EFFECTS OF CATFISH AND CRAWFISH IMPORTS ON U.S. DOMESTIC PRICES

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ABSTRACT

Recent increases in imports of catfish and crawfish have caused concern as to their impact on domestic prices. This study identifies the linkages between imports of these goods and U.S. producer prices. Increases in imports of catfish are shown to decrease related domestic prices. However, recent trends show a simultaneous increase in both imports and domestic prices of crawfish. An increase in consumer income also typically indicates a corresponding increase in the demand for catfish and crawfish. This study also showed that an increase in the supply of trout, clams, and chicken caused the domestic price of catfish to decrease, and an increase in the supply of pork generated a decrease in the domestic price of crawfish. The models showed different relationships between domestic prices of these goods and other aquaculture and meat products. In addition, the reciprocal of the direct elasticity is not always a good approximation of the direct flexibility because of the stochastic properties of the econometric model. As a result, it is not proper to use the indirect price flexibility from inverted direct price elasticity with other variables for catfish and crawfish.

Keywords: *Crawfish, Catfish, Import Demand Flexibilities*

BACKGROUND

Lower-priced imported goods often displace domestically produced goods. Currently, many U.S. producers of catfish and crawfish are contending with economic hardships resulting from low-priced, imported product. Although catfish and crawfish enter the domestic market through a variety of different agents or market channels, the imported goods are consumed indiscriminately along with domestically produced product (U.S. International Trade Commission, 2003). Consequently, imported and domestically produced product is considered homogenous. Price appears to be the strongest motivator in terms of influencing consumer's willingness to purchase the good (Tomek and Robinson, 1990). The influence of price on consumers' decisions is only heightened due to the fact that it is difficult to distinguish between domestic and imported goods. The price of domestic production is typically higher than the price in major exporting countries due to relatively high U.S. costs of production (U.S. International Trade Commission, 2003).

LITERATURE REVIEW

Gorman (1959) established a literature base for fish demand analysis. Gorman started with the proposition that the price of fish depends, in part, on the quantity consumed and consumer income, in addition to shadow prices of basic characteristics shared by all types of fish.

Houck (1965 and 1966) illustrated that price flexibility is a very useful measure of the effect a change in quantity supplied will have on the prices of agricultural products. Many agricultural production processes are such that market supplies of related commodities are determined largely in advance of current prices. Meinken, Rojko, and King (1956) wrote that the reciprocal of the price flexibility (indirect price elasticity) equals the price elasticity (direct price elasticity) only if cross flexibilities are zero. Harlow (1962) notes that if the effects of other goods are taken into account, the price elasticity is greater than that obtained by taking the reciprocal of price flexibility. This means that the direct price flexibility is less than that obtained by taking the reciprocal of the elasticity. Waugh (1964) wrote that the reciprocal of price flexibilities is often taken to represent elasticities of demand. He preferred to use flexibilities themselves rather than their reciprocals. If the elasticity of demand is needed, he would prefer to use regression equations, with quantities as the dependent variables.

The major implications of previous research include that the quantity effect on price can be easily estimated in an inverse demand system. Second, the reciprocals of direct price flexibilities are not in general the same as the direct price elasticity. Finally, the reciprocal of the price flexibility is absolutely less than the true elasticity if there are discernible cross effects with other commodities.

Huang (1994) examines the relationships between price elasticities and price flexibilities with emphasis on comparing a directly estimated demand matrix and an inverted demand matrix. He concluded that the common practice of inverting an elasticity matrix to obtain measures of flexibilities or vice versa can cause sizable measurement errors. Therefore, it is not proper to use the inverted elasticity or flexibility measurements in agricultural policy and program analysis. Consistent with Waugh's view, the flexibilities from a directly estimated inverse demand system should be used to assess the price effects of quantity changes. However, to evaluate quantity effects of price changes, elasticities from a direct demand system should be used.

Eales (1996) disagreed with Huang's recommendation for three reasons. First, at least one set of direct estimates must be biased and inconsistent. Second, inversion of sensitivity matrices from conditional demand may or may not produce good estimates of unconditional sensitivities. That is, if one estimates a direct demand system and inverts the elasticity matrix, it cannot, in general, be expected to produce good estimates of the unconditional flexibilities and vice versa. Finally, expenditures cannot be viewed as predetermined in conditional demand systems. He argued that one should not employ directly estimated elasticities unless one can assume that those estimates are consistent, i.e., prices and expenditure are predetermined.

However, according to Huang's reply to Eales's comment, there are at least two drawbacks in obtaining a matrix of demand elasticities by inverting a directly estimated price flexibility matrix or vice verse. He indicated that in the process of inversion, the point estimates must be treated as pure numbers representing the true parameters, ignoring the stochastic properties of the estimates.

This theory has been applied in several instances to the aquaculture industry. Several previous studies (e.g. Katzner (1970), Salvas-Bronsard et al. (1977), Laitinen and Theil (1979), Anderson (1980), and Barten and Bettendorf (1989)) suggest that the inverse demand function ($P_i = f(Q)$, where P_i represents the price of good *i* and Q represents the quantity of good *i* and other related goods) is preferred to the direct demand function ($Q_i = g(P)$) when anticipating future trends of price and quantity for perishable fishery products.

