Effects of Catfish, Crawfish, and Shrimp Imports on U.S. Domestic Prices

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Abstract

Recent increases in imports of catfish, crawfish, and shrimp have caused concern as to their impact on domestic prices. This study seeks to identify the linkages between imports of these goods and producer prices. Increases in imports of catfish and shrimp are shown to decrease related domestic prices. However, recent trends show a simultaneous increase in both imports and domestic prices of crawfish.

Background

Lower-priced imported goods often displace domestically produced goods. Currently, many U.S. producers of catfish, crawfish, and shrimp are contending with economic hardships resulting from low-priced, imported catfish, crawfish, and shrimp. The dramatic increase in catfish imports in 2001 caused prices to plummet. The farm catfish price fell almost continuously throughout the year, from a high of 69 cents per pound at the beginning of the year to a low of 55 cents a pound in December. After 2001, the farm price for catfish continued its downward trend, albeit more slowly, reaching a low of nearly 50 cents per pound. The relatively low production costs in Vietnam stimulated exports to the U.S. market. More than 90 percent of U.S. catfish imports originated from Vietnam.

The declining price for crawfish is a bit different from catfish. Until 1999, the crawfish price hovered between $3.50 and $3.00 per pound. However, during the 1999-2000 and 2000-2001 crawfish seasons, an extreme drought reduced production quantities. As a result, crawfish imports increased. In 2001, imports peaked at 5,859 metric tons. This represented a more than 300 percent increase in imports when compared to the 1,762 metric tons imported in 1999. In the early 1990s, crawfish farming in Louisiana was a wellestablished, profitable business. Since then, crawfish farmers in Louisiana, who account for 85-95 percent of total U.S. production, suffered as a result of increased imports of low-priced crawfish. Almost all imported crawfish is exported from China.

Shrimp imports, on the other hand, have had a more dramatic effect on domestic prices than was demonstrated when describing the two previously discussed commodities. The 2002 price plunged from $7.95 per pound to a mere $6.21 per pound, an almost 22% decrease from the previous year. Since 1996, the constant increase of shrimp consumption resulted in domestic supply shortages. Consequently, shrimp imports have increased constantly over the years in order to keep pace with consumer demand. In 2004, shrimp fishermen in eight states plan to file petitions seeking increased tariffs on shrimp imports from Thailand, China, Vietnam, Ecuador and a handful of other nations that supply nearly 90 percent of the U.S. market. This would serve as an emergency tariff protecting against a domestic price decline.

Even though domestic catfish, crawfish, and shrimp producers are facing strong competition from low-priced imports, the perceived health benefits associated with the consumption of these goods has resulted in increased consumption of these aquaculture products. Aquaculture products like catfish, crawfish, and shrimp are becoming an important source of protein in addition to red meat and chicken. Along with increased health concerns, many high income consumers are now consuming more fish, as demonstrated by the dramatic increase in per capita consumption of shrimp. Yearly increases in consumption of catfish, crawfish, and shrimp are representative of new eating trends and consumers' health concerns. However, the domestic aquaculture industry is facing strong competition from low-priced imports. This study is intended to isolate the effect, not only of imports of catfish, crawfish, and shrimp, but also income and other related products on the domestic price. To accomplish this objective, this study will use the inverse demand equation to estimate the direct price flexibility. These estimated price flexibilities are used to analyze the effects of changes in imports, income, and supplies of other related products. In addition, this study will estimate the indirect price flexibility, using the ordinary demand system to compare indirect and direct flexibilities.

Literature Review

The major implications of previous research is that 1) the reciprocals of the direct price flexibilities are not in general the same as the direct price elasticity and 2) 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 sizes of difference between 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. To evaluate quantity effects of price changes, however, only elasticities from a directly estimated ordinary demand system should be used.

Eales (1996) disagreed with Houng'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 an ordinary meat demand system and inverts the elasticity matrix, it cannot, in general, be expected to produce good estimates of the unconditional meat 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 is willing to believe that those estimates are consistent, i.e., prices and expenditure are predetermined.

