of 192 observations.

Figure 1.1 depicts the total trade value of frozen fillets of the studied species and their market shares in the U.S market between 1998-2013[2]. The figure provides two main insights. First, total trade value has consistently risen over the studied time period. Second, the import of tilapia and Vietnamese pangasius is the main engine for such growth. Consequently, tilapia and Vietnamese pangasius saw their market shares thriving whereas U.S catfish, cod, pollock and haddock witnessed their shares vanishing. In the early 2010s tilapia replaced cod and U.S catfish to be the dominant species with more than 40% of the market, followed by Vietnamese pangasius.

The Analytical Framework

We took advantage of the empirical model developed in Asche and Zhang (2013) to analyze the potential structural break induced by the catfish regulations. Essentially, the model is a blend of the well-known inverse AIDS model (IAIDS) (Moschini and Vissa, 1992; Eales and Unnevehr, 1994; Brown, Lee and Seale, 1995; Barten and Bettendorf, 1989) and the transition function (Moschini and Meike, 1989). An inverse demand system like the IAIDS allows for the retrieval of quantity flexibilities that reveal which

[2] Total trade value is the sum of import values and U.S catfish revenue.

products most depress prices of U.S catfish frozen fillets. The transition function is in essence a dummy modified to take on increasing values between 0 and 1.

Among major imported whitefish, Vietnamese pangasius is the only product that has confronted with major policy changes. Before the labeling regulation was initiated, imported frozen fillets of Vietnamese pangasius, although present in minimal quantity, were trending upward to reach a high in early 2001 (figure 1.2). As a consequence of two consecutive protective measures, imports of the species propelled downhill to its record low in July 2004. August 2004 marked the recovery of Vietnamese pangasius imports, followed by a consistent uptrend[3]. Thus, it appears that a transition function which allows for a smooth structural change over time would be more appropriate that a traditional dummy variable which represents an abrupt structural change.

A standard IAIDS model with a linear quantity index and seasonal dummies can be expressed as follows:

(1) $$w_{it} = \alpha_i + \beta_i lnQ_t + \sum_j \gamma_{ij} lnq_{jt} + \sum_s \phi_{is} D_{st}$$

[3] Surprisingly enough, during the tumultuous time for Vietnamese pangasius U.S catfish was still losing its market share, while that of tilapia was rising (Figure 1A in the Appendix).

where w_{it} is the expenditure share of good *i* in month *t*; lnQ_t is the Divisia volume index defined as $lnQ_t = \sum_j w_j \, lnq_j$; q_{jt} is the quantity of good *j* sold in month *t*; and D_{st} are quarterly dummy variables[4]. The transition function (h_t) is defined as follows:

$$(2) \qquad h_t = \begin{cases} 0 & \text{for t} = 1, \dots, \tau_1 \\ \frac{t-\tau_1}{\tau_2-\tau_1} & \text{for t} = \tau_1 + 1, \dots, \tau_2 - 1 \\ 1 & \text{for t} = \tau_2 \dots \text{T} \end{cases}$$

where τ_1 and τ_2 represents the beginning and the end of the structural change. The gap between τ_1 and τ_2 is the period of transition from one regime to the other. The IAIDS model incorporating the transition functions is given in the following equation:

$$(3) \qquad w_{it} = \alpha_i + \xi_i h_t + (\beta_i + \lambda_i h_t)\ln Q_t + \sum_j \big(\gamma_{ij} + \lambda_{ij} h_t\big)\ln q_{jt} + \sum_s (\phi_{is} + \vartheta_{is} h_t) D_{st}$$

All variables are defined as above. All other expressions are parameters to be estimated. The demand theory implies the following restrictions on parameters:

$$(3a) \qquad \textstyle\sum_{j=1}^{5} \lambda_{ij} = 0, \sum_{j=1}^{5} \gamma_{ij} = 0 \qquad \text{(homogeneity)}$$

$$(3b) \qquad \gamma_{ij} = \gamma_{ji}, \lambda_{ij} = \lambda_{ji} \qquad \text{(symmetry)}$$

$$(3c) \qquad \textstyle\sum_{i=1}^{5} \beta_i = 0, \sum_{i=1}^{5} \gamma_{ij} = 0, \sum_{i=1}^{5} \lambda_{ij=} = 0, \sum_{i=1}^{5} \lambda_i = 0$$

$$\textstyle\sum_{i=1}^{5} \phi_{is} = 0, \sum_{i=1}^{5} \vartheta_{is} = 0, \sum_{i=1}^{5} \xi_i = 0, \sum_{i=1}^{5} \alpha_i = 1 \qquad \text{(adding-up)}$$

[4] Quarterly rather than monthly dummies are used for simplicity, but also because Wessells and Wilen (1994) found little difference in the two approaches.

Whether the catfish regulations lead to a structural change can be ascertained via the tests of the following hypotheses:

(4a) $\vartheta_{is} = 0 \ \ \forall\, i, s$

H_0: constant seasonal effects

(4b) $\lambda_i = 0 \ \ \forall\, i$

H_0: constant scale effects

(4c) $\lambda_{ij} = 0 \ \ \forall\, i, j$

H_0: constant Antonelli effects

(4d) $\vartheta_{is} = \lambda_i = \lambda_{ij} = 0 \ \ \ \forall\, i, j, s$

H_0: no structural change in the coefficients

In order to ease the economic interpretation, estimated parameters from the model are used to compute scale and Marshallian quantity flexibilities using the following formulas:

(5a) $$f_i = -1 + \frac{\beta_i + h_t \lambda_i}{w_i}$$ (scale flexibility)

(5b) $$f_{ij} = -\delta_{ij} + \frac{\gamma_{ij} + h_t \lambda_{ij}}{w_i} + \frac{\beta_i + h_t \lambda_i}{w_i} w_j$$ (uncompensated quantity flexibility)

where δ_{ij} is the Kronecker delta. For the first and third regimes where h_t is a constant, flexibilities are evaluated at average expenditure shares. In the second regime, non-constant h_t allows for the calculation of flexibilities at each value of expenditure shares.

Applying equation (3) to the set of considered whitefish, the system to be estimated consists of 5 equations. Quarterly dummies were used to account for seasonal effects. τ_1 was set at Jan 2001 to account for the possibility that the labeling legislation may have had effects before it was officially enacted (late 2001). τ_2 was set at Aug 2004 when Vietnamese pangasius frozen fillets started to stabilize and grow. Because the labeling and antidumping policies were enacted one after the other within only 2 years, we used only one dummy to represent both protective measures. In order to circumvent the issue of spurious regression induced by non-stationary time series, the model was estimated in its first-difference form:

$$(6) \qquad \Delta w_{it} = \xi_i + \beta_i \Delta lnQ_t + \lambda_i \Delta(h_t lnQ_t) + \sum_{j=1}^{5} \gamma_{ij} \Delta lnq_{jt} + \sum_{j=1}^{5} \lambda_{ij} \Delta(h_t lnq_{jt}) + \sum_{s=1}^{3} \phi_{is} D_{st} + \sum_{s=1}^{3} \vartheta_{is} \Delta(h_t D_{st})$$

Empirical results

Hypotheses tests

We first estimated the IAIDS model to test for theoretical restrictions on the demand system. The system was estimated with a common rho value (-0.106) for all equations to correct for autocorrelation. The common rho, which is the average of the correlation coefficients of individual equations, was applied to ensure that SUR estimators were invariant to the equation dropped. The equation for Vietnamese pangasius has the lowest R^2 of 43%. The rest 4 equations have R^2 ranging from 85%-92%. Homogeneity and symmetry restrictions are not compatible with the data[5]. However, in order to derive flexibilities that are consistent with theory, we elected to impose these restrictions. SUR estimates of parameters are presented in Appendix 1.1. We note that insignificant intercepts indicate lack of changing preference or taste over time. Insignificant estimates of the Divisia volume index in the equations for cod, otherwhite and U.S catfish indicate homothetic preferences for the respective products (Xie et al., 2009). Most of the estimates pertaining to the interaction terms $h_t lnq_{it}$ are highly significant, indicating the presence of a structural change.

Results of the tests for a structural change (hypotheses 4a through 4d) are presented in table 1.1. The test results indicate that both scale effects and Antonelli effects are subject to a structural change. Whereas, the null hypothesis of constant seasonal effects cannot be rejected. The joint test on no structural change results in the rejection of the null. In view of the test results, it is legitimate to incorporate the transition function into the IAIDS to enable scale and quantity flexibilities to vary before and after the regulations[6].

Before-and after-regulation scale and Marshallian quantity flexibilities

Given the paucity of economic interpretation of the estimated coefficients in the IAIDS, we focus on flexibilities which are evaluated at sample means for the first (before regulation) and third (after regulation) regimes, and are reported in table 1.2.

[5] For homogeneity, computed Wald = 26.40 versus 5% critical Wald=1.95. For symmetry, computed Wald = 11.97 versus 5% critical Wald=1.77

[6] We experimented with other combinations of τ_1 and τ_2 by holding τ_1 while changing τ_2, as well as the other way around. Tests results do not changes the conclusion on the presence of the structural change.

All the scale flexibilities are negative in sign, indicating non-inferior goods. Thus, all products benefit from increase in aggregate expenditure. For cod, U.S catfish and other wildwhite, their scale flexibilities are roughly one with minuscule changes between regimes. This suggests nearly homothetic preferences for these fish in the market. Tilapia behaved pretty oddly as its scale flexibility is not statistically significant in the first regime. What is more, tilapia had no demand interrelationship with other fish (none of its cross flexibilities are significant). This compares with Norman-Lopez and Asche's (2008) finding that income elasticity of tilapia frozen fillets was insignificant, and that U.S catfish and tilapia frozen fillets did not compete in the same market[7] based on data between 1997-2006.

Attracting our attention is Vietnamese pangasius' scale flexibility. In the first regime, it generates exceptionally high scale flexibility. An elastic (inelastic) scale flexibility implies an inelastic (elastic) expenditure elasticity (Park and Thurman, 1999). Thus, its negative and elastic scale flexibility implies that consumers view Vietnamese pangasius frozen fillets as necessary goods (inelastic expenditure elasticity). Before the labeling legislation was enforced, Vietnamese pangasius was labeled and promoted as catfish. The price gap between the two species (with pangasius being substantially cheaper) may possibly explain why Vietnamese pangasius is deemed as necessary goods while U.S catfish is not. In the third regime, Vietnamese pangasius features substantially reduction in its scale flexibility (i.e. scale flexibility became less elastic), indicating a shift in punters' perception about the product. Moreover, it is the only species whose demand

[7] Norman-Lopez and Asche included only two species in their study.

becomes more expenditure elastic. The uneven distribution of benefit from increase in aggregate expenditure which is in favor of Vietnamese pangasius may play a part in explaining the constant rise of this product.

Quoting from Anderson (1980), quantities flexibilities "tell you how much price *i* must change in order to induce the consumer to absorb marginally more of good *j*". Hence, negative own flexibilities imply that for the considered fish products prices must fall in order to induce demand to rise. Vietnamese pangasius' own flexibility is the largest; and it is twice as large as that of U.S catfish. To put it in perspective, in order to induce the same increase in demand, pangasius price has to drop twice as much as catfish price does (in percentage term). Vietnamese pangasius' relatively high flexibility conforms to the well-known strategic behavior of Vietnamese exporters using keen pricing policy to induce demand in the U.S market. After the break, Vietnamese pangasius price becomes less sensitive to changes in its own quantity. This translates into a favorable market condition that paves the way for Vietnamese exporters to flood the U.S market without the fear of excessive price drop. In the same manner, cod and U.S catfish prices are less responsive to changes in own supplies. On the contrary, prices of tilapia and otherwhite become more sensitive to own-quantity changes.

Cross flexibilities measure changes in marginal valuations of a product in response to changes in quantities supplied of its substitute goods (Goodwin et al., 2003). A large flexibility (in absolute term) signifies that a product is under strong competition, and thus would experience a large price drop as a result of an increase in the quantities supplied of competing products (Asche and Zhang, 2013). Before the advent of the catfish regulations, interproduct relationships in the market are characterized by substitution between U.S catfish and wild whitefish. Substitution effects are asymmetric with U.S catfish being dominant. Vietnamese pangasius and tilapia with minimal market shares barely have an effect on prices of any fish.

In the third regime, supplies wild whitefish become less influential on the formation of U.S catfish price. Effect of Vietnamese pangasius on U.S catfish price, although increasing, remains tiny. It is tilapia imports that most depress U.S catfish price. To be more specific, the effect of tilapia supplies on U.S catfish price is 10 times larger than that of Vietnamese pangasius supplies. Moreover, although being a fast-growing species, the effect of Vietnamese pangasius imports on U.S catfish price is even 5 times smaller than that of otherwhite. Hence, it is evident that it is not Vietnamese pangasius imports that most depress U.S catfish price.

Before the regulations, Vietnamese pangasius price is highly sensitive to changes in U.S catfish quantity. This is quite understandable as Vietnamese pangasius possessed tiny market share, and the species was marketed after U.S catfish. Even more, Vietnamese pangasius' own flexibility is far smaller than its cross flexibility with respect to U.S catfish quantity. After the break, a hefty reduction is observed for the effect of U.S catfish quantity on Vietnamese pangasius price, which is in part attributable to U.S catfish losing its market share while its rival was constantly thriving. The estimated flexibilities also reveal that quantities of other fish put more pressure on U.S catfish price than on

Vietnamese pangasius price. This might be an indication of Vietnamese pangasius having formed a lower-price market segment to which other whitefish do not belong.

The third regime witnesses the fast growth of tilapia surpassing cod and catfish to dominate the market. Before the break, the species with minimal market share does not affect prices of any fish. Things change after the break as tilapia emerges to be the leading species in determining prices of all other fish. What is more, the effects of tilapia quantity on prices of other fish are larger than the effects of quantities of other fish on tilapia price.

Time-varying Marshallian cross-quantity flexibilities

In the preceding analysis, flexibilities for the first and third regimes are evaluated at mean expenditure shares, and therefore are constant. In the second regime, varying transition function h_t varies makes it possible to compute flexibilities at each value of expenditure shares. This results in the so-called time-varying flexibilities which are plotted in figure 1.3 and 1.4. We focus on the substitutability between U.S catfish and other fish.