This analysis will show the difference between true and stochastic parameters in the following theoretical framework section. One drawback of these procedures is that the inverted results are quite sensitive to the numerical structure (e.g., existence of a singularity problem) of a demand matrix being inverted, and could result in unstable results. Due to the stochastic nature of time series data, the consistency between direct and indirect flexibilities remains a controversial issue.

THEORETICAL FRAMEWORK

The biological nature of the production process results in many fishery products being produced annually or only at regular time intervals. Some of these products are perishable or semi-perishable, and cannot be stored for long periods. The products must be consumed within a certain period of time. Hence, the situation results in fixed supply and a given level of demand for a specific time period. In the short term, the level of production cannot be changed. For such goods, the causality is from quantity to price (i.e., a price-dependent demand equation describes the situation).

Catfish and crawfish share characteristics in common with other fishery products such as a biological production lag and perishability. Therefore, this study will focus on the estimation of direct price flexibilities of fixed supplied own products, related products, and shift variables, such as income.

The theoretic price flexibility is often treated as the inverse of the price elasticity. It is the percentage change in price resulting from a particular change in quantity, other factors held constant. The price flexibility coefficient (F) is defined as

$$F = \frac{\delta P / P}{\delta Q / Q} = \left(\frac{\delta P \cdot Q}{\delta Q \cdot P} \right).$$

As Houck and Eales indicate, under certain parameter conditions the price flexibility (F) is equal to the reciprocal of the corresponding price elasticity. If demand is inelastic, then the absolute value of the indirect price flexibility coefficient is likely to be greater than one. A flexible price is consistent with an inelastic demand. In other words, a small change in quantity has a relatively large impact on price. If demand is elastic, then the absolute value of the indirect price flexibility coefficient is likely to be less than one. An inflexible price is consistent with an elastic demand.

In a statistical model, however, the direct price flexibilities are derived from the inverse demand function in which price is a function of quantities of own and related goods and a shift variable in which indirect price flexibilities are acquired utilizing the direct demand function. In this case, quantity is a function of the prices of own and related goods as well as income. As Huang indicated, the reciprocal of the flexibility (elasticity) is not always a good approximation of the elasticity (flexibility) since different variables are held constant in the two statistical equations. The difference between the estimations of both stochastic parameters can be seen in the following examples. Assume that there are two goods, Q_1 and Q_2, and their respective prices, P_1 and P_2, as well as income, Y. One can estimate both linear regression models for the inverse and direct demand equations.

First, the inverse demand statistical equations are shown as follows:

Equation 1: $\ln P_1 = \beta_{10} + \beta_{11} \ln Q_1 + \beta_{12} \ln Q_2 + \beta_{13} \ln Y + \varepsilon_1$, and

Equation 2: $\ln P_2 = \beta_{20} + \beta_{21} \ln Q_1 + \beta_{22} \ln Q_2 + \beta_{23} \ln Y + \varepsilon_2$,

where ε_i is the random error term. According to the assumption of statistical regression model, $E(\varepsilon_i) = 0$ and $\boldsymbol{Q}$ and ε are independent, such that $E(\boldsymbol{Q} \cdot \varepsilon) = 0$ where $\boldsymbol{Q}$ represents the set of quantities (Q_1, Q_2).

Second, the direct demand statistical equations are shown as following:

Equation 3: $\ln Q_1 = \alpha_{10} + \alpha_{11} \ln P_1 + \alpha_{12} \ln P_2 + \alpha_{13} \ln Y + u_1$, and

Equation 4: $\ln Q_2 = \alpha_{20} + \alpha_{21} \ln P_1 + \alpha_{22} \ln P_2 + \alpha_{23} \ln Y + u_2$,

where u_i is the random error term. According to the assumption of linear regression model, $E(u_i) = 0$ and $\boldsymbol{P}$ and u are independent, such that $E(\boldsymbol{P} \cdot u) = 0$ where $\boldsymbol{P}$ represents the set of prices (P_1, P_2).

Using the four different equations, the relationships among parameters can be estimated, representing direct flexibilities in equation 1 and 2 and direct elasticities in equation 3 and 4. Furthermore, it can be shown that $\beta_1 \neq \frac{1}{\alpha_1}$ and $\beta_2 \neq \frac{1}{\alpha_2}$.

In addition to this, assume that $P = Q'\beta + \varepsilon$. P and Q are vectors of prices and quantities. We can then rewrite this equation as $Q = P'\alpha + u$, where $\alpha = \frac{1}{\beta}$, and $u = \frac{-1}{\beta}\varepsilon$. Further manipulation allows the following to be obtained:

Equation 5: $\alpha = (P'P)^{-1} P'Q$,

Equation 6: $\alpha = (P'P)^{-1} P'(P\alpha + u)$,

Equation 7: $\alpha = (P'P)^{-1} P'P\alpha + (P'P)^{-1} P'u$,

Equation 8: $\alpha = (P'P)^{-1} P'P\left(\frac{1}{\beta}\right) + (P'P)^{-1} P'\left(\frac{-1}{\beta}\varepsilon\right)$,

Equation 9: $\alpha = \frac{1}{\beta} - (P'P)^{-1} P'\left(\frac{1}{\beta}\varepsilon\right)$.