However, according to Houang'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. Another drawback is that the inverted results are quite sensitive to the numerical structure (for example, existence of a singularity problem) of a demand matrix being inverted, and that could cause unstable results. Due to stochastic properties in estimating elasticities or flexibilities by adopting time series data, the consistency between direct and indirect flexibilities is still a controversial issue.

Theoretical Framework

Previous studies suggest that the inverse demand function[1] is preferred to the ordinary demand function[2] when anticipating future trends of price and quantity for agricultural products. The biological nature of the production process results in many agricultural 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

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[1]Inverse demand function is defined as follows:
$P_i = \beta_0 + \beta_1 Q_1 + \beta_2 Q_2 + \ldots + \beta_n Q_n$
Where
P_i: price of good i
$Q_1 \ldots Q_n$: own and other related goods supplied in the market including shift variable

[2]Ordinary demand function is defined as follows:
$Q_i = \alpha_0 + \alpha_1 P_1 + \alpha_2 P_2 + \ldots + \alpha_{n-1} P_{n-1} + \alpha_n Y$
Where
Q_i: quantity of good i
$P_1 \ldots P_{n-1}$: prices of own and other related goods
Y: income

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, crawfish, and shrimp share characteristics common to other agricultural products such as a biological production lag and perishability. 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

$$F = \frac{\Delta P / P}{\Delta Q / Q} = \left(\frac{\Delta P}{\Delta Q}\right)\left(\frac{Q}{P}\right)$$

As Houck and Eales indicated, 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 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 flexibility is derived from the inverse demand function in which price is a function of the supplied commodity, related commodities, and a shift variable. In contrast, the indirect price flexibility is acquired utilizing the ordinary demand function. In this case, quantity is a function of the price of the product as well as income. As Houng 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 equations. The difference between the estimation of true and stochastic parameters can be seen in the following examples. First, let us assume that there are two goods, X_1 and X_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 demand and ordinary demand equations.

First, the inverse demand regression is modeled as follows:

Equation 1: $P_1 = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 Y + \varepsilon_1$

Equation 2: $P_2 = \beta'_0 + \beta'_1 X_1 + \beta'_2 X_2 + \beta'_3 Y + \varepsilon_2$

P_1 is the price of good *1*, P_2 is the price of good *2*, X_1 is the quantity of good *1*, X_2 is the quantity of good *2*, Y represents income, and ε is the random error term. According to the assumption of linear regression model, $E(\varepsilon_i) = 0$, and Xi and ε_i are independent. Secondly, the ordinary demand regression is modeled as following:

Equation 3: $X_1 = \alpha_0 + \alpha_1 P_1 + \alpha_2 P_2 + \alpha_3 Y + e_1$

Equation 4: $X_2 = \alpha'_0 + \alpha'_1 P_1 + \alpha'_2 P_2 + \alpha'_3 Y + e_2$

In these equations, P_1 is the price of good 1, P_2 is the price of good 2, X_1 is the quantity of good 1, X_2 is the quantity of good 2, Y represents income, and e is the random error term. According to the assumption of linear regression model, $E(e_i) = 0$, and P_i and e_i are independent.

By using four different equations, we can estimate the relationships among parameters, βi, $\beta' i$, αi, and $\alpha' i$. It can be shown that $\beta_0 = \frac{-\alpha_0 - \alpha_2 \beta'_0}{\alpha_1}$, $\beta_1 = \frac{-\alpha_2 \beta'_1 + 1}{\alpha_1}$, and

$$\beta_2 = \frac{-\alpha_2 \beta'_2}{\alpha_1}.$$

In addition to this, let us assume $P = X'\beta + \varepsilon$. P and X are vectors of 1×n dimension. We can then rewrite this equation as $X = P'\frac{1}{\beta} - \frac{1}{\beta}\varepsilon$, where $\alpha = \frac{1}{\beta}$, and $e = \frac{-1}{\beta}\varepsilon$. Further manipulation allows the following to be obtained:

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

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

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

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

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

If P and ε are not independent, then $\alpha \neq \frac{1}{\beta}$; however, if P and ε are independent, the direct price flexibility is equal to the reciprocal of the price elasticity.