Substitution between U.S catfish and other fish is a fairly dynamic process. None of the time paths indicates a one-time structural change in cross-quantity effects. The time paths of substitutability between U.S catfish and wild whitefish suggest declining competition as the cross flexibilities dwindle (figure 1.3). The effects of U.S catfish quantity on prices of wild whitefish are greater than the effects of wild whitefish quantities on U.S catfish price. Substitutability between U.S catfish and tilapia is characterized by more negative cross flexibilities, indicating stronger competition (figure 1.4). The competition between Vietnamese pangasius and U.S catfish is far less strong than that between U.S catfish and tilapia. Although Vietnamese pangasius gains more influence on U.S catfish price, the magnitude of the effect still remains tiny.

One might notices that the flexibility of Vietnamese pangasius with respect to U.S catfish quantity for the second regime goes excessively negative. Although being absurd, this corresponds with the fact that Vietnamese pangasius' market share, being tiny in the first place, continuously dropping during the second regime. By the end of 2004, as Vietnamese pangasius imports started to grow, its cross flexibility became well-behaved.

Conclusion

In this study, we investigated the competition between U.S catfish and Vietnamese pangasius frozen fillets before and after the enactment of the labeling legislation and the antidumping duty. The analysis was broadened to include tilapia and wild whitefish. We aimed to sketch a picture of the U.S whitefish market in which U.S catfish and Vietnamese pangasius, among other fish, are market players. Hypothesis testing suggests that the catfish regulations lead to a structural change in the whitefish market. Estimated flexibilities from an inverse AIDS system reveals that before the regulations, U.S catfish price is only affected by quantities of wild whitefish. After the regulations, tilapia imports emerges to have the largest influence on the formation of U.S catfish price. The effect of tilapia imports on U.S catfish price was 10 times larger than that of Vietnamese pangasius imports. The bottom line is that because Vietnamese pangasius has the least depressing effect on U.S catfish price, any protective measures that aim to curb Vietnamese pangasius imports will not fruitfully benefit the U.S catfish industry. Furthermore, the antidumping, particularly, although it can raise the final price of Vietnamese pangasius imports, cannot guarantee that the U.S consumers will switch to U.S catfish not other fish like tilapia. Lastly, by confining their attention to Vietnamese pangasius, the U.S catfish industry may have neglected other rivals, especially tilapia.

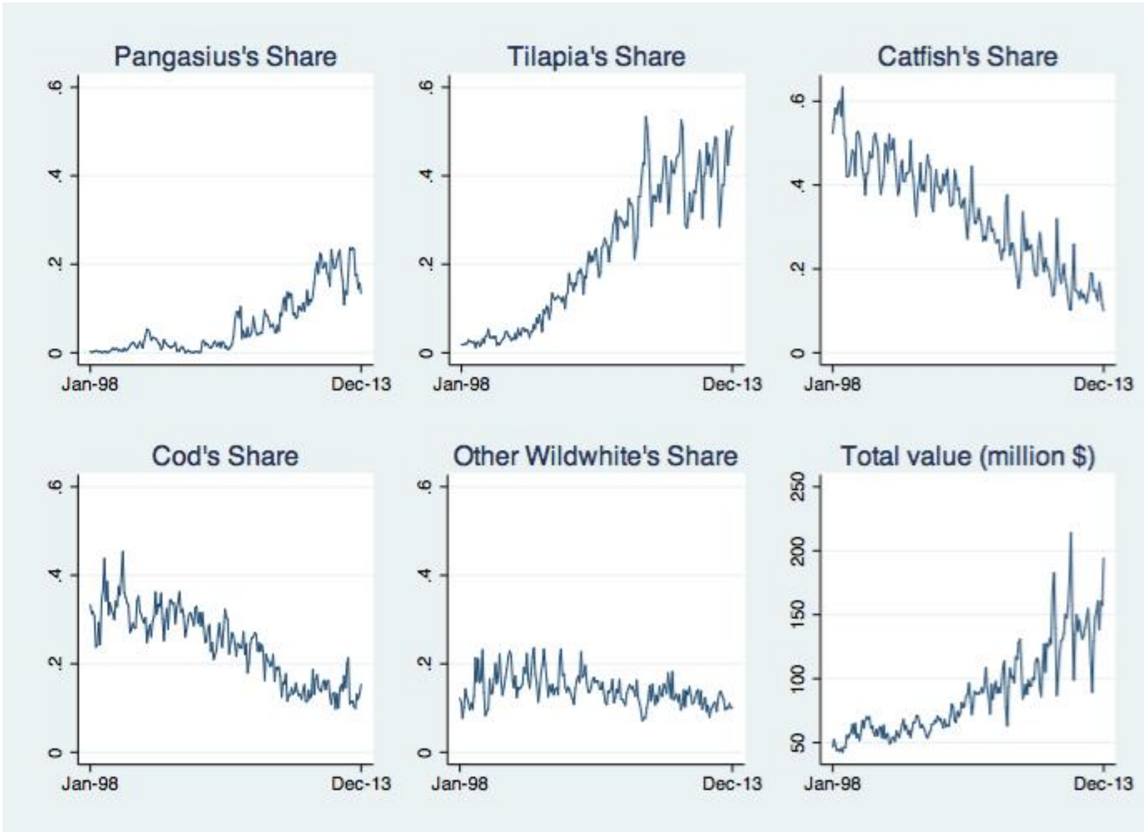

Figure 1.1. Market Shares of Whitefish Frozen Fillets in The U.S Market, 1998-2013

Figure 1.2. Market Share of Vietnamese Pangasius Frozen Fillets in Three Regimes

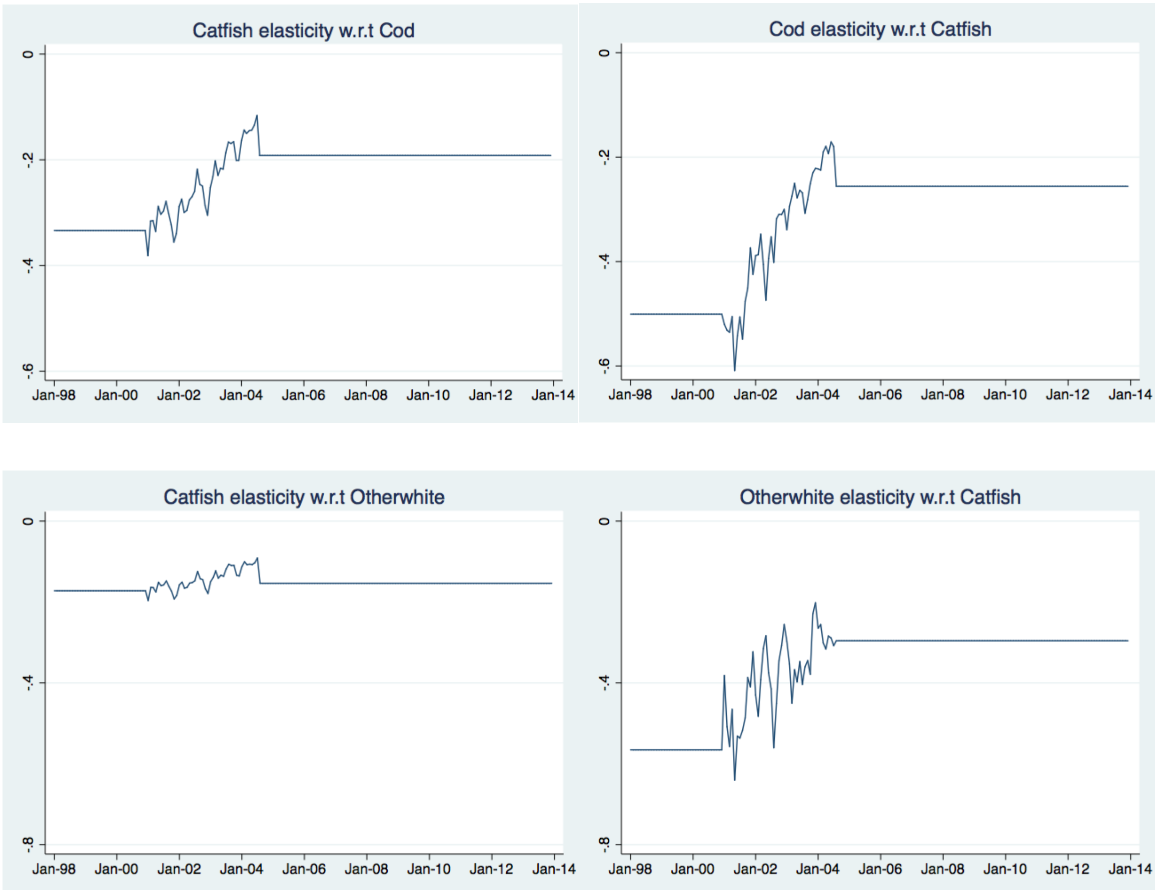

Figure 1.3. Substitution Between U.S Catfish and Wild Whitefish

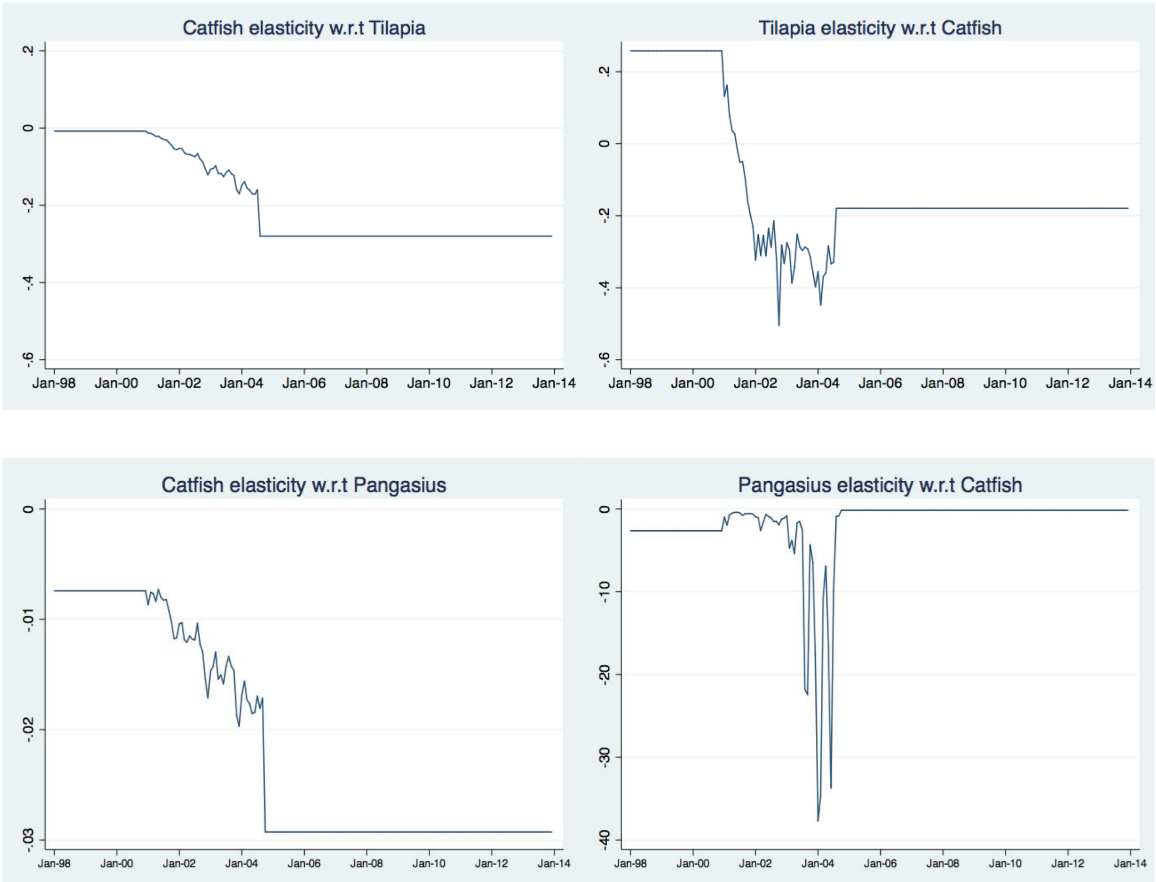

Figure 1.4. Substitution Between U.S Catfish and Tilapia and Vietnamese Pangasius

Table 1.1. Results of the Tests for Structural Change

Hypothesis	No. of restrictions	Computed Wald	Critical Wald[a]	Result
Constant scale effects	4	2.81	2.38	Reject
Constant Antonelli effects	10	67.65	1.84	Reject
Constant seasonal effects	12	1.48	1.77	Fail to reject
No structural break	26	28.55	1.51	Reject

[a] Critical values are at 5% level of significance.

Table 1.2. Scale and Quantity Flexibilities Before and After Regulations

Price of	Scale flexibilities	With respect to Quantity of				
		Pangasius	Tilapia	Cod	Otherwhite	Catfish
			Before regulation			
Pangasius	-5.455*	-0.908*	-0.034	-2.149*	0.307	-2.671*
	(1.469)	(0.386)	(0.311)	(0.556)	(0.367)	(0.780)
Tilapia	-0.176	0.031	-0.379*	0.034	-0.121	0.257
	(0.369)	(0.083)	(0.173)	(0.184)	(0.145)	(0.257)
Cod	-0.996*	-0.015*	-0.020	-0. 311*	-0.148*	-0.501*
	(0.031)	(0.001)	(0.013)	(0.025)	(0.015)	(0.030)
Others	-0.974*	0.053*	0.043	-0.317*	-0.098*	-0.565*
	(0.070)	(0.015)	(0.027)	(0.039)	(0.040)	(0.058)
Catfish	-0.988*	-0.008	-0.008	-0.334*	-0.172*	-0.466*
	(0.024)	(0.005)	(0.011)	(0.017)	(0.012)	(0.030)

Table 2. Continued.