If P and ε are correlated, then $\frac{\ }{\beta}$; however, if P and ε are not correlated, the direct price flexibility is equal to the reciprocal of the price elasticity.

Flexibility coefficients that are analogous to the concepts of cross elasticity and income elasticity may also be defined. The cross flexibility of *i* with respect to *j* is the percentage change in the price of commodity *i* in response to a one percent change in the quantity supplied of commodity *j*, other factors held constant. The relationship is as follows:

Equation 10:
$$F_{ij} = \left(\frac{\delta P_i \cdot Q_j}{\delta Q_j \cdot P_i} \right).$$

The cross flexibility, based on the quantity of a substitute, is expected to be negative. This is in contrast to the cross elasticity for a substitute, which is usually positive. A large supply of a substitute results in a lower price for the substitute, which in turn, results in a decline in demand for the first commodity. The lower demand implies a reduction in price. Hence, a larger supply of the substitute, commodity *j*, reduces the price of the commodity *i* (Tomek and Robinson, 1991).

The price flexibility of income is the percentage change in price in response to a one percent change in income, other factors held constant. It is calculated as follows:

Equation 11:
$$F_{iy} = \left(\frac{\delta P_i \cdot Y}{\delta Y \cdot P_i} \right).$$

Typically, the price flexibility of income is expected to be positive for normal goods. However, the relationship among demand, supply, price, and income must be investigated. In the traditional demand system, the income variable shifts the demand curve. If there is an increase in income, the demand curve will move to the right so that quantity demanded, for a normal good, will increase at the same price. An increase in quantity demanded will increase the price. An increase in price will increase the quantity supplied as well. If an increase in the quantity supplied is greater than the increase in quantity demanded resulting from increased income, then over-supply will occur, resulting in a price decrease. As a result, the sign of the price flexibility of the income coefficient is ambiguous in the inverse demand system. It depends upon the relative impact of income on demand versus the impact of price on supply.

Empirical Analysis

As Boyle, Gorman, and Pudney (1977) and Barten and Bettendorf (1989) indicated, the price of fish products depends mainly on the quantity consumed and income and, in part, on the shadow prices of basic characteristics shared by all types of fishery products. Therefore, the models in this study are formulated to examine the relationship between domestic crawfish price and quantities supplied of not only the own good but also other related goods. In so doing, this study seeks to isolate the effect of the import supply of crawfish on the domestic price. In addition, this study also seeks to examine the theoretical relationship between the direct price flexibility and the reciprocal of the price elasticity for crawfish.

To achieve these objectives, this study uses direct and inverse demand equations to estimate direct price elasticities and flexibilities. The direct demand equation is used to estimate the direct price elasticities. The estimated coefficients will then be converted into the reciprocal of price elasticities for comparison with the values of the direct price flexibilities estimated through the inverse demand equation. This study approximates a conceptual demand relationship in the following form:

Equation 12:
$$\ln Q_i = \sum\nolimits_j e_{ij} \ln P_j + \eta_i \ln Y, \qquad i,j = 1,2,\ldots, n$$

where $e_{ij} = \left(\frac{\partial Q_i}{\partial P_j} \right) \left(\frac{P_j}{Q_i} \right)$ is the price elasticity of the i^{th} commodity with respect to a price change of the j^{th} commodity. If $i = j$, then e_{ij} is the own price elasticity, and if $i \neq j$, then e_{ij} is the cross price elasticity. The income elasticity of the i^{th} commodity is $\eta_i = \left(\frac{\partial Q_i}{\partial Y}\right)\left(\frac{Y}{Q_i}\right)$. We assume that e_{ij} is the usual type of demand elasticity matrix in a general equilibrium model with own price elasticities on the diagonal and cross elasticities arranged around the rest of the matrix. In view of classical demand theory, this elasticity matrix is constrained by symmetry $(e_{ij} / w_j + \eta_i = e_{ji} / w_i + \eta_j)$, homogeneity $\left(\sum_j e_{ij} + \eta_i = 0\right)$, and the Engel Aggregation Condition $\left(\sum w_i \eta_i = 1\right)$, where $w_i = \frac{P_i Q_i}{Y}$ is the expenditure weight of the i^{th} commodity.