Flexibility coefficients that are analogous to the concepts of income elasticity and cross elasticity may also be defined. The price flexibility of income is the percentage change in price in response to a 1 percent change in income, other factors held constant. It is calculated as follows:

Equation 10: $F_{iy} = (\frac{\Delta P_i}{\Delta Y})(\frac{Y}{P_i})$

Typically, the price flexibility of income is expected to be positive for normal goods. However, before asserting that this is true, we must investigate the relationship between demand, price, income, and supply. In the ordinary demand system, income will shift the demand curve. If there is an increase in income, the demand curve will move to the right so that at the same price, quantity demanded will increase. The increase price results in an increase in supply. According to economic theory, an increase in supply will decrease price. As a result, in the inverse demand equation it is difficult to predict the sign of the income coefficient in the inverse demand system. The cross flexibility of *i* with respect to *j* is the percentage change in the price of commodity *i* in response to a 1 percent change in the quantity supplied of commodity *j*, other factors held constant. The relationship is as follows:

Equation 11: $F_{ij} = (\frac{\Delta P_i}{\Delta Q_j})(\frac{Q_j}{P_i})$

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 under consideration, commodity *i* (Tomek and Robinson, 1991).

Empirical Analysis

The models in this study are formulated to examine the relationship between imports of own products, specifically, the domestic prices of these products, with imports of substitutes and income serving as exogenous independent variables (e.g., demand shifters). The ordinary demand equation is used to estimate the direct price elasticity of each variable. The estimated coefficient will then be converted into the reciprocal of price elasticity for comparison with the value of the direct price flexibility estimated by the inverse demand equation. This study approximates a conceptual demand relationship in the following form:

Equation 12: $lnQ_i = \sum_j e_{ij}\, lnP_j + \eta_i\, lnM \qquad i, j = 1,2, \ldots\ldots, n$

where $e_{ij} = (\partial Q_i/\partial P_{ij})(P_{ij}/Q_i)$ 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 $\eta_i = (\partial Q_i/\partial M)(M/Q_i.)$ We assume that e_{ij} is the usual type of demand elasticity matrix in a general equilibrium model with direct elasticities on the diagonal and cross elasticities arranged around the diagonal in symmetric positions. In view of classical demand theory, this elasticity matrix is constrained by symmetry $(e_{ji}/w_i + \eta_j = e_{ij}/w_j + \eta_i)$, homogeneity $(\sum e{ij} + \eta_i = 0)$, and the Engel aggregation condition $(\sum w_i\eta_i = 1)$, where $w_i = P_iQ_i/M$ is the expenditure weight of the i^{th} commodity.

To estimate the direct price flexibility, it is important to understand the concept of the Antonelli matrix. The Antonelli equation, as opposed to the Slutsky equation, refers to the effect of a change in quantity on the price of the good. Houck and Huang 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 estimated flexibility, 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:

$$lnP_i = \sum_j f_{ij}\, lnQ_j + \gamma_i\, lnM \qquad i,j = 1,2, \ldots\ldots, n$$

where $f_{ij} = (\partial P_i/\partial Q_{ij})(Q_{ij}/P_i)$ 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. $\gamma_i = (\partial P_i/\partial M)$ is the price flexibility of the i^{th} commodity with respect to income.

The conceptual models are formulated to examine the effects of imports of catfish, crawfish, and shrimp on the domestic prices of these goods, since previous research has indicated that imports are one of the most important factors influencing the domestic prices of catfish, crawfish, and shrimp. Since no individual supplier affects the market price, this study considers this market as competitive. Thus all suppliers, including importers, are treated as price takers. As a result, the price and quantity are determined by interactions of demand and supply.

To estimate direct price flexibility coefficients for the variables used in this model, this study presents three different types of inverse demand functions. Using these models, coefficients of the variables are compared. 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 flexibility in the manner of the differential-form demand model suggested by Haung. The inverse demand functions are estimated by the Seemingly Unrelated Regression (SUR) model to improve the efficiency of estimation since the error terms of the individual equations of each commodity may be correlated. To accomplish this, the SUR models are applied to monthly data.