Price of	Scale flexibilities	With respect to Quantity of				
		Pangasius	Tilapia	Cod	Otherwhite	Catfish
		After regulation				
Pangasius	-1.372*	-0.799*	-0.194*	-0.097*	-0.117*	-0.165*
	(0.094)	(0.030)	(0.037)	(0.026)	(0.023)	(0.035)
Tilapia	-0. 882*	-0.001	-0.439*	-0.172*	-0.083*	-0.179*
	(0.027)	(0.007)	(0.016)	(0.013)	(0.012)	(0.019)
Cod	-1.011*	-0.015	-0.349*	-0. 220*	-0.171*	-0. 256*
	(0.047)	(0.012)	(0.025)	(0.031)	(0.024)	(0.034)
Others	-1.023*	-0.057*	-0.263*	-0.251*	-0.156*	-0.296*
	(0.070)	(0.018)	(0.037)	(0.035)	(0.044)	(0.081)
Catfish	-0.986*	-0.029*	-0.280*	-0.192*	-0.154*	-0. 332*
	(0.043)	(0.010)	(0.020)	(0.019)	(0.019)	(0.039)

Note: Numbers in parentheses are asymptotic standard errors. Asterisks indicate significance at 5% or better.

Chapter 2

Testing for Separability in US Consumer Preferences for Fish: Results from a Generalized Conditional Demand System

Introduction

Between 1999-2013, U.S per capita consumption of fish and shellfish product has gone from a low of 15.4 lbs. in 1999 to its all-time peak of 16.6 lbs. in 2004 before starting to decline gradually to its record low of 14.5 lbs. in 2013. In spite of ups and downs in consumption, the top 10 most consumed seafood products have experienced modest changes except for the upsurge of tilapia consumption since 2002, and for the departure of scallops and flatfish (flounders and sole) from the list as a consequence of pangasius' debut in 2009. Shrimp, salmon and tuna always occupy the top three positions. The middle of the list witnesses the competition among whitefish including pollock, tilapia, pangasius, cod and catfish. Crab and clam close the list.

The literature on the demand structure for seafood products in the U.S market has developed considerably during the last two decades, covering a range of issues. A common practice in the econometric modeling of seafood demand, and indeed in empirical demand analysis generally, is to invoke weak separability of preferences and two-stage budgeting (Eales and Unnevehr, 1988; Davis and Jensen, 1994) because in many cases researchers are interested in the analysis of a specific commodity group. By assuming separability among goods analysts may confine their studies to a demand system that consists only of equations for one good from different origins (Asche and Zhang, 2013; Jones et al., 2008; Xie et al., 2009), or of different qualities (Muhammad and Hanson, 2009; Jones and Muhammad, 2011), or of different varieties (Sellen and Goddard, 1997; Carew et al., 2004). Although many empirical studies for seafood demand have utilized separability, such an assumption is often used as a maintained untested hypothesis. Edgerton (1997) noted the use of separability would be erroneous if the assumption was incorrect. On the other side, it would be inefficient if it was correct but its implication was disregarded.

On one hand, separability allows reducing the number of estimated parameters to a manageable size, and hence renders empirical demand analysis tractable. On the other hand, quoting from Moschini et al. (1994), "the analysts cannot escape the fact that the convenience of an assumption is no substitute for its truth". At issue here is the bias that must arise when the particular restrictions implied by weak separability are not compatible with the data.

The primary purpose of our analysis is to test for separability in US consumer preferences for fish. Results should contribute to understanding the nature of U.S seafood consumption by showing how US consumers allocate seafood expenditure. Moreover, the study makes a modest contribution by adding to the growing body of empirical evidence on separability in demand for agricultural products. As others have done, a complete demand system is not specified. Rather, we assume that fish in aggregate is separable from all other food and non-food commodities.

We confine our study to the most consumed fish in the U.S, that is, shrimp, crab, salmon, tuna, farmed whitefish (tilapia, pangasius, and US catfish), and wild whitefish (pollock and tilapia). Two general separability structures were selected a priori for testing. First, we postulate that whitefish and crab are separable from the top 3 (shrimp, salmon and tuna). This hypothesis is inspired by the fact that the top three positions have been very consistent during the last two decades despite changes in seafood consumption. The only major change was salmon replacing tuna in the 2nd place in 2013 and thereafter (Appendix 2.1). The second hypothesis asserts that finfish (salmon, tuna, and whitefish) and shellfish (shrimp and crab) are separable. Hypothesis 1 and 2 are competing in the sense that only one of them may be true (or they are both not true). Depending on the outcomes of these basic tests, auxiliary tests would proceed. In the event that hypothesis 1 is true, we further hypothesize that salmon and tuna are separable from shrimp, and that whitefish are separable from crab. In the event that hypothesis 2 is true, we further postulate that within fish we have two separable groups, whitefish (farm and wild) and salmon and tuna. Similar to Eales and Wessells (1999), we approached the research objective with a generalized ordinary demand system expressed in quantity dependent form (Eales et al., 1997). Tests were performed to identify if any of the alternative demand models nested within the general system are compatible with the data. Given the chosen model, separability tests were carried out following the method developed in Moschini et al. (1994).

The article is organized as follows. In the next section I presents the generalized demand system and the associated tests for separability. Data and estimation procedures are explained in the next section followed by presentation and interpretation of the empirical results. The final section concludes with a brief summary.

The Analytical Framework

The Generalized Demand Model

This study utilizes the generalized demand model (Eales et al., 1997) for estimation because the system is consistent with demand theory, enables the computation of price and income elasticities, and allows for tests on theoretical restrictions of homogeneity and symmetry. More importantly, the separability test (Moschini et al., 1994) was developed for the ordinary demand system. The specification is expressed as follows:

$$\mathrm{dw_i} = \alpha_i + (\beta_i + \theta_1 \overline{w}_i)\mathrm{dlnQ} + \sum_{j=1}^{N}(\gamma_{ij} + \theta_2 \overline{w}_i(\delta_{ij} - \overline{w}_j))\mathrm{dlnp_j} \qquad (1)$$

where $\mathrm{w_i} = p_i q_i / \sum_{j=1}^{N} p_j q_j$ is the budget share of good *i*; $\mathrm{dlnQ} = \sum_{j=1}^{N} \overline{w}_j \, \mathrm{dlnq_j}$ is the Divisia volume index; $\mathrm{q_j}$ and $\mathrm{p_j}$ denote the quantity and the nominal price of good *j*; and δ_{ij} is the Kronecker delta. In this model $\overline{w}_j = (w_{j,t} + w_{j,t-1})/2$ is the two-period moving average of the market share, where subscript *t* denotes time. All variables are specified as finite changes, for example, $\mathrm{dw_i} = w_{i,t} - w_{i,t-1}$. The intercept α_i is added to capture change in budget share due to changes in tastes and preferences (Deaton and Muellbauer, 1980).

Nested in the generalized model are four demand models that have gained popularity on applied work, namely, the differential Almost Idea Demand System (AIDS), the

Rotterdam as well as two hybrid models - the National Bureau of Research (NBR) and the Central Bureau of Statistics (CBS)[8]. The generalized model permits testing if any of the four simpler models suffices to represent consumer preferences. The restrictions on the nesting parameters θ_1 and θ_2 and the resulting models were presented in table 2.1.

The Tests for Separability

Without loss of generality, let q^A and q^B denote some subvectors of the commodity vector q such that $q = (q^A, q^B)$. q^A is said to be (weakly) asymmetrically separable from q^B if the direct utility function can be written as $u = u(u_A(q^A), q^B)$, where u_A is the subutility function. This expression implies that there is a preference ordering associated with q^A *alone*. Choices over q^A bundles are made independently of q^B. q^A and q^B are symmetrically separable if the direct utility function take the form $u = u(u_A(q^A), u_B(\, q^B))$.

Following Moschini et al. (1994), group A is asymmetrically separable from group B if the following relationship holds for all goods *i* and *j* in group A and good *k* in group B:

$$\frac{\sigma_{ik}}{\sigma_{jk}} = \frac{e_i}{e_j} \tag{2}$$

[8] Although detailing on how the nested models were related, Neves (1994) did not nest them within a more generalized specification.

where σ_{ij} denotes the Allen-Uzawa elasticity of substitution between good *i* and *j*[9], and e_i the expenditure elasticity for good *i*. A and B are symmetrically separable if equation (2) also holds in reverse, that is, for all goods *k*, *m* ∈ B and good *i* ∈ A.

Under the generalized demand model, compensated cross price and expenditure elasticities, and the Allen-Uzawa elasticity of substitution are calculated using the following formulas (Eales et al., 1997):

$$e_{ik} = \frac{\gamma_{ik}}{w_i} - w_k(\theta_2 - 1) \quad \text{(compensated } \textit{cross} \text{ price elasticity)} \tag{3a}$$

$$e_i = \frac{\beta_i}{w_i} + 1 + \theta_1 \quad \text{(expenditure elasticity)} \tag{3b}$$

$$\sigma_{ik} = \frac{e_{ik}}{w_k} \quad \text{(Allen-Uzawa elasticity of substitution)} \tag{3c}$$

Thus, the restriction for the separability of goods *i*, *j* ∈ A from good *k* ∈ B is given by:

$$\frac{\gamma_{ik} - w_i w_k(\theta_2 - 1)}{\gamma_{jk} - w_j w_k(\theta_2 - 1)} = \frac{\beta_i + w_i(1+\theta_1)}{\beta_j + w_j(1+\theta_1)} \tag{4a}$$

or equivalently

$$\gamma_{ik} = \frac{\beta_i + w_i(1+\theta_1)}{\beta_j + w_j(1+\theta_1)}(\gamma_{jk} - w_j w_k(\theta_2 - 1)) + w_i w_k(\theta_2 - 1) \tag{4b}$$

[9] It is worth noting the Allen-Uzawa elasticity of substitution is symmetric, that is, $\sigma_{ij} = \sigma_{ji}$.

Let $U = U^0[q_1, q_3, q_4, q_2, q_5, q_6]$ denote the unrestricted utility function where all six included products are non-separable. We consider two hypotheses of different separable structures, all of which are tested against the unrestricted utility function. Depending on the outcomes of these basic tests, auxiliary tests will be performed to explore further structure of separability among the products.

The first hypothesis to be tested is whether whitefish (i = 5, 6) and crab (i = 2) are separable from the top 3 including shrimp (i = 1), salmon (i = 3) and tuna (i = 4) This implies that the utility function can be written as $U = U^0[h(q_1, q_3, q_4), k(q_2, q_5, q_6)]$. Following earlier discussion, this hypothesis requires 8 *non-redundant* restrictions for symmetric separability[10]. These restrictions can be represented in equation (5). The first six restrictions are for the *asymmetric* separability of whitefish and crab from the top 3, while the last two restrictions are sufficient for *symmetric* separability.

$$
\begin{aligned}
&\frac{\sigma_{12}}{\sigma_{15}} = \frac{e_2}{e_5}, \quad \frac{\sigma_{16}}{\sigma_{15}} = \frac{e_6}{e_5} \\
&\frac{\sigma_{32}}{\sigma_{35}} = \frac{e_2}{e_5}, \quad \frac{\sigma_{36}}{\sigma_{35}} = \frac{e_6}{e_5} \\
&\frac{\sigma_{42}}{\sigma_{45}} = \frac{e_2}{e_5}, \quad \frac{\sigma_{46}}{\sigma_{45}} = \frac{e_6}{e_5} \\
&\frac{\sigma_{35}}{\sigma_{45}} = \frac{e_3}{e_4}, \quad \frac{\sigma_{15}}{\sigma_{45}} = \frac{e_1}{e_4}
\end{aligned} \tag{5}
$$

[10] *Non-redundant* means overlapped (implied) restrictions are discarded.

If the preference structure indicated in equation (5), hereafter referred to as "Hypothesis 1", cannot be rejected, we further test whether salmon (i = 3) and tuna (i = 4) are separable from shrimp (i = 1) (Hypothesis 1.1), and whether whitefish (i = 5, 6) are separable from crab (i =2) (Hypothesis 1.2). These restrictions implies the utility function can be written as $U = U^0[h(q_1, x(q_3, q_4)), k(q_2, z(q_5, q_6))]$. Hypothesis 1.1 and 1.2 each requires one additional restriction expressed respectively in (6a) and (6b).

$$\frac{\sigma_{13}}{\sigma_{14}} = \frac{e_3}{e_4} \qquad (6a)$$

$$\frac{\sigma_{25}}{\sigma_{26}} = \frac{e_5}{e_6} \qquad (6b)$$

The second general hypothesis to be tested is whether, finfish (salmon, tuna, and whitefish, i = 3,..,6) are separable from shellfish (shrimp and crab, i = 1, 2) such that the utility function can be written as $U = U^0[f(q_1, q_2), g(q_3, q_4, q_5, q_6)]$. The 7 *non-redundant* restrictions that are necessary and sufficient for the symmetric separability between finfish and shellfish are as follows:

$$\frac{\sigma_{13}}{\sigma_{15}} = \frac{e_3}{e_5}, \quad \frac{\sigma_{14}}{\sigma_{15}} = \frac{e_4}{e_5}, \quad \frac{\sigma_{16}}{\sigma_{15}} = \frac{e_6}{e_5}$$

$$\frac{\sigma_{23}}{\sigma_{25}} = \frac{e_3}{e_5}, \quad \frac{\sigma_{24}}{\sigma_{25}} = \frac{e_4}{e_5}, \quad \frac{\sigma_{26}}{\sigma_{25}} = \frac{e_6}{e_5} \qquad (7)$$

$$\frac{\sigma_{15}}{\sigma_{25}} = \frac{e_1}{e_2}$$

In the event that the restrictions in equation (7), hereafter referred to as "Hypothesis 2", cannot be rejected, we then test further whether whitefish (i = 5, 6) are separable from salmon (i = 3) and tuna (i = 4), in addition to finfish being separable from shellfish (Hypothesis 2.1). In other words, the preference structure can be expressed as $U = U^0[f(q_1, q_2), g(u(q_3, q_4), v(q_5, q_6))]$. This hypothesis entails all restrictions as expressed in (7) plus the following 3 restrictions for *symmetric* separability:

$$\frac{\sigma_{35}}{\sigma_{36}} = \frac{e_5}{e_6}, \quad \frac{\sigma_{45}}{\sigma_{46}} = \frac{e_5}{e_6}$$

$$\frac{\sigma_{35}}{\sigma_{45}} = \frac{e_3}{e_4} \tag{8}$$

Data and Estimate Procedures

The generalized demand system in equation (1) is applied to the U.S imported fish market. Specifically, we estimate a system of 6 equations corresponding to shrimp (i = 1), crab (i = 2), salmon (i = 3), canned tuna (i = 4), farmed whitefish (tilapia, American catfish, and pangasius; i = 5), and wild whitefish (cod and pollock; i = 6). Except for catfish, monthly data on import quantities (kg) and values (US dollars) for the period 1999-2013 were obtained from the Marine Fisheries Services. Because retail/wholesale level prices for imported fish are not available, import prices are used as measure for market prices of imported fish. For each of the two aggregates (farmed and wild whitefish), group prices were constructed using the Stone price index. Group expenditure was the sum of individual import values. Group quantity was computed by diving the group expenditure by the group price index. Monthly data for US-raised catfish, wholesale prices and quantities, were taken from the Catfish Database 2013 (Hanson and Sites, 2013)[11]. Quantities data are summarized in table 2.2.