Related to the direct price flexibility, it is important to understand the concept of the Antonelli matrix. The Antonelli equation refers to the effect of a change in quantity on the price of the good. Houck (1966) and Huang (1994) stated that there are fewer flexibility estimates than elasticity estimates because most economists are not familiar with the Antonelli matrix essential for performing flexibility analysis. Huang's study states that when forecasting prices from an inverse demand model, flexibilities are more accurate. Also, price flexibility studies, using a direct method of flexibility estimation, would permit more accurate pricing forecasts to evaluate the effects of quantity changes on prices. This study approximates a conceptual inverse demand relationship of the following form:

Equation 13: $$\ln P_i = \sum_j f_{ij} \ln Q_j + \gamma_i \ln Y,$$

for all $i,j = 1,2,\ldots, n$, where $f_{ij} = \left(\frac{\partial P_i}{\partial Q_j}\right)\left(\frac{Q_j}{P_i}\right)$ is the price flexibility of the i^{th} commodity with respect to a quantity change of the j^{th} commodity. If $i = j$, then f_{ij} is the own price flexibility, and if $i \neq j$, then f_{ij} is the cross price flexibility. $\gamma_i = \left(\frac{\partial P_i}{\partial Y}\right)\left(\frac{Y}{P_i}\right)$ is the price flexibility of the i^{th} commodity with respect to income. We assume that f_{ij} is the usual type of inverse demand matrix in a general equilibrium model with own flexibility on the diagonal and cross flexibilities in the rest of the matrix. The conceptual models are formulated to examine the effects of quantity on price.

Empirical direct price flexibilities are estimated through the inverse demand model. To accomplish this, this study assumes weak separability of the total commodity bundle into these types of nine fishery products and three red meats on the one hand and other groups on the other hand. The study can then treat these twelve products in isolation from the other products. Then, only the quantities and prices for these products and total expenditure for this group matter. For computational efficiency of price flexibility, each model is formulated using double log equations. In the double log inverse demand equations, the estimated coefficients directly represent the price flexibilities. The inverse demand functions are estimated using the Ordinary Least Squares method. To accomplish this, monthly data is used.

The first model estimated is as follows:

(1) $P_n = f(Q_m, Y)$,

where P_n is the deflated domestic price ($n = ca, cr$ for catfish or crawfish, respectively), Q_m is the quantity of imported product, and for theoretical consistence, $Y = \sum_i P_i Q_i$ represents income or expenditure on the nine fishery products and three red meats. This model is intended to isolate the effects of the imported good and income on the domestic price. This model assumes that the imported good is an imperfect substitute for the domestically supplied good. Under this assumption, the model estimates the direct price flexibility.

The second model estimated is as follows:

(2) $P_n = f(Q_m, Q_{us}, Y)$,

where Q_{us} is the domestically supplied quantity of catfish or crawfish. As in the previous model (1), this model assumes that the imported good is heterogeneous with the domestic good. This model is intended to isolate the effects of not only imported goods but the domestically supplied good as well.

The third model estimated is as follows:

(3) $P_n = f(Q_m, Q_{us}, S_m, S_{us}, Y)$,

where S_m is the imported quantity of related goods, and S_{us} is the domestically supplied quantity of related goods. This model is formulated to examine the effects of imported and domestically supplied own goods, imported and domestically supplied related goods, and income on domestic crawfish price.

The next models are formulated to estimate direct price elasticity and flexibility as follows:

(4) $Q_n = f(P_n, P_{sub}, Y)$, and

(5) $P_n = f(Q_n, Q_{sub}, Y)$,

where Q_n is the quantity demanded of catfish or crawfish, P_n is the deflated domestic price as in model (1), P_{sub} is the deflated price of related goods, and Q_{sub} represents related goods. The price elasticities obtained through model (4) will be compared with the quantity flexibilities estimated in model (5).

DATA

The models are generated using monthly data ranging from 1980 through 2002 on imports, domestic supply and demand, and real prices of crawfish and other fishery products, and three major meat products. The model is estimated using data from the following sources: U.S. Import and Exports of Fishery Products Annual Summary, 1990-2004; Livestock, Dairy and Poultry Situation and Outlook, Economic Research Service, USDA; and the Disposable Personal Income data used in the study were obtained from the U.S. Department of Commerce. The inverse demand functions utilize price as the dependent variable so that price flexibilities can be estimated directly. The indirect price flexibilities are calculated using inverse elasticities.

RESULTS AND DISCUSSION: CATFISH

The results of the regression analyses for models 1, 2, and 3 are presented in Table 1. Each of the three models shows a negative but non-significant relationship between catfish imports and U.S. domestic catfish price. Although the relationship is not shown to be significant, it is interesting to note the similarity in magnitudes for catfish imports across the three models, ranging from -0.0066 to -0.0087.

The sign for domestic catfish landings is positive in both models 2 and 3, although only the coefficient in model 2 proved to be statistically significant. While the sign is not what would be normally expected, it may be the case that the causal linkage between domestic price and domestic landings is that of price driving production rather than supply influencing price.

Models one and two show a significant and negative relationship between income and the domestic price of catfish. As mentioned earlier, the coefficient of the income flexibility is ambiguous in the inverse demand system, depending on the relative impact of income on demand versus the impact of price on supply. However, this negative relationship causes one to question the characteristics of catfish with respect to its being a normal or an inferior good. As imports and the domestic production of other competing goods are considered in model 3, the magnitude of the income effect decreases in absolute terms from approximately -1.7 to -0.5, while decreasing in significance from the 1% to the 10% level.