The first model is estimated as follows:

(1) $P_{us} = f\,(Q_m, Y)$

where P_{us} is deflated domestic price, Q_m is quantity of imports, and Y is deflated per capita disposable income. 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. To do this, imports of catfish, crawfish, and shrimp are predetermined.

The second model is estimated as follows:

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

where Q_{us} is domestic production and inventory. As in the previous model (1), this model assumes that the imported good is heterogenous with the domestic good. This model is intended to isolate the effects of not only imported goods but also the domestically supplied good.

The next two models are estimated as follows:

(3) $Q_d = f\,(P_{us}, P_{sub}, Y)$

(4) $Q_s = f\,(P_{us}, C)$

where Q_d is domestic demand, P_{us} is deflated domestic price, P_{sub} is deflated prices of related goods, Y is deflated per capita disposable income, Q_s is domestic supply (domestic production plus inventory), and C is the input cost to produce these goods. These two models are intended to estimate the direct price elasticity of domestic demand and supply.

The final model is estimated as follows:

(5) $P_{us} = f\,(Q_m, Q_{us}, S_m, S_{us}, Y)$

where S_m is imported substitutes, and S_{us} is domestically produced substitutes. This model is formulated to examine the effects of imported goods, domestically produced goods, imported substitutes, domestically produced substitutes, and income. The coefficients estimated through these models will be compared with each other. As previously mentioned, the price flexibilities estimated through each model are also compared with the reciprocal of direct price elasticities to confirm the difference between true parameters derived from economic theory and stochastic parameter estimated by the stochastic regression model.

Data

The models are generated using monthly data ranging from 1980 through 2002 on imports, domestic supply and demand, and real prices of catfish, crawfish, shrimp, and three other aquaculture products, and three major meats. The model is estimated using data from the following sources: (1) U.S. Import and Exports of Fishery Products Annual Summary, 1980-2002 (2) Livestock, Dairy and Poultry Situation and Outlook, Economic Research Service, USDA, and (3) the disposable personal income used in the study was obtained from the U.S. Department of Commerce.

Results and Discussion

As is consistent with the initial assumption of this study, Table 1 shows that the indirect price flexibility is generally not the same as the direct price flexibility. The direct flexibilities are shown to be less, in absolute terms, than the indirect price flexibilities. As a result, sizable errors can be created when using the indirect price flexibility derived from inverted price elasticity with other variables for agricultural policy and program analyses.

Table 2 shows that there is an inverse relationship between imports and domestic price in catfish and shrimp. Although imports of catfish and shrimp negatively affect domestic price, the size of the impact is shown to be small. If imports of catfish and shrimp increase by 10%, the prices will decrease by 0.2% and 0.7%, respectively. Unlike catfish and shrimp, imports and the domestic price of crawfish are shown to have a positive relationship. Decreases in domestic production of crawfish caused by a heavy drought generated high domestic prices. Consequently, a large amount of crawfish is imported from other countries to meet domestic demand. Imports of crawfish increasing by 10% were shown to correspond with a price increase by 0.3%. Causality is an important issue here. Table 2 also showed that income has a negative impact on the domestic prices of catfish and shrimp and a positive impact on domestic price of crawfish. If disposable personal income increases by 10%, the price of catfish and shrimp will decrease by 5.3% and the price of crawfish will increase by 1.9%.

Imports and domestic production have varying effects on domestic prices of catfish, crawfish, and shrimp, as shown in Table 3. Model (2) assumed that imported and domestically produced goods are heterogeneous and both have an effect on the domestic price of each good. Like in model (1), imports have a negative impact on domestic prices of catfish and shrimp but a positive impact on the price of crawfish. However, domestically produced catfish and shrimp are positively related to the domestic prices of catfish and shrimp, respectively, but domestically produced crawfish has a negative relationship with the domestic price of crawfish. Table 3 showed that a 10% increase in domestic productions of catfish and shrimp will generate a 1.4% and 0.1% increase in the domestic prices of catfish and shrimp, respectively. On the other hand, a 10% increase in domestic production of crawfish will decrease the domestic price of crawfish by 0.09%. The effect of income is shown to be the same with model (1) for each good.