As shown in table 2.2, trade volume over the sample period increased roughly 1.5 times from 6,348 to 8,355 thousand metric tons. The main engine for such growth was salmon, tuna and farmed whitefish. Imported shrimp and crab stagnated while imported wild whitefish were on a downtrend. Consequently, although still being the leading species in consumption, market share for shrimp declined. Crab and wild whitefish found themselves in a similar situation with shrinking market shares. The beneficiaries were salmon, tuna and farmed whitefish as they saw their shares rising.

We started our estimation procedure with the Hausman (1978) test to affirm the exogeneity of prices and expenditure. Following the exogeneity test was model selection. Each of the nested models was tested against the generalized models using the Wald tests. Finally, depending upon the test outcomes, the tests for separability were performed on the chosen model.

For testing purposes, the Wald test is computationally appealing, as it requires estimating only the non-restricted model. This is particularly true as separability restrictions are nonlinear, which renders the formulation of the restricted model somewhat cumbersome, not to mentioned other linear restrictions for homogeneity and symmetry in a demand-

[11] White data on imported fish are available up-to-date, catfish database at wholesale level are not available after 2013.

system setting. The Wald test, unfortunately, has a severe drawback, that is, its numerical value is not invariant when the procedure involves nonlinear restrictions (Dagenais and Dufour 1991)[12]. For this reason, the likelihood ratio test is recommended. According to Laitinen (1978) and Meisner (1979), likelihood ratio tests of restrictions in large demand systems are, however, biased toward rejection. Hence, the "adjusted" test proposed by Italianer (1985), defined as follows, is conducted:

$$LR_0 = LR\left[\frac{MT-1/2(N_U+N_R)-1/2M(M+1)}{MT}\right] \tag{9}$$

where LR is the likelihood ratio from the regular likelihood ratio test; M is the number of equations; T is the number of observations; N_U is the number of parameters in the model restricted only by homogeneity and symmetry; and N_R is number of parameters in the model additionally restricted by separability constraints. It is asymptotically χ^2distributed with degrees of freedom equal to the number of restrictions.

Results

Concerning the Hausman test, the instruments used are lagged prices, lagged expenditures, the world food price index, an agricultural raw materials price index, a world energy price, and bilateral exchange rates between the US dollar and major seafood

[12] Please refer to Moschini et al. 1994 for a detailed discussion.

exporters to the US[13]. The resulting statistic is 29.47. The 5% critical value from a χ^2 with 35 degrees of freedom is 49.80[14]. Hence, the test result failed to reject the exogeneity of prices and expenditures. As the null hypothesis of price and expenditure exogeneity cannot be rejected, the least square estimators (SUR) are consistent and more efficient than 3SLS estimators (Hill et al., 2008). Thus, using SUR, the generalized model was tested to determine whether it could be rejected in favor of one of the nested models. As shown in table 2.3, the computed Wald statistics for all the nested models exceed the critical value. Hence, test results indicate that, given the dataset in use, the generalized model is the suitable specification to model U.S fish demand, and we proceed on that basis.

Separability tests were carried out by comparing estimates of the generalized model with only homogeneity and symmetry imposed to estimates obtained when additional restrictions implied by separability (equations 5-8) are imposed. The Italianer's adjusted likelihood ratio test was used. Because the separability restrictions involve expenditure shares, tests were performed at mean data points for these parameters. Because the separability restrictions are nonlinear, the restricted models were estimated using nonlinear SUR. Potential autocorrelation was corrected using the Cochrane-Orcutt (1949) procedure prior to the separability tests. Test results are presented in table 2.4.

[13] Monthly data on these indices were taken from International Monetary Fund website. Monthly exchange rates data were taken from the website created by Antweiler (2007). Major seafood exporters to the US are Canada, Chile, China, Indonesia, Norway, Thailand, Iceland, and Vietnam.

[14] 35 degrees of freedom as seven variables are treated as endogenous in each of the five equations in the alternative models. Tests are done without homogeneity and symmetry restrictions.

As shown in table 2.4, hypothesis 1 is rejected at the 5% level. It means that the top 3 (shrimp, salmon and tuna) cannot be treated as separable from whitefish and crab (or vice versa). Given the rejection of hypothesis 1, hypotheses 1.1. and 1.2 are rejected at no surprise. Alternatively, symmetric separability between finfish and shellfish (hypothesis 2) cannot be rejected. This suggests finfish and shellfish are symmetrically separable. Furthermore, we also failed to reject the symmetric separability between whitefish and salmon and tuna (hypothesis 2.2).

Edgerton (1997) noted it would be inefficient if separability was corrects but its implication was disregarded. In light of this, the 6-equation model was estimated with and without separability restrictions[15]. Own-price and expenditure elasticities, evaluated at mean expenditure shares, were computed following each estimation. As shown in table 2,5, estimated elasticities show minimal differences between two models, except for salmon. Moreover, confidence intervals are strikingly similar. It therefore appears that, given our dataset, changes from imposing separability restrictions on the 6-equation system are too modest to matter.

Following the separability structure in hypothesis 2 and 2.1, one may choose to estimate three separate 2-equation systems for shrimp and crab, salmon and tuna, and farmed and wild whitefish. It may be of some interest to see how elasticities estimated from a 6-equation system with separability imposed differ from those generated from three

[15] Restrictions imposed pertain to hypothesis 2 and 2.1, expressed in equations (7) and (8).

separate 2-equation systems. From table 2.6, expenditure elasticities are generally different; and these differences are statistically significant, as the confidence intervals do not overlap (4 out of 6 cases). Point estimates for price elasticities show less variation with overlapping confidence intervals, except for farmed whitefish. Hence, the overall impression here is that it is not inappropriate to estimate separate demand systems for products of interest, as the benefits from a simplified demand system may outweigh the costs (bias in estimated parameters/elasticities). However, if one is to estimate unconditional elasticities which are better suited for policy analysis, it may be desirable to maintain separability restrictions within a more complete demand system (Moschini et al. 1994).

Conclusion

In this study we aimed to explore the separability in US consumer preferences for fish. Included fish are the top most consumed products in the US. The generalized demand system was utilized to explore seafood (import) demand in the US. Test results show that none of the nested models are compatible with the data. Hence, the generalized system was used to test for separability among seafood products. Results indicate that (at the highest level of aggregation) shellfish (shrimp and crab) are separable from finfish (salmon, tuna and whitefish) and vice versa. Additionally, within the finfish group whitefish are separable from salmon and tuna. We were unable to test for separability between salmon and tuna, as well as between shrimp and crab. Further disaggregation of these products would be, therefore, preferable and render the tests possible. This, however, would make the problem addressed here more cumbersome. At this point, it appears that results provide some support for the common separability assumption concerning fish products. Hence, one may choose to model fish products separately or simultaneously with separability restrictions imposed. The two approaches, although theoretically equivalent, may generate two sets of elasticities of differing magnitudes. Given our dataset, the benefits (a simplified demand system) may outweigh the costs (bias in estimated parameters/elasticities).

Table 2.1. Restrictions on the Nesting Parameters

	Restriction	
Model	θ_1	θ_2
AIDS	0	0
Rotterdam	-1	1
CBS	0	1
NBR	-1	0

Table 2.2. Import Volumes and Market Shares for U.S Most Consumed Seafood

Product	Shrimp	Crab	Salmon	Tuna	F.whitefish	W.whitefish	Total
Year span				Volume (thousand tons)			
1999-2003	2,013	445	898	1,357	964	671	6,348
2004-2008	2,769	600	1,186	1,380	1,414	616	7,965
2009-2013	2,731	511	1,295	1,438	1,818	562	8,355
Year span				Market share (%)			
1999-2003	0.48	0.11	0.12	0.10	0.12	0.07	1.0
2004-2008	0.42	0.14	0.15	0.11	0.13	0.06	1.0
2009-2013	0.40	0.11	0.18	0.13	0.15	0.04	1.0

Source: National Marine Fisheries Service, and Hanson and Site (2013).

Table 2.3. Tests for Restricted Versions of the Generalized Model

Model	Restriction	Computed χ^2	Result
AIDS	$\theta_1 = 0,\ \theta_2 = 0$	6.59	Reject
Rotterdam	$\theta_1 = -1,\ \theta_2 = 1$	1074	Reject
CBS	$\theta_1 = 0,\ \theta_2 = 1$	849	Reject
NBR	$\theta_1 = -1,\ \theta_2 = 0$	95.6	Reject

Note: The critical value at 5% significant level with 2 degrees of freedom is 5.99 for all cases.

Table 2.4. Results of Separability Test

Separability between	Log likelihood	Italianer LR_0	No. of restrict.	Critical values	Results
Top 3 and whitefish & crab	2778	18.9	8	15.5	Reject
Shrimp and salmon & tuna	2778	19.1	9	16.9	Reject
Whitefish and crab	2778	18.9	9	16.9	Reject
All of them above	2778	19.2	10	18.3	Reject
Shellfish and finfish	2786	4.9	7	14.1	Fail to reject
Whitefish and salmon & tuna	2785	6.4	10	18.3	Fail to reject

Notes: Top 3 includes shrimp, salmon and tuna. The log likelihood of the unrestricted model is 2788. The adjustment for the Italianer log likelihood ratio (LR_0) is about 0.9. χ^2 critical values are at 5% significant level.

Table 2.5. Price and Expenditure Elasticities from Models with and w/o Separability

Products	Own-price elasticities			Expenditure elasticities		
	W/out separability	With separability	Ratio	W/out separability	With separability	Ratio
Shrimp	-0.90	-0.91	1.01	1.40	1.39	0.99
	(-1.13, -0.65)	(-1.08, -0.74)		(1.25, 1.54)	(1.24, 1.53)	
Crab	-0.82	-0.85	1.03	1.73	1.76	1.01
	(-1.17, -0.46)	(-1.11, -0.59)		(1.39, 2.05)	(1.42, 2.09)	
Salmon	-0.64	-0.48	0.75	0.17	0.23	1.35
	(-0.89, -0.37)	(-0.67, -0.28)		(0.02, 0.32)	(0.11, 0.33)	
Tuna	-1.09	-1.19	1.09	0.73	0.63	0.86
	(-1.39, -0.79)	(-1.45, -0.93)		(0.45, 0.99)	(0.40, 0.84)	
Farmed	-1.11	-1.09	0.98	0.54	0.57	1.05
whitefish	(-1.41, -0.80)	(-1.34, -0.82)		(0.36, 0.71)	(0.40, 0.73)	
Wild	-0.96	-0.95	0.99	0.66	0.67	1.01
whitefish	(-1.36, -0.55)	(-1.32, -0.57)		(0.30, 1.02)	(0.34, 0.99)	

Note: All estimated elasticities are significant at 5% or better. Numbers in parentheses are 95% confidence intervals.

Table 2.6. Price and Expenditure Elasticities from 6-equation and 2-equation Models

	Own-price elasticities			Expenditure elasticities		
Products	6-eq. system	2-eq. system	Ratio	6-eq. system	2-eq. system	Ratio
Shrimp	-0.91	-0.85	0.93	1.39	0.92	0.66
	(-1.08, -0.74)	(-1.06, -0.65)		(1.24, 1.53)	(0.70, 1.13)*	
Crab	-0.85	-0.70	0.82	1.76	0.87	0.49
	(-1.11, -0.59)	(-1.05, -0.35)		(1.42, 2.09)	(0.24, 1.50)*	
Salmon	-0.48	-0.56	1.16	0.23	0.38	1.65
	(-0.67, -0.28)	(-0.79, -0.32)		(0.11, 0.33)	(0.00, 0.76)	
Tuna	-1.19	-1.24	1.04	0.63	1.83	2.90
	(-1.45, -0.93)	(-1.52, -0.95)		(0.40, 0.84)	(1.34, 2.33)*	
Farmed	-1.09	-0.68	0.62	0.57	0.54	0.94
whitefish	(-1.34, -0.82)	(-0.88, -0.48)*		(0.40, 0.73)	(0.26, 0.82)	
Wild	-0.95	-1.25	1.31	0.67	1.83	2.73
whitefish	(-1.32, -0.57)	(-1.54, -0.96)		(0.34, 0.99)	(1.25, 2.40)*	

Note: All estimated elasticities are significant at 5% or better. Numbers in parentheses are 95% confidence intervals. Asterisks denote non-overlapping confidence intervals.

Chapter 3

The Effects of Exchange Rates on Export Prices of Vietnamese Pangasius

Introduction

An increasing number of species have entered the international seafood market in significant volumes, and pangasius (*Pangasius hypophthalmus*) is one of the most successful as measured in volume (Asche et al., 2009). Vietnam is currently the world's largest producer of pangasius (FAO, 2010); and the product is a flagship of the country's seafood exports. Traditionally exported to the U.S, Vietnamese pangasius is now shipped to a large number of global markets. As export and import prices of the product are not expressed in the same currency, exchange rate adjustments may potentially play a contributing role in price formation. As a wedge between import and export prices, exchange rate realignments can alter the price received by the exporter even if the import price remains unchanged. Conversely, exchange rate realignments can shift the price paid by the importer even if the exporter does not change the price at all.

Motivating this exercise is the continuous devaluation of the Vietnamese currency (VND) which may in effect act as an implicit subsidy (Schuh 1976). Faced with domestic currency devaluation, exporters may (1) keep the export price (in domestic currency) unchanged to gain competitiveness in foreign markets (producer currency pricing), (2) increase the export price to broaden the profit margin (local currency pricing), or (3) choose some combination in between[16]. Figure 3.1 plots the trade-weighted exchange rate between VND and major importers' currencies, while figure 3.2 sketches the export price (VND) and the import price (foreign currency unit-FCU) of Vietnamese pangasius exports[17]. Altogether, these two figures graphically suggest the contribution of VND devaluation toward the opposite trends in the import and export prices.