The impact of seasonality varies among the three models. Although less significant than the results in models one and two, model three shows elevated price levels beginning in February and diminishing in June and July with the highest price levels occurring in March, April, and May. The seasonality trend in model three appears smoother, but less significant, than those seen in models one and two. According to the dummy variables in models one and two, there is an indication that late spring through the summer months tends to experience the highest domestic catfish prices, with elevated prices from May through October.

With respect to the cross-commodity effects determined in Model 3, domestic crawfish landings, domestic trout landings, domestic scallop landings, and domestic chicken production all had the expected negative sign at either the 1, 5, or the 10% level of significance. Of imported products, only imported trout showed any level of significance, exhibiting an expected negative impact at the 5% level of significance. Contrary to expectations, domestic beef production proved to have a positive impact on domestic catfish prices at the 1% level of significance. No other cross-commodity effects were significant at the 10% level.

Table 2 presents a comparison between price elasticities obtained through model (4) the quantity flexibilities estimated in model (5). It is important to note to note that neither a complete demand nor inverse demand system is estimated. In model (4), catfish and other product prices are regressed on catfish quantity, while model (5) regresses catfish and other product quantities on catfish price. In this case, the price elasticity of catfish demand (0.5940), when inverted, yields an indirect quantity flexibility for catfish of 1.6835. This estimation is significantly higher than the 0.0009 flexibility obtained through the inverse demand model.

Just as Meinken, Rojko, and King (1956) noted, the reciprocal of the price flexibility (indirect price elasticity) equals the direct price elasticity only if cross flexibilities are zero. Similar precautions should be taken when attempting to obtain flexibilities. Although several of the cross effects appear to be negligible, there are several instances in which the cross effects are significant and quite sizeable, especially in the cross flexibility cases of trout, chicken, and beef, and in the cross elasticity cases of oysters, chicken, and pork. Given this, it is not surprising that the indirect flexibilities are not a reasonable approximation of those estimated directly.

RESULTS AND DISCUSSION: CRAWFISH

The results of the regression analyses for models 1, 2, and 3 are presented in Table 3. Each of the three models shows a positive and significant relationship between crawfish imports and the U.S. domestic crawfish price. Although the relationship does not exhibit the sign initially expected, it is likely that the causality is that of domestic prices driving imports rather than imports influencing the domestic price.

The sign for domestic crawfish landings is negative in both models 2 and 3, with a level of significance of 5% in the case of model 2 and 10% in the case of model 3. The negative sign is as expected, indicating that increases in domestic production have a negative impact on domestic prices.

All three models show a positive relationship between income and the domestic price of crawfish. Although only model one shows any level of significance (10%), the positive sign is consistent with the characteristics of a normal good.

The seasonality dummies exhibit very little in the way of significance. Although little can be inferred from these coefficients, the apparent trend of higher prices in the first part of the year with a drop-off in May or June is consistent with the decrease in consumption corresponding with the end of Lent.

With respect to the cross-commodity effects determined in Model 3, beef and pork imports, and domestic beef production all had the expected negative sign at either the 5 or 10% level of significance. Contrary to expectations, domestic shrimp landings, domestic tilapia landings, and domestic clam landings proved

to have a positive impact on domestic crawfish prices at the 1% level of significance. This could result from a complementary relationship between these products and crawfish in some cases, or possibly from an income effect resulting from decreased shrimp, tilapia, or clam prices allowing for increased expenditures on crawfish. No other cross-commodity effects were significant at the 10% level.

Table 4 presents a comparison between price elasticities obtained through model (4) and the flexibilities estimated in model (5). It is important to note that neither a complete demand nor inverse demand system is estimated. In model (4), crawfish and other product prices are regressed on crawfish quantity, while model (5) regresses crawfish and other product quantities on crawfish price. In this case, the price elasticity of crawfish demand (-0.5683), when inverted, yields an indirect flexibility for crawfish of -1.7596. This estimation is significantly lower than the -0.0095 flexibility obtained through the inverse demand model.

Just as Meinken, Rojko, and King (1956) noted, the reciprocal of the price flexibility (indirect price elasticity) equals the direct price elasticity only if cross flexibilities are zero. Similar precautions should be taken when attempting to obtain flexibilities. Although several of the cross effects appear to be negligible, there are several instances in which the cross effects are significant and quite sizeable, especially in the cross flexibility cases of clams, chicken, and beef, and in the cross elasticity cases of shrimp, tilapia, scallops, and pork. Given this, it is not surprising that the indirect flexibilities are not a reasonable approximation of those estimated directly.