Table 4 showed that pork is a complimentary good for catfish, crawfish, and shrimp at statistically significant level, while beef is a substitute good for these three goods. Table 4 also shows that increases in disposable personal income increase consumption of catfish, crawfish, and shrimp. As a result, the model (3) showed that these three goods are normal goods.

The relationship between the domestic productions, imports and domestic prices of catfish, crawfish, and shrimp is presented in table 5. The domestic price of catfish is shown to have a positive relationship with domestic production of catfish, but it is statistically insignificant. Catfish imports are also shown to have a positive relationship with domestic production of catfish. Table 5 showed that if imports of catfish increase by 10%, domestic production of catfish increases by 0.5%. However, the results were statistically insignificant. The domestic production of crawfish is shown to have a negative relationship with the domestic price of crawfish. During early 2000, bad weather conditions reduced domestic production of crawfish so that domestic prices and imports of crawfish increased. Table 5 showed that a 1% increase in domestic price of crawfish causes domestic production of crawfish to decrease by 4.6%, and a 1% increase in imports of crawfish reduces domestic production by 0.2% but it is statistically insignificant. Like catfish, the domestic price of shrimp is shown to have a positive relationship with the domestic supply of shrimp, but it is shown statistically insignificant. Shrimp imports are also shown to have a positive relationship with domestic production of shrimp. SUR showed that a 10% increase in imports of shrimp results in a 0.6 increase in the domestic supply of shrimp.

In the extended model (5), this study estimated a variety of direct price flexibilities for these three goods including not only own goods produced domestically and imported but also eight other goods produced domestically and imported as independent variables. Table 6 shows that imports of shrimp and trout and domestic production of clams have a negative relationship with the domestic price of catfish at a statistically significant level.

It showed that 10% increases in imports of shrimp and trout and in domestic production of clam decrease the domestic catfish price by 2.7%, by 0.7%, and by 1.6%, respectively at a statistically significant level. Table 7 shows that imports of pork have a negative relationship with the domestic crawfish price at a statistically significant level, while imports of catfish have a positive relationship. It showed that a 10% increase in imports of pork decreases the domestic crawfish price by 3.26%, while a 10% increase in imports of catfish increases the domestic crawfish price by 0.3%. Table 8 shows that the domestic production of catfish has a positive relationship with domestic price of shrimp and domestic production of clam and imports of pork have a negative relationship with domestic price of shrimp at a statistically significant level. It showed that 10% increases in domestic clam production and in imports of trout and pork decrease the domestic shrimp price by 1.4%, by 0.5%, and by 3.1%, respectively, while a 10% increase in domestic production of catfish increases the domestic shrimp price by 0.87%.

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 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) a practical means of determining the impact of a given import volume change on domestic prices; (b) an account of the potentially perishable nature and seasonality of lightly processed commodities; (c) the extent of substitutability between the domestic good, the imported good, and other related domestic and imported goods; and (d) account for any simultaneity between domestic demand and supply. In incorporating these features, this procedural study progressed from simpler to more complicated formulations, permitting observations of any gains from additional modeling sophistication.

As previously assumed, 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 for catfish, crawfish, and shrimp. 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 ordinary demand system for agricultural policy and program analyses.

This study confirmed that increases in imports of catfish and shrimp decreased their respective domestic prices, while imports of crawfish have increased along with an increase in the domestic price of crawfish. This implies that the high domestic price generated during the collapse in domestic production due to heavy droughts in 2000 and 2001 strongly attracted imports of crawfish. This study shows that own prices of catfish, crawfish, and shrimp have had a negative relationship with consumption and increased income led to increased consumption of these three goods, implying that these are normal goods. An increase in income increases the domestic prices of catfish and shrimp, while an increase in income corresponded with decreased domestic prices for crawfish. This study also showed that trout, clam, chicken, and pork affected domestic prices of catfish, crawfish, and shrimp at a statistically significant level. An increase in the supply of trout, clam, and chicken caused the domestic price of catfish to decrease, an increase in the supply of pork generated a decrease in