One can study the effects of exchange rate movements from the importer's or the exporter's perspectives. This study is interested in the pass-through of exchange rate adjustments into the export price. Knowledge of the reaction of export prices to exchange rates is important for at least two reasons. First, such elasticity is crucial to the evaluation of price competitiveness. Second, the responsiveness of export prices to exchange rates governs the reaction of export volumes to exchange rates (Bussière, 2007). For the case of Vietnamese pangasius which is an important source of export earnings, such knowledge is particularly essential. To the best of our knowledge, this is the first study that estimates the elasticity of Vietnamese pangasius export prices to exchange rates. This exercise relies on the analytical framework in Xie, Kinnucan and Myrland (2008) to achieve its objective. Besides, our study compares to Thong et al. (2016) since export demand elasticities were also estimated as a by-product of the analysis.

[16] Exchage rate pass-through to export price is zero for producer currency pricing, and minus 1 for local currency pricing. Empirical estimates generally tend to be significantly different from 0 and -1 (e.g. see Bussière, Chiaie and Peltonen, 2008)

[17] The import price in foreign currency unit (FCU) is equal to the export price (VND) multiplied by the trade-weighted exchange rate between VND and major importers' currencies.

In the next section we detail the model specification as well as the construction of exchange rate indices. Specifically, we extend the inverse AIDS system (Barten and Bettendorf, 1989) to incorporate exchange rates. Flexibilities from the estimated model are computed and hypotheses are tested. Discussion is presented alongside with the results. The paper concludes with a brief summary of key findings.

The Analytical Framework

Basic Specification

As shown in Brown, Lee and Seale (1995), inverse demand models all start with the following basic specification form:

$$(1) \qquad w_i \, \mathrm{d}ln\pi_\mathrm{i} = h_i \, d\ln Q + \sum_j h_{ij} \, d\ln q_j \qquad i = 1, \ldots, n$$

where $\pi_i = p_i/y$ is the normalized price of good i; p_i and q_i are the nominal price and quantity of good i; $y = \sum_{i=1}^{n} p_i q_i$ is total expenditure; $w_i = p_i q_i / y$ is the expenditure share for good i; $d\ln Q = \sum_i w_i d\ln q_\mathrm{i}$ is the Divisia volume index; h_i and h_{ij}, respectively the scale and quantity effects, are parameter to be estimated. In essence, equation (1) is the specification for the inverse Rotterdam model. By imposing restrictions on h_i and/or h_{ij}, other inverse demand systems (AIDS, CBS, and NBR) can be achieved.

2.2. Incorporating Exchange Rates

Following Xie et al. (2008), the exchange rates may be incorporated into the basic specification as follows. First, let us define $p_i = p_i^x . Z_i$ or equivalently:

(2) $$\mathrm{d}lnp_i = \mathrm{d}lnp_i^x + \mathrm{d}lnZ_i$$

where p_i is the import price of good *i* in the importer's currency, p_i^x is the export price of good i in the exporter's currency, and Z_i is the bilateral exchange rate that converts the export price into the currency of the import price. The Z_i variables are expressed as the importers' currency unit divided by the exporter's currency unit. This way, an increase in Z_i reflects the exporter's currency strengthening. Now, totally differentiating the budget constraint $y = P.Q$ to yield:

(3) $$d\ln y = d\ln P + d\ln Q$$

where $\mathrm{d}lnP = \sum_i w_i \mathrm{d}lnp_i$ is the Divisia price index. Substituting equation (2) into (3) results in:

(4) $$d\ln y = \sum_i w_i \mathrm{d}lnp_i^x + \sum_i w_i \mathrm{d}lnZ_i + d\ln Q$$

Finally, substituting equation (4) into (1), and rearranging terms yields the demand system that has exchange rates as explanatory variables:

(5) $$w_i d\ln\pi_i^x = h_i d\ln Q + \sum_j h_{ij} d\ln q_j + \sum_j c_{ij} d\ln Z_j$$

where $\pi_i^x = p_i^x/y^x = p_i^x/P^x Q$ is the normalized price in the exporter's currency, $\mathrm{d}lnP^x = \sum_i w_i \mathrm{d}lnp_i^x$ is the Divisia price index in exporters' currencies, and $c_{ij} = w_i w_j - w_i \delta_{ij}$ are coefficients on the exchange rate variables. Theory implies the following restrictions on h_i, h_{ij} and c_{ij}:

(6a) $\sum_i h_i = 0 \quad \sum_i h_{ij} = 0 \quad \sum_i c_{ij} = 0$ (Adding up)

(6b) $\sum_j h_{ij} = 0 \quad \sum_j c_{ij} = 0$ (Homogeneity)

(6c) $h_{ij} = h_{ji} \quad c_{ij} = c_{ji}$ (Antonelli symmetry)

Estimated parameters are used to compute scale, quantity and exchange rate flexibilities using the following formulas:

(7a) $f_i = \frac{\partial \ln \pi_i^x}{\partial \ln Q} = \frac{h_i}{w_i}$ (Scale flexibility)

(7b) $f_{ij}^* = \frac{\partial \ln \pi_i^x}{\partial \ln q_j} = \frac{h_{ij}}{w_i}$ (*Compensated* quantity flexibility)

(7c) $f_{ij} = \frac{\partial \ln \pi_i^x}{\partial \ln q_j} + w_j \frac{\partial \ln \pi_i^x}{\partial \ln Q}$ (*Uncompensated* quantity flexibility)

(7d) $z_{ij} = \frac{\partial \ln \pi_i^x}{\partial \ln Z_j} = \frac{c_{ij}}{w_i}$ (Exchange rate flexibility)

As with the scale and quantity flexibilities, exchange rate flexibilities expressed in equation (7d) measure the pass-through of exchange rate movements into *normalized price* π_i^x. The pass-through into *non-normalized* price p_i^x is given by the following equations (see Appendix 3.1 for derivation):

(8) $$z_{ij}^{A} \equiv \frac{\partial lnp_i^x}{\partial lnZ_j} = \frac{c_{ij}}{w_i(1-w_i)}$$

Substituting $c_{ij} = w_i w_j - w_i \delta_{ij}$ into equation (8) yields the exchange rate flexibilities in terms of budget shares:

(9a) $$z_{ii}^{A} = -1 \quad \text{(own-effect)}$$

(9b) $$z_{ij}^{A} = \frac{w_j}{(1-w_i)} > 0 \quad \text{(cross-effect)}$$

When output supplies are fixed, sellers bear the full incidence of exchange rate movements[18]. A 1% appreciation in the exporter's currency causes the price received by the exporter to decrease by 1% (i.e. exchange rate pass-through is complete). Equation (9a) lends itself to a test for market efficiency. If the market is efficient in the sense that exchange rate pass-through is complete, it is sufficient to test whether the estimated own-exchange rate flexibilities defined in equation (8) are minus one[19].

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18 Exchange rate flexibilities measure *ceteris paribus* effects of exchange rate adjustments (i.e. holding quantities constant).

19 Quoting from NcNew and Fackler (1997 p. 192) "the concepts of efficiency and the LOP are synonymous and taken to mean that arbitrage opportunities are quickly eliminated and therefore negligible in observed variables, including prices." By this definition, if LOP doesn't hold that would imply the market is inefficient. Thus, if complete pass-through is defined as a situation where LOP does hold, it follows that the market is efficient.

Finally, in order to obtain the inverse AIDS model from the basic specification, restrictions on parameters $h_i = b_i - w_i$ and $h_{ij} = \gamma_{ij} - w_i\delta_{ij} + w_i w_j$ are imposed on equation (5), where δ_{ij} is the Kronecker delta, w_i (and w_j) are expenditure shares as defined above, and b_i and γ_{ij} are parameters in the inverse AIDS model (Brown et al., 1995). Rearranging terms and adding an intercept, the inverse AIDS model can be written as follows:

(10) $$w_i d\text{ln}w_i^x = b_i \text{d}lnQ + \sum_j \gamma_{ij} \text{dln}q_j + \sum_j c_{ij} d\text{ln}Z_j$$

where $w_i^x = p_i^x q_i / y^x = p_i^x / P^x Q$ is the expenditure share defined in the exporter's currency. Equation (10) differs from equation (5) in that expenditure share replaces normalized price as the dependent variable, and preference change is captured through the inclusion of the intercept (Deaton and Muellbauer, 1980). Theoretical restrictions on b_i and γ_{ij} follow naturally: $\sum_i b_i = 0$, $\sum_i \gamma_{ij} = 0$ (Adding-up), $\sum_j \gamma_{ij} = 0$ (Homogeneity), $\gamma_{ij} = \gamma_{ji}$ (Antonelli symmetry). Theoretical restrictions on c_{ij} remained unchanged. Similarly, imposing restrictions on h_i and h_{ij} does not affect the calculation of exchange rate flexibilities, but will modify the formulas for quantity and scale flexibilities:

(11a) $$f_i = \frac{h_i}{w_i} = -1 + \frac{b_i}{w_i}$$ (Scale flexibility)

(11b) $$f_{ij} = \frac{h_{ij}}{w_i} + w_j \frac{h_i}{w_i} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} + w_j \frac{b_i}{w_i}$$ (Uncompensated quantity flexibility)

Empirical Specification

Equation (10) is applied to the case of Vietnamese pangasius exports. The exporter's currency is Vietnamese Dong (or VND). Each equation represents export demand from each importing region. Specifically, four-equation system is estimated corresponding to exports of pangasius frozen fillets to four regions: North America (i = 1), EU (i = 2), and Non-EU (i = 3) and ROW (i = 4)[20]. We implicitly assume pangasius frozen fillets are weakly separable from all other goods, including other product forms/cuts of pangasius.

As individual importers are grouped, exchange rates would enter as indices which are constructed as follows:

$$d\ln Z_i = \sum_{j=1}^{J} k_{ij}\, d\ln B_i^j \qquad (12)$$

where Z_i is the trade-weighted exchange rate corresponding to region i, k_{ij} is the *within-group* quantity share of pangasius exports sold in market j (within region i), and B_i^j is the corresponding bilateral exchange rate between importer j and Vietnam, expressed as the importer j's currency unit divided by the Vietnamese currency unit (VND). Hence, a decrease in Z_i represents devaluation of the Vietnamese currency.

[20] North America includes the U.S and Canada. EU includes Eurozone importers. Non-EU includes European importers that are not Eurozone members. Rest of the world (ROW) includes Australia, New Zealand, and Asian importers. The grouping helps reduce the number of equations to be estimated. More importantly, it eliminates missing data problem. Although Vietnamese pangasius is shipped to a great number of markets, only small portion of those are consistent importers.

For North America, the Z_1 variable is computed using USD/VND and CAD/VND. For the EU market, EUR/VND (Z_2) is the appropriate rate to use. For Non-EU (Z_3) and ROW (Z_4), the Z variables are constructed correspondingly to major importers of each group.[21] Monthly exchange rate data are obtained from the website developed by Antweiler (Antweiler, 2007).

In estimating equation (10), differentials are approximated with first differences. For instance, $d\ln Z_i$ is approximated as $\Delta \ln Z_i = \ln Z_{i,t} - \ln Z_{i,t-1}$, where subscript t denotes time[22]. Monthly dummy variables are added to account for seasonality. The coefficients of each of these eleven dummies must add up to zero over equations to satisfy adding-up restriction. The final estimating equation takes the form:

$$\bar{w}_{i,t} d\ln w_{i,t}^{x} = \alpha_i + b_i \Delta lnQ_t + \sum_{j=1}^{4} \gamma_{ij} \Delta \ln q_{j,t} + \sum_{j=1}^{4} c_{ij} \Delta \ln Z_{j,t} + \sum_{m=1}^{11} \varphi_m D_{m,t} \quad (12)$$

where $\bar{w}_{i,t} = (w_{i,t} + w_{i,t-1})/2$, $\Delta lnQ_t = \sum_{j=1}^{4} \bar{w}_{j,t} \Delta \ln q_{j,t}$, $\Delta lnP_t^x = \sum_{j=1}^{4} \bar{w}_{j,t} \Delta \ln p_{j,t}^x$. The system was estimated using Seemingly Unrelated Regression (SUR). One equation was dropped to avoid singularity in the covariance matrix. Estimates are invariant to the dropped equation, provided that the error terms are free of autocorrelation (Deaton and Muellbauer, 1980). The system was estimated with a common rho value for all equations

[21] Major importers in the Non-EU market are Poland (PLN/VND), Romania (RON/VND), Switzerland (CHF/VND), and United Kingdom (GBP/VND). For ROW, they are Australia (AUD/VND), Japan (JPY/VND), Thailand (THB/VND), Singapore (SGD/VND) and Malaysia (MYR).

[22] The process of first differencing is likely to make variable stationary (Matsuda, 2005), and hence eliminates spurious regression.

to correct for serial correlation. The common rho, which is the average of the correlation coefficients of individual equations, was applied to ensure SUR estimators are invariant to the equation dropped[23].

Market Description

Monthly data on export values and quantities of Vietnamese pangasius frozen fillets (January 2007-March 2014) were obtained from the International Trade Center (www.trademap.org). The product was sorted under two separated codes HS030429 (frozen fish fillets, between 2007–2012) and HS030462 (Pangasius frozen fillets, 2012 and thereafter). Although the code HS030429 was applied to all frozen fish fillets, cross checking revealed that more than 95% of frozen fish fillets exported from Vietnam were pangasius (Thong et al., 2016).

About 90% of pangasius production outputs are destined for export, almost all of which are exported as frozen fillets (Duijn van et al., 2012). Pangasius exports increased roughly from 720 to 1,200 million USD between 2007-2011 before declining to approximately 905 and 867 million USD in 2012 and 2013, respectively (table 3.1). EU and the U.S are the most important markets, together accounting for approximately two-third of total export values. The year of 2012 marked the first time the US surpassed EU to be the largest market. This is pretty impressive knowing that EU, although often referred to as a single market, consists of several importers.

[23] Using the common rho value, we transformed the data using the Cochrane-Orcutt (1949) procedure before estimating the system with SUR.

Exports to EU were mainly driven by Spain, Netherlands and Germany, collectively accounting for more than 50% (Appendix 3.2.A). Within the non-EU group, Poland used to be the largest trade partner. Its importance, however, dwindled with the rise of the UK and Russian markets (Appendix 3.2.B). Among ROW importers Australia accounted for about 50% of group imports until 2011 before losing its importance to such emerging markets as Thailand, and Malaysia (Appendix 3.2.C.)