Table 1. Ordinary Least Squares Analysis of Factors Affecting U.S. Domestic Catfish Price

Variable	Model (1)		Model (2)		Model (3)	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Intercept	29.7965	14.89***	30.0232	15.37***	13.2652	4.41***
Catfish Imports	-0.0066	-0.87	-0.0087	-1.17	-0.0058	-0.97
Catfish Domestic Landings			0.1045	3.05***	0.0459	1.63
Crawfish Imports					-0.0037	-0.82
Crawfish Domestic Landings					-0.0183	-3.45***
Shrimp Imports					0.0139	0.34
Shrimp Domestic Landings					0.0123	0.38
Tilapia Fresh Imports					-0.0296	-1.19
Tilapia Frozen Imports					0.0124	1.12
Tilapia Canned Imports					0.0227	1.61
Tilapia Domestic Landings					-0.0090	-1.61
Trout Imports					-0.0338	-2.02**
Trout Domestic Landings					-0.0145	-1.72*
Clam Imports					-0.0206	-0.58
Clam Domestic Landings					-0.0223	-0.50
Oyster Imports					-0.0001	-0.00
Oyster Domestic Landings					-0.0099	-0.23
Mussel Imports					-0.0175	-0.66
Mussel Domestic Landings					-0.0104	-1.17
Scallop Imports					0.0054	0.23
Scallop Domestic Landings					-0.0449	-2.08**
Chicken Domestic Production					-0.6531	-4.40***
Beef Imports					0.0157	0.31
Beef Domestic Production					0.5929	3.74***
Pork Imports					0.0006	0.01
Pork Domestic Production					-0.1459	-0.89
Income	-1.7032	-14.0***	-1.7553	-14.58***	-0.5058	-1.76*
January	0.0670	1.92*	0.0858	2.47**	0.0164	0.38
February	-0.0625	-1.75	-0.0579	-1.66*	0.0682	1.52
March	0.0352	1.01	0.0169	0.49	0.1142	2.24**
April	0.0214	0.61	0.0039	0.11	0.1337	2.60***
May	0.1097	3.08***	0.0930	2.64***	0.1053	1.64
June	0.1161	3.31***	0.1044	3.03***	0.0569	0.80
July	0.0855	2.45**	0.0763	2.23**	0.0385	0.62
August	0.1379	3.89***	0.1423	4.11***	0.0068	0.12
September	0.0636	1.82*	0.0612	1.79*	-0.0239	-0.49
October	0.1399	3.88***	0.1163	3.23***	-0.0387	-0.92
November	0.0148	0.43*	-0.0096	-0.27	-0.0380	-1.11
SSE	1.499969		1.419700		0.559121	
DFE	165		164		132	
MSE	0.00909		0.00866		0.00424	
RMSE	0.09535		0.09304		0.06508	
SBC	-275.3640		-280.0215		-294.3225	
AIC	-319.9874		-327.8323		-413.4829	
R^2	0.6268		0.6468		0.8522	
Durbin-Watson	0.9017		1.0159		1.2326	

*: Statistically significant at the 10% level
**: Statistically significant at the 5% level
***: Statistically significant at the 1% level

Table 2. Comparison of Price Elasticities and Quantity Flexibilities

Variable	Direct Elasticity (Model 4)		Direct Flexibility (Model 5)	
	Estimate	t-ratio	Estimate	t-ratio
Catfish	0.5940	1.50	0.0009	0.05
Crawfish	-0.0802	-0.57	-0.0082	-1.80*
Shrimp	0.5465	1.85*	0.0394	1.51
Tilapia	0.0750	0.53	-0.0111	-0.88
Trout	-1.0442	-0.85	-0.0861	-5.44***
Clam	-0.1845	-0.51	-0.0662	-1.45
Oyster	0.5120	4.02***	-0.0386	-0.96
Mussel	0.1701	0.22	0.0000	0.00
Scallop	-0.3216	-1.14	-0.0366	-1.20
Chicken	-2.5993	-2.32**	-0.4006	-3.90***
Beef	-0.1297	-0.19	0.8319	6.24***
Pork	1.1868	2.08**	-0.0593	-0.52
Income	1.5892	3.66**	-1.0991	-5.20***
SSE		11.537103		0.8559422
DFE		166		165
MSE		0.0695		0.00519
RMSE		0.2636		0.07202
SBC		88.9893		-375.7825
AIC		44.2879		-420.4053
R^2		0.4282		0.7871
Durbin-Watson		0.9564		0.9161

*: Statistically significant at 10%
**: Statistically significant at 5%
***: Statistically significant at 1%

CONCLUSION

The Trade Adjustment Assistance Program allows the Secretary of Agriculture to compensate certain growers for economic damages incurred when imports have reduced domestic prices. The imported good must, even if lightly processed, be a close substitute for the domestic raw product. Compensation may be warranted if imports have brought domestic prices below 80% of the five-year, 1998-2002 average (United States Department of Labor: Employment and Training Agency, 2002).

Agricultural and fishery prices may decline for reasons unrelated to changes in import supply. For example, they may fall on account of changes in income, or in the availability of the commodity's substitutes. Thus, in order to distinguish between import effects and other effects on domestic prices, this study constructed econometric models to provide a practical means of determining the impact of a given import volume change on domestic prices; an account of the potentially perishable nature and seasonality of lightly processed commodities; the extent of substitutability between the domestic good, the imported good, and other related domestic and imported goods; and account for any simultaneity between domestic demand and supply. In incorporating these features, this study progressed from simple to more complex formulations, permitting the observation of any gains from additional modeling sophistication.

This study indicates that imports of catfish may decrease the domestic catfish price. However, despite the negative sign, this relationship did not prove to be significant even at the 10% level. At the same time, domestically supplied catfish is shown to have a positive relationship with the domestic price. Income and the domestic price of catfish are shown to have a negative relationship. Each model shows a seasonal effect on the domestic price of catfish, with higher prices tending to occur in the late spring and summer. The study also shows that domestically produced

Table 3. Ordinary Least Squares Analysis of Factors Affecting U.S. Domestic Crawfish Price

Variable	Model (1)		Model (2)		Model (3)	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Intercept	-4.3030	-1.30	-0.2270	-0.06	3.1784	0.49
Crawfish Imports	0.0246	3.82***	0.0235	3.71***	0.0260	2.69***
Crawfish Domestic Landings			-0.0222	-2.57**	-0.0215	-1.88*
Catfish imports					0.0045	0.35
Catfish Domestic Landings					0.0281	0.46
Shrimp Imports					-0.0600	-0.68
Shrimp Domestic Landings					0.1363	1.96*
Tilapia fresh imports					0.0171	0.32
Tilapia frozen imports					-0.0097	-0.40
Tilapia canned imports					-0.0132	-0.43
Tilapia Domestic Landings					0.0281	2.33**
Trout Imports					0.0089	0.25
Trout Domestic Landings					0.0022	0.12
Clam Imports					0.1043	1.36
Clam Domestic Landings					0.2313	2.38**
Oyster Imports					-0.0196	-0.44
Oyster Domestic Landings					0.0560	0.60
Mussel Imports					0.0349	0.61
Mussel Domestic Landings					-0.0283	-1.48
Scallop Imports					-0.0174	-0.34
Scallop Domestic Landings					0.0555	1.19
Chicken Domestic Prod. Beef					0.4540	1.42
Imports					-0.2239	-2.07**
Beef Domestic Prod.					-0.6106	-1.78*
Pork Imports					-0.2419	-1.71*
Pork Domestic Prod.					-0.4861	-1.38
Income	0.3728	1.85*	0.1299	0.59	0.5017	0.81
January	-0.0310	-0.54	-0.0053	-0.09	0.1033	1.11
February	0.0320	0.55	0.0584	1.01	0.0429	0.44
March	0.0347	0.61	0.1079	1.71*	0.1961	1.78*
April	0.0351	0.61	0.1293	1.91*	0.0333	0.30
May	0.0606	1.03	0.1720	2.39**	-0.0760	-0.55
June	-0.0299	-0.53	0.0724	1.05	-0.1592	-1.04
July	-0.0230	-0.41	0.0454	0.74	-0.1278	-0.95
August	-0.0262	-0.46	-0.0135	-0.24	-0.1911	-1.50
September	-0.0146	-0.26	-0.0452	-0.80	-0.1772	-1.69
October	-0.0133	-0.23	-0.0325	-0.57	-0.1403	-1.54
November	0.0178	0.32	-0.0002	-0.00	-0.0728	-0.98
SSE	3.9204		3.7693		2.6118	
DFE	166		165		132	
MSE	0.0236		0.0228		0.0198	
RMSE	0.1537		0.1511		0.1407	
SBC	-105.2965		-107.1789		-32.2769	
AIC	-149.9980		-155.0732		-151.4373	
R^2	0.1936		0.2247		0.4134	
Durbin-Watson	0.9720		1.0045		1.2655	

*: Statistically significant at 10%
**: Statistically significant at 5%
***: Statistically significant at 1%

Table 4. Comparison of Price Elasticities and Quantity Flexibilities

Variable	Direct Elasticity (Model 4)		Direct Flexibility (Model 5)	
	Estimate	t-ratio	Estimate	t-ratio
Crawfish	-0.5683	-0.81	-0.0095	-0.97
Catfish	0.9132	0.46	0.0587	1.44
Shrimp	3.4875	2.36**	0.0118	0.21
Tilapia	-1.4705	-2.06**	0.0045	0.17
Trout	0.2232	0.04	0.0179	0.53
Clam	-1.6214	-2.23**	0.2235	2.30**
Oyster	0.8169	-0.75	0.1348	1.58
Mussel	0.9531	0.25	0.2627	0.59
Scallop	-4.2841	-3.03***	0.0214	0.33
Chicken	4.8627	0.87	0.4387	2.01**
Beef	3.8818	1.15	-0.6063	-2.14**
Pork	-6.0027	-2.08**	-0.2460	-1.01
Income	-4.0427	1.28	-0.0099	0.19
SSE		286.8741		3.8591
DFE		165		165
MSE		1.7386		0.0233
RMSE		1.3185		0.1529
SBC		665.0301		-106.2104
AIC		620.4067		-150.8338
R^2		0.2765		0.2060
Durbin-Watson		0.5040		0.9898

*: Statistically significant at 10%
**: Statistically significant at 5%
***: Statistically significant at 1%

crawfish, trout, scallops, and chicken and imported trout have a negative relationship with the domestic price of catfish, while domestically produced beef has a positive relationship with the catfish price.