As Vietnamese pangasius began to thrive, a wide range of protective measures has been used. In the U.S, catfish labeling was initiated in late 2001, followed by the antidumping duty which came into effect in late 2003. Most recently, the catfish inspection program has been passed which is claimed to protect U.S consumers from adulterated fish imports from Asia. In European Union, Vietnamese pangasius is faced with an uphill battle to protect its product image. A broad set of mass media, including blogs, newspapers, documentaries and parliamentary transcripts, has been persistent in picturing Vietnamese pangasius as an unsafe and unsustainable product (Bush and Duijf, 2011; Little et al. 2012) because the species is farmed in the heavily polluted Mekong River and contains pesticides and chemicals residues. However, there is no scientific evidence supporting the various claims that have been used to slander Vietnamese pangasius (Murk et al., 2016).

Results

Theoretical restrictions on quantity variables are imposed as maintained hypotheses. Whereas, exchange-rate homogeneity and symmetry are tested to explore whether they are compatible with the data. Results are affirmative (table 3.2). Hence, the remaining discussion will be based on results with these restrictions imposed.

Estimation results for the final model using SUR are presented in table 3.3. The R^2s range from 0.86 to 0.94 with ROW's equation exhibiting the least explanatory power and Non-EU the most. Own and cross-quantity estimates are all significant. By contrast, none of the estimates for the Divisia volume index are significant. Own exchange-rate effects are negative and significant for North America, EU and Non EU. Cross exchange-rate effects are positive or insignificant.

Scale and Quantity Flexibilities

The scale and quantity flexibilities evaluated at mean expenditure shares are reported in table 3.4. All the scale flexibilities are significant with EU being most elastic (-1.04) and North America being least (-0.92). These estimates suggest a 1% increase in the scale of pangasius frozen fillet exports would cause normalized export prices in VND to fall by between 0.92% to 1.04% depending on destination market and *holding exchange rate constant*. According to Park and Thurman (1999), an elastic (inelastic) scale response implies an inelastic (elastic) income response. It appears that EU and ROW demand for pangasius frozen fillets is income inelastic, while in North America and Non-EU the demand is income elastic.

Estimated (uncompensated) own flexibilities are all inelastic, which *ceteris paribus* indicates a potential for expansion in the existing markets without substantial reduction in prices. Quoting from Anderson (1980), quantities flexibilities "tell you how much price *i* must change in order to induce the consumer to absorb marginally more of good *j*". Hence, for instance, in order to induce a 1% increase in export volumes to EU, export price must drop by 0.49%, while for North America the figure is 0.31%. Our estimates compare to those in Thong et al. (2016).

Houck (1966) showed that the inverse of the absolute value of the own-quantity flexibility sets the lower bound on the own-price elasticity. Thus, with inelastic own-quantity flexibilities export demands for Vietnamese pangasius appear to be price elastic. This result compares to previous studies' findings that demand for fish was price elastic (Park et al., 2004; Lee and Kennedy, 2008, 2010). This is one reason why Vietnamese exporters are consistently using keen prices to accumulate market shares[24].

Estimated cross flexibilities are highly significant and negative in sign. In this study where one product is exported to different markets, negative cross flexibilities can be interpreted as market substitutability. This therefore suggests that when confronted with obstacles in one market, Vietnamese exporters may divert exports to other markets. Negative cross flexibilities also indicate that increased exports to one market would depress export prices to that market and all other markets. This is because prices for similar products are likely to be similar and stay synchronized over time (Asche, 2014).

[24] While this strategy has proven successful, they might wind up in another dispute. Recall that the U.S catfish producers filed the antidumping petition when the market share for Vietnamese pangasius was about 10%. Had Vietnamese exporters not priced their products aggressively low, they might not have lost the case, or there might have been no antidumping petition at all in the first place.

Exchange Rate Flexibilities

Exchange rate flexibilities for normalized and absolute price are identical in signs and statistical significance (table 3.5). The latter, however, exceeds the former in absolute value. With that in mind, we confine our discussion to the absolute price (exchange rate) flexibilities, as they are more interpretable.

In North American, EU and Non-EU markets, exchange rates do play a role in the formation of export prices, generating significant flexibilities with expected signs (negative). The EUR/VND rate (Z_2) generates 3 significant estimates as compared to 2 estimates each for the North America and Non-EU indices (Z_1 and Z_3). What is more, estimated flexibilities pertaining to Z_2 are larger than those for Z_1 and Z_3. Hence, it appears that the EUR/VND has the largest influence on price formation.

Hypothesis Tests

Recalling from table 3.3 that in every equation the own exchange-rate effects are larger (in absolute value) than the own-quantity effects. Statistical tests were performed to verify whether these differences were significant. The null hypothesis is the equality of the own-quantity and the own-exchange rate effects (i.e. H_0: $|\gamma_{ii}| = |c_{ii}|$). At 5% we are able to reject the null for Non-EU, but fail to do so for North America and EU (table 3.6). Thus, the test results suggest the importance of exchange rate adjustments relatively to export quantity changes.

Turing to exchange rate pass-through, tests were performed against the null H_0: $z_{ii}^{A} = -1$ (i.e. complete pass-through), which indicates the incidence of currency realignments is borne largely by the exporting sector, especially in the short run when export supply is inelastic. It also suggests markets are efficient at converting of currency changes into price changes (Xie et al., 2008). The null is rejected for all markets, which implies that exchange rate pass through is incomplete. Thus, it appears that with respect to Vietnamese pangasius frozen fillets none of the importing markets is efficient. Market power may be a plausible explanation knowing that virtually all pangasius imported to the European Union and the U.S comes from Vietnam.

Implication to Antidumping

That the exchange rate pass-through to export prices is incomplete (about 50%) suggests a nontrivial split of the incidence is born by the importing sector. This has an implication to the antidumping duty which has been imposed on Vietnamese pangasius frozen fillets in the U.S market.

The purpose of the antidumping is to narrow the gap between Vietnamese pangasius and U.S catfish so that the imported product may lose its attraction in the U.S consumers' eyes. Yet, by passing part of the VND devaluation into the import price (denominated in USD), Vietnamese exporters are probably able to keep the tax-exclusive import price so low that the tax-inclusive import price can stay sufficiently below the U.S catfish price. As noted in Quagrainie and Engle (2002), as long as wholesalers and retailers do not see a convincing reason for paying a price premium for U.S catfish, they will opt for the lower-priced product. Consequently, the efficacy of the antidumping may be impeded. Figure 3.3 and 3.4 provide supportive graphical evidence for our arguments.

Figure 3.3 plots the import prices (USD) of frozen fillets of Vietnamese pangasius with and without the tax and the U.S catfish price[25]. Without tax, the imports from Vietnam are about $3/kg cheaper than the U.S-raised product. The tariff helps narrow the gap to about $1.5/kg[26]. It is worth noting that while the tax-inclusive import price is pretty stable with modest fluctuation, the tax-exclusive import price trends downward. In figure 3.4, although the (tax-exclusive) import price (USD) tends downward, the export price (VND) tends upward; and this is possible because of the VND devaluation against the USD.

Simulation

As an illustration, we simulated the model to have an insight into the extent to which currency realignments and export quantity changes (ceteris paribus) affected 2010-2013 export prices. During this period, VND devaluation led to decreases of 9%, 9% and 35% in the exchange rate indices for North America, EU and Non-EU, respectively. Over the same period, exports to North America increased by 77% while exports to EU and Non-EU fell by 36% and 38%, respectively. Multiplying those figures with the corresponding

[25] Vietnam-wide tax rates were used to compose the tax-inclusive price. Between 2007-2008, the rate was 63.88%. From 2009-2013, the rate was $2.11/kg (Federal Register, 2007-2013). Wholesale prices of U.S catfish frozen fillets were obtained from Hanson and Site (2013).

[26] Price gaps are even larger after 2011.

quantity and exchange rate flexibilities yields the changes in export prices (%) due to changes in export volumes and exchange rates[27]. Results are presented in table 3.7.

While changes in export prices are most attributable to changes in export quantities, exchange rate realignments play a contributing role. This is most apparent for Non-EU where the overall effect of VND devaluation (9%) exceeds the overall effect of export changes (-2%), leading to a 7% increase in export price. In contrast, VND devaluation works in tandem with export changes to depress export price to EU by 4%. For North America, the overall effect of quantity changes overwhelmingly exceeds the overall effect of exchange rate changes, leading to an 8% reduction in export price to this market.

Conclusion

This study finds that exchange rates and export quantities work hand in hand to determine the export price of Vietnamese pangasius. Specifically, in North America, EU and Non-EU markets, the effects of currency realignments are at least as large as the effects of export volume changes. The exchange rate pass-through to export prices is about 50%, which means that a 10% devaluation in the VND lead to a 5% increase in the export price (denominated in VND). Statistical tests suggest that exchange rate pass-through is incomplete. In other words, export prices do not move one in one with exchange rates. Market power may possibly a potential contributing factor, knowing that Vietnam is the world's largest pangasius producer.

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[27] The model was simulated using the uncompensated quantity flexibilities and the normalized price exchange rate flexibilities. Insignificant exchange rate flexibilities are set to 0.

In addition to suggesting market is inefficient, incomplete pass-through also means that part of the incidence of exchange rate realignments is passed into the import prices in foreign currencies. This way, Vietnamese exporters can increase their profit margins, while still enjoying improved competitiveness in foreign markets. With respect to the antidumping duty, this implies that the efficacy of the protective measure may possibly be diluted.

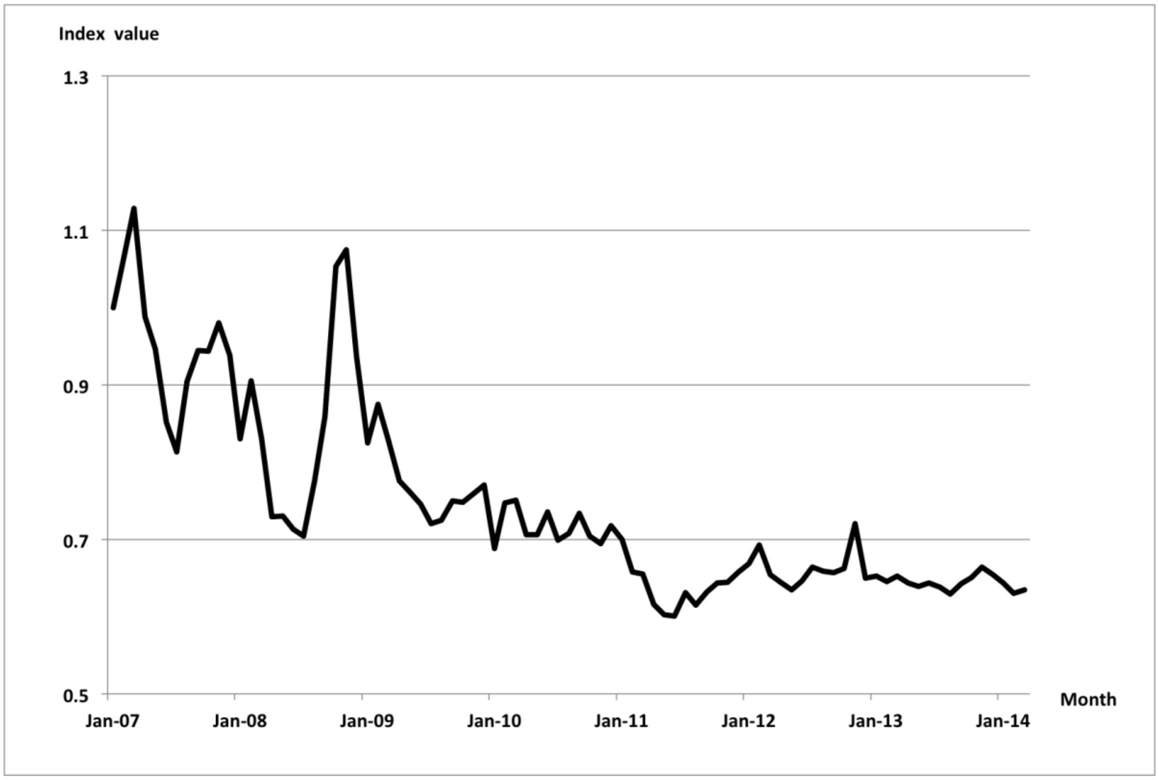

Figure 3.1. Trade-Weighted Exchange Rates Between VND and Major Importers' Currencies (FCU/VND; Jan 2007 = 1).

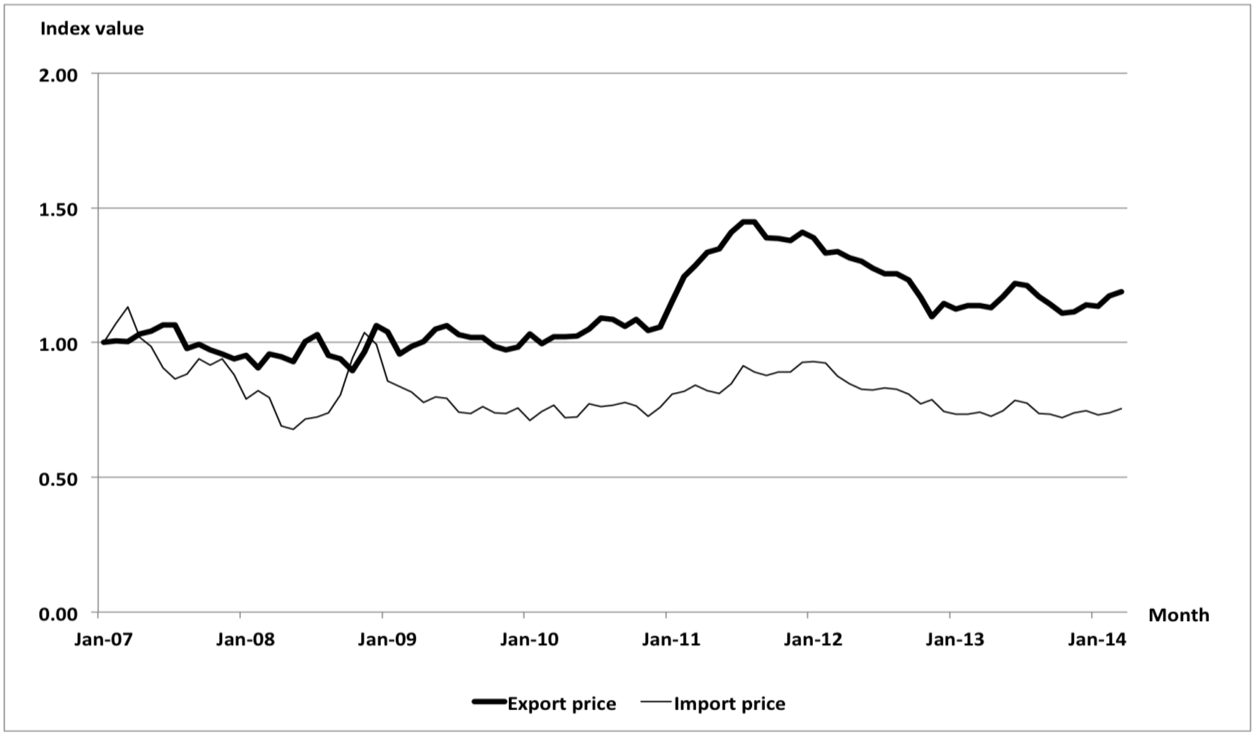

Figure 3.2. Export Price (VND) and Import Price (FCU) of Vietnamese Pangasius Frozen Fillets (Jan 2007 =1).

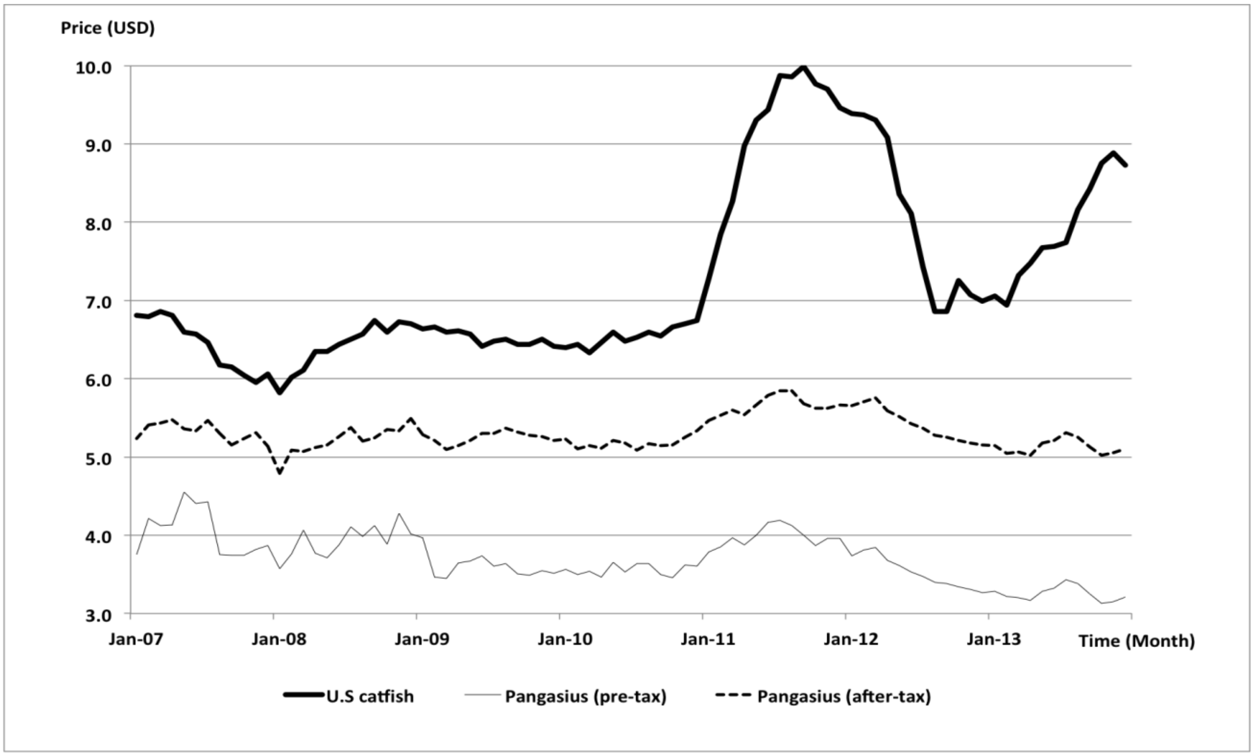

Figure 3.3. Prices (USD/kg) of Frozen Fillets of Vietnamese Pangasius and U.S Catfish.

Note: U.S catfish prices are at wholesale level.

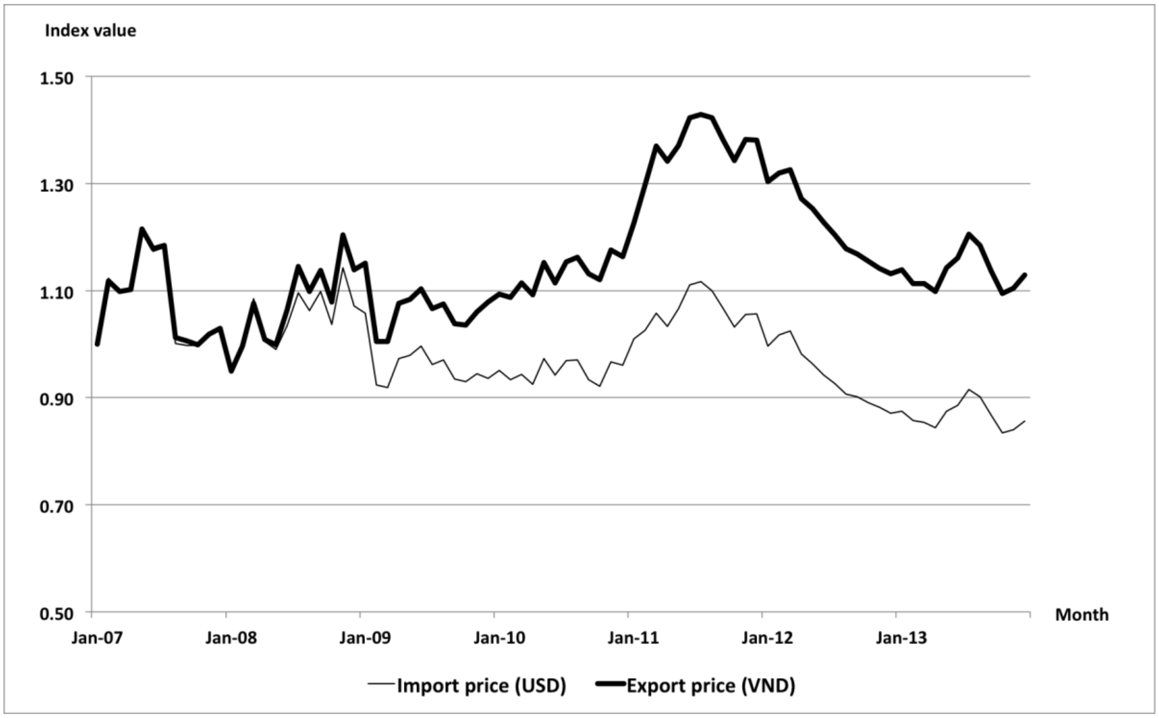

Figure 3.4. Export Price (VND) and Import Price (USD) of Vietnamese Pangasius Frozen Fillets in the U.S Market (Jan 2007 =1)

Note: Import prices are tax-exclusive.

Table 3.1. Export Values of Vietnamese Pangasius, 2007-2013

Year	Market shares (%)				Total
	North America	EU	Non-EU	ROW	(Million USD)
2007	0.16 (0.13)	0.51	0.20	0.14	720
2008	0.16 (0.13)	0.51	0.20	0.13	875
2009	0.20 (0.17)	0.50	0.18	0.12	902
2010	0.23 (0.19)	0.44	0.21	0.12	963
2011	0.34 (0.30)	0.38	0.16	0.12	1,190
2012	0.40 (0.38)	0.33	0.15	0.12	905
2013	0.41(0.39)	0.29	0.15	0.14	867

Note: In the North America column, numbers in parentheses are the market shares of the U.S.

Table 3.2. Tests of Theoretical Restrictions on Exchange Rates

Hypothesis	Number of restrictions	Wald Test p-value	Result
Exchange rate homogeneity	3	0.87	Fail to reject
Exchange rate symmetry	3	0.40	Fail to reject
Both	6	0.14	Fail to reject

Note: Tests were performed with quantity restrictions imposed.

Table 3.3. SUR Estimates of Inverse AIDS System for Vietnamese Pangasius

Equation	Intercept	$d\ln Q$	$d\ln q_1$	$d\ln q_2$	$d\ln q_3$	$d\ln q_4$	$d\ln Z_1$	$d\ln Z_2$	$d\ln Z_3$	$d\ln Z_4$	R^2
1	0.001	0.020	0.184*	-0.108*	-0.097*	-0.027*	-0.107*	0.088*	0.018	0.001	0.92
	(0.18)	(0.90)	(21.67)	(-14.68)	(-10.21)	(-5.00)	(-2.28)	(1.95)	(1.26)	(0.14)	
2	-0.003	-0.020		0.222*	-0.071*	-0.042*		-0.137*	0.054*	-0.005	0.91
	(-0.86)	(-1.07)		(20.73)	(-13.49)	(-6.88)		(-2.92)	(3.95)	(-0.65)	
3	-0.001	0.002			0.137*	-0.016*			-0.066*	-0.005	0.94
	(-0.26)	(0.13)			(25.71)	(-4.06)			(-5.21)	(-0.96)	
4	0.003	0.002				0.087*				0.009	0.86
	(1.04)	(-0.13)				(13.80)				(1.52)	

Note: Asterisks (*) denote significance at 5% or better. The system was estimated with exchange rate homogeneity and symmetry imposed. Asymptotic t-ratios are in parentheses. 1 = North America, 2 = EU, 3 = Non-EU, 4 = ROW.

Table 3.4. Estimated Scale and Quantity Flexibilities

Equation	f_i	f_{i1}	f_{i2}	f_{i3}	f_{i4}	w_i
1	-0.926	-0.310	-0.362	-0.165	-0.088	0.275
	(-11.30)	(-7.83)	(-8.43)	(-8.06)	(-3.85)	
2	-1.049	-0.271	-0.490	-0.178	-0.108	0.420
	(-22.88)	(-12.19)	(-15.64)	(-13.12)	(-6.45)	
3	-0.986	-0.273	-0.395	-0.225	-0.092	0.178
	(-9.54)	(-6.73)	(-7.29)	(-7.30)	(-3.23)	
4	- 1.028	-0.226	-0.358	-0.121	-0.321	0.127
	(-8.91)	(-4.43)	(-5.50)	(-3.73)	(-6.66)	

Note: All flexibilities are significant at less than 1%. Numbers in the last columns are the mean expenditure shares used to compute flexibilities. Asymptotic t-ratios are in parentheses. 1 = North America, 2 = EU, 3 = Non-EU, 4 = ROW.

Table 3.5. Estimated Exchange Rate Flexibilities

Equation	Normalized Price Flexibilities				Absolute Price Flexibilities			
	z_{i1}	z_{i2}	z_{i3}	z_{i4}	z_{i1}	z_{i2}	z_{i3}	z_{i4}
1	-0.389*	0.318*	0.066	0.004	-0.537*	0.439*	0.092	0.005
	(-2.28)	(1.95)	(1.26)	(0.14)	(-2.28)	(1.95)	(1.26)	(0.14)
2	0.209*	-0.327*	0.129*	-0.011	0.360*	-0.564*	0.222*	-0.018
	(1.96)	(-2.92)	(3.95)	(-0.65)	(1.95)	(-2.92)	(3.95)	(-0.65)
3	0.103	0.304*	-0.376*	-0.031	0.125	0.370*	-0.457*	-0.038
	(1.26)	(3.95)	(-5.21)	(-0.96)	(1.26)	(3.95)	(-5.21)	(-0.96)
4	-.009	-0.038	-0.025	0.073	-0. 011	-0.044	-0.028	0.084
	(-0.15)	(-0.72)	(-0.53)	(1.76)	(-0.15)	(-0.72)	(-0.53)	(1.76)

Note: Asterisks denote significance at 5% or better. Asymptotic t-ratios are in parentheses. 1 = North America, 2 = EU, 3 = Non-EU, 4 = ROW.

Table 3.6. Hypothesis Tests

	Equivalency of Exchange Rate and Quantity Effects[a]			Complete Exchange Rate Pass-through[b]		
Equation	Computed Value	p-value	Result	Computed Value	p-value	Result
1	0.077	0.11	Fail to reject	0.462	0.05	Reject
2	0.085	0.08	Fail to reject	0.435	0.03	Reject
3	0.070	< 0.01	Reject	0.542	< 0.01	Reject

[a] Null hypothesis: $|\gamma_{ij}| = |c_{ij}|$
[b] Null hypothesis: $z_{ii}^{A} = -1$
Note: 1 = North America, 2 = EU, 3 = Non-EU

Table 3.7. Effects of Export Changes and Exchange Rate Realignments on Pangasius Export Prices

Export price	Effects of Export Changes (%)				
	North America	EU	Non-EU	ROW	Overall
North America	-24	13	6	-4	-9
EU	-21	18	7	-5	-1
Non-EU	-21	14	9	-4	-2
	Effects of Exchange Rate Realignments (%)				
	North America	EU	Non-EU	ROW	Overall
North America	4	-3	0	0	1
EU	-2	3	-4	0	-3
Non-EU	0	-3	12	0	9
	Combined Effects (%)				
	North America	EU	Non-EU	ROW	Overall
North America	-20	10	6	-4	-8
EU	-23	21	3	-5	-4
Non-EU	-21	11	21	-4	7

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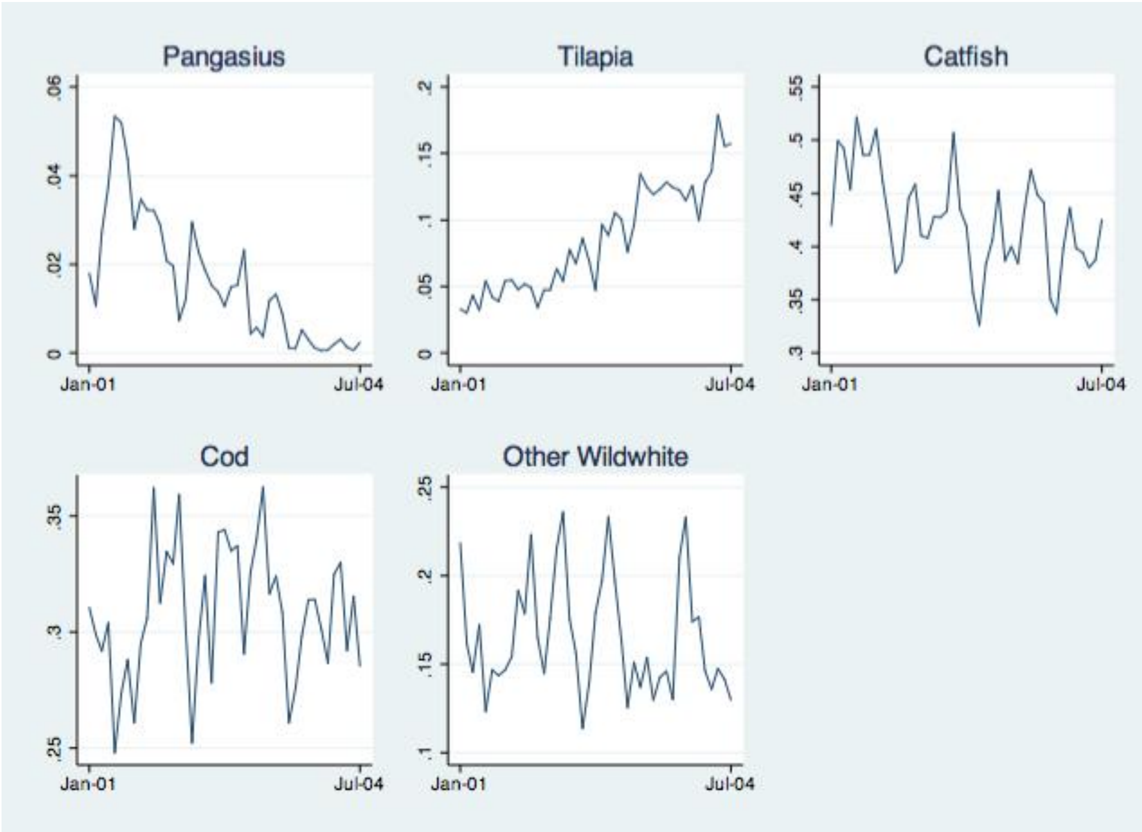
Appendix 1.1. Market Shares of Whitefish Frozen Fillets, Jan 2001- Jul 2004



Appendix 1.2. SUR Estimates of the Parameters for the Inverse AIDS Model

Independent variables	Vietnamese Pangasius	Tilapia	Cod	Otherwhite	U.S Catfish
$\Delta\ln q_1$	0.001 (0.36)				
$\Delta\ln q_2$	0.001 (0.31)	0.017** (3.55)			
$\Delta\ln q_3$	-0.005** (-2.44)	-0.007* (-1.64)	0.225** (28.50)		
$\Delta\ln q_4$	0.007** (3.47)	-0.007* (-1.73)	-0.048** (-10.20)	0.134** (23.10)	
$\Delta\ln q_5$	-0.004 (-1.54)	-0.004 (-0.73)	-0.165** (-20.33)	-0.086** (-13.72)	0.257** (20.45)
$\Delta(h\ln q_1)$	0.023** (5.54)				
$\Delta(h\ln q_2)$	-0.008** (-2.33)	0.159** (21.50)			
$\Delta(h\ln q_3)$	0.003 (0.82)	-0.058** (-9.69)	-0.077** (-7.90)		
$\Delta(h\ln q_4)$	-0.015** (-4.54)	-0.027** (-4.77)	0.016** (2.54)	-0.024** (-2.93)	
$\Delta(h\ln q_5)$	-0.003 (-0.87)	-0.067** (-9.48)	0.116** (12.87)	0.048** (6.28)	-0.094** (-6.99)
$\Delta\ln Q$	-0.034** (-3.18)	0.022** (2.26)	0.001 (0.02)	0.004 (0.39)	0.007 (0.50)
$\Delta(h\ln Q)$	-0.004 (-0.61)	0.016** (3.31)	-0.003 (-0.71)	-0.007 (-1.39)	-0.002 (-0.50)
D_1	0.003 (0.91)	0.004 (0.91)	0.005* (1.99)	-0.012** (-4.34)	0.001 (0.33)

D_2	-0.002 (-0.52)	0.002 (0.63)	0.003 (1.03)	0.001 (0.48)	-0.004 (-1.37)
D_3	-0.003 (-0.85)	0.004 (1.22)	0.003 (0.90)	0.000 (-0.05)	-0.003 (-1.00)
$\Delta(hD_1)$	0.003 (0.63)	-0.001 (-0.17)	-0.008^{*} (-2.22)	0.013^{**} (3.58)	-0.007^{*} (-1.79)
$\Delta(hD_2)$	0.004 (0.76)	-0.002 (-0.49)	-0.005 (-1.24)	0.006 (1.50)	-0.003 (-0.68)
$\Delta(hD_3)$	-0.002 (-0.50)	-0.001 (-0.21)	-0.003 (-0.73)	0.007^{*} (1.81)	-0.001 (-0.27)
Intercept	0.002 (0.84)	-0.003 (-1.54)	-0.003 (-1.60)	0.003 (1.37)	0.001 (0.74)
R^2	0.43	0.91	0.89	0.85	0.92

Appendix 2.1. America's Top 10 favorite seafood species 2009-2015

	2009		2011		2013		2015	
Rank	Item	lb.	Item	lb.	Item	lb.	Item	lb.
1	Shrimp	4.10	Shrimp	4.20	Shrimp	3.60	Shrimp	4.00
2	Tuna	2.50	Tuna	2.60	Salmon	2.70	Salmon	2.88
3	Salmon	2.04	Salmon	1.95	Tuna	2.30	Tuna	2.20
4	Alaska pollock	1.45	Alaska pollock	1.31	Tilapia	1.43	Tilapia	1.38
5	Tilapia	1.21	Tilapia	1.29	Alaska pollock	1.15	Alaska pollock	0.97
6	Catfish	0.84	Pangasius	0.63	Pangasius	0.77	Pangasius	0.74
7	Crab	0.59	Catfish	0.56	Cod	0.61	Cod	0.60
8	Cod	0.42	Crab	0.52	Catfish	0.57	Crab	0.56
9	Clams	0.41	Cod	0.50	Crab	0.55	Catfish	0.52
10	Pangasius	0.36	Clams	0.33	Clams	0.47	Clams	0.33

Source: National Fisheries Institute

Appendix 3.1. Derivation of the Expression for Absolute Price Flexibilities with respect to Exchange Rates

Following Xie et al. (2009), we re-derived the formula for the absolute price flexibilities with respect to exchange rates. Recall that $\pi_i^x = p_i^x/P^x Q$. Then,

$$\frac{\partial \ln \pi_i^x}{\partial \ln Z_j} = \frac{\partial \ln p_i^x}{\partial \ln Z_j} - \frac{\partial \ln P^x}{\partial \ln Z_j} - \frac{\partial \ln \mathrm{Q}}{\partial \ln Z_j} \quad \text{(A1)}$$

Note that the last term on the right hand side $\partial \ln \mathrm{Q}/\partial \ln Z_j$ is zero. The second term $\partial \ln P^x/\partial \ln Z_j$ can be expressed as follows:

$$\frac{\partial \ln P^x}{\partial \ln Z_j} = \frac{\partial \ln P^x}{\partial \ln p_i^x}\frac{\partial \ln p_i^x}{\partial \ln Z_j} = w_i \frac{\partial \ln p_i^x}{\partial \ln Z_j} \quad \text{(A2)}$$

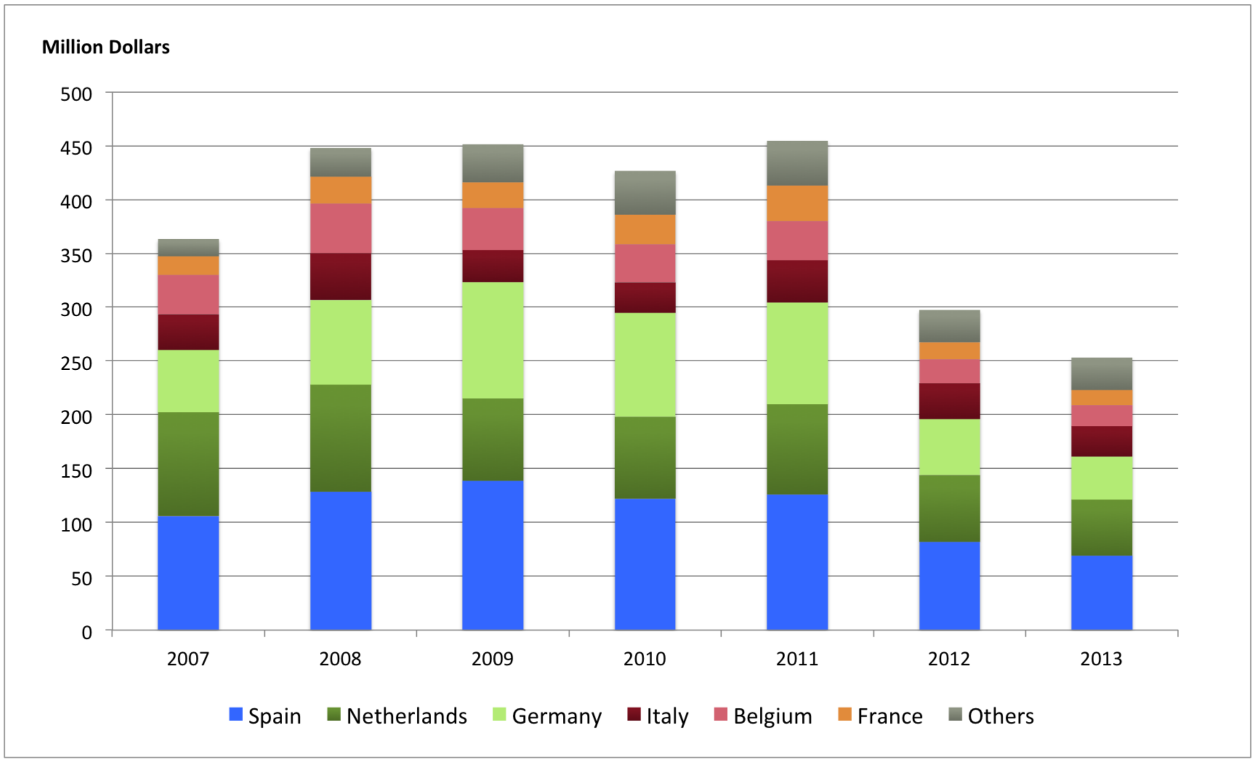
Combing (A1) and (A2) results in the desired expression:

$$\frac{\partial \ln \pi_i^x}{\partial \ln Z_j} = \frac{c_{ij}}{w_i} = (1 - w_i)\frac{\partial \ln p_i^x}{\partial \ln Z_j}$$

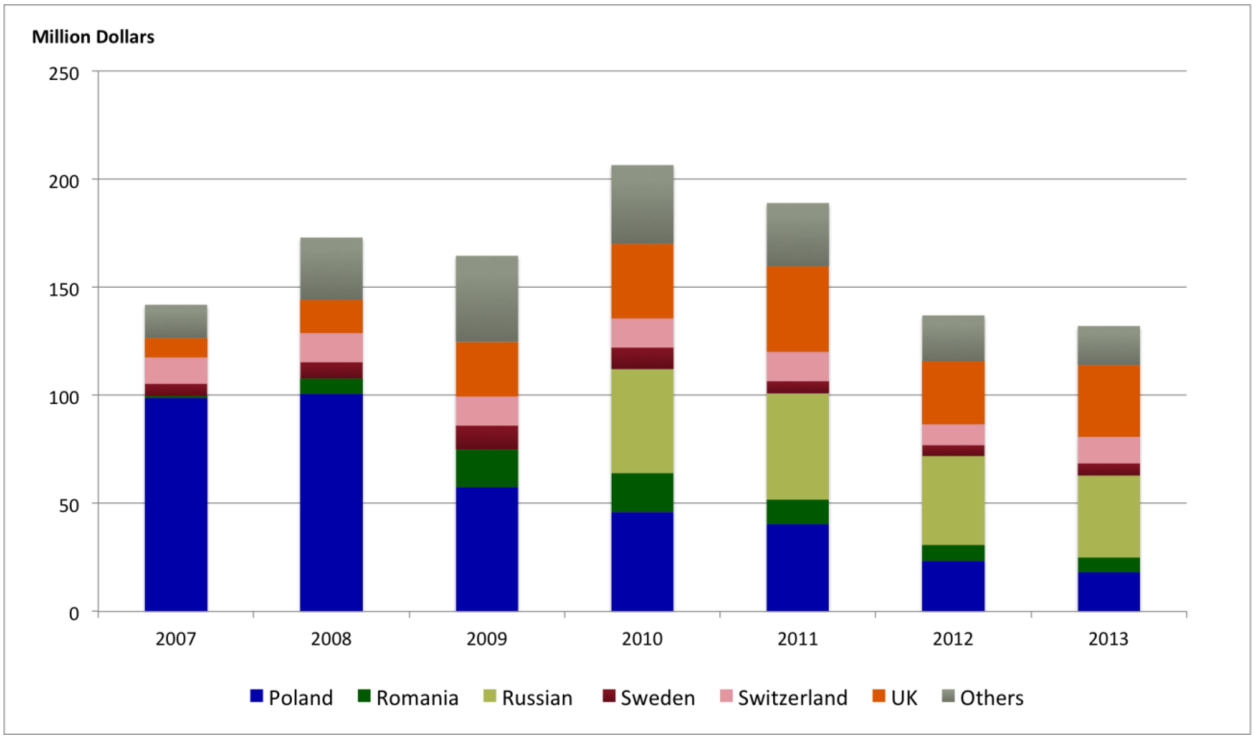
or more simply,

$$\frac{\partial \ln p_i^x}{\partial \ln Z_j} = \frac{c_{ij}}{w_i(1-w_i)} \quad \text{(A3)}$$

Appendix 3.2.A. Market Shares of EU Importers



Appendix 3.2.B. Market Shares for Non-EU Importers



Appendix 3.2.C. Market Shares for ROW Importers