This study also confirmed that imports of crawfish have increased along with an increase in the domestic price of crawfish. At the same time, domestic supply of crawfish has a negative relationship with the domestic price, implying that the high domestic price generated during the collapse in domestic production resulting from the drought in 2000 and 2001 attracted imports of crawfish. Although each model shows a seasonal effect on the domestic price of crawfish, it is not shown consistently. This study also showed that increases in the domestic supplies of shrimp, tilapia, and clam resulted in an increase in the domestic crawfish price while increases in imported and domestic supplies of beef and the imported supply of pork decreased domestic crawfish price.

As previously asserted, this study showed that the reciprocal of the direct elasticity is not a perfect approximation of the direct flexibility because of the stochastic nature of the inverted direct price elasticity with other variables. Since the inverse of the price elasticity estimate is not the same as the direct price flexibility estimated values, this analysis lends support to the assertion that it is not proper to use elasticities estimated in the direct demand system for policy and program analyses.

REFERENCES

Anderson, R.W. (1980) Some theory of inverse demand for applied demand analysis, *European Economic Review* 14, 281-290.

Bailey, C., S. Jentoft, and P. Sinclair (1996) *Aquacultural Development: Social Dimensions of an Emerging Industry*. Westview Press, Inc., Boulder, CO.

Barten A.P. and L.J. Bettendorf (1989) Price formation of fish: An Application of an Inverse Demand System, *European Economic Review* 33, 1509-1525.

Boyle, J.R., W.M. Gorman and S.E. Pudney (1977) Demand for related goods: A progress report: M.D. Intriligator, ed., *Frontiers of quantitative economics*, vol. IIA (North-Holland, Amsterdam) chapter 2c, 87-101.

Cunningham, S., M.R. Dunn, and D. Whitmarsh (1985) *Fisheries Economics: An Introduction*. St. Martin's Press, Inc., New York, NY.

Gorman, W. M. (1959) The demand for fish, an application of factor analysis, Research paper no. 6, Series A (Faculty of Commerce and Social Science, University of Birmingham), Abstracted in Econometrica 28, 649-650.

Greig L., Sambidi P., and Harrison, R. W. (2003) *Crawfish Industry Profile*. Agricultural Marketing Resource Center, Iowa State University.

Eales, J. (1996) A further look at flexibilities and elasticities: comment. *American Journal of Agricultural Economics.* 78, 1125-1129.

Food and Agriculture organization of the United Nations (2001) *Ad hoc EIFAC/EC working party on market perspectives for European freshwater aquaculture*. European Inland Fisheries Advisory Commission (EIFAC) Occasional Paper No. 35.

Hatch, U. and H. Kinnucan (1993) *Aquaculture: Models and Economies*. Westview Press, Inc., Boulder, CO.

Houck, J.P. (1965) The relationship of direct price flexibilities to direct price elasticities. *Journal of Farm Economics*, 47, 789-792.

Houck, J.P. (1966) A look at flexibilities and elasticities. *Journal of Farm Economics*, 48, 225- 232.

Huang, K.S. (1994) A further look at flexibilities and elasticities. *American Journal of Economics*, 76, 313-317.

Jolly, C.M. and H.A. Clonts (1993) *Economics of Aquaculture.* Food Products Press, an imprint of The Haworth Press, Inc., Binghamton, NY.

Keefe, A.M. and Curtis, M.J. (2001) Price flexibility and international shrimp supply, *Aquaculture Economics and Management*, 5(1/2), 37-47.

Kim, H.Y. (1997a) Inverse demand systems and welfare measurement in quantity space. *Southern Economic Journal*, vol.63, pp.663-679.

Kim, H.Y. (1997b) Functional separability and elasticities of complementarity. *American Journal of Agricultural Economics*, vol.79, pp.1177-1181.

Kromhout, D., E.B. Bsschieter, and C.L. Coulander (1985) The inverse relationship between fish consumption and 20-year mortality from coronary heart disease. *New England Journal of Medicine*, 312:1205-9.

Laitinen, K. and H. Theil (1979) The Antonelli matrix and reciprocal Slutsky matrix, *Economic Letters* 3, 153-157.

Schrank, W.E. and N. Roy (1989) *Econometric Modeling of the World Trade in Groundfish*. NATO ASI Series E: Applied Sciences - Vol. 201.

Tomek, W.G. and Kenneth, L.R. (1990) *Agricultural Product Prices*. 3rd edition. The Cornell University Press. Ithaca and London.

United States Department of Agriculture (2001) *Imports Provide Competition for Domestic Production*. USDA Aquaculture Outlook, LDP-AQS-14.

United States Department of Agriculture (2003) *Aquaculture production forecast to grow but many uncertainties loom*. U.S. Department of Agriculture, Aquaculture Outlook, LDP-AQS-18.

U.S. International Trade Commission (2003) *Crawfish Tail Meat from China*. Washington, DC 20436. Investigation No. 731-TA-752 (Review).

Waugh, F. V. (1964) *Demand and Price Analysis: Some Examples from Agriculture*, USDA Tech. Bul, 1316, pp.29-30. Logical relationships among price flexibilities are developed in Appendix 3, pp.80-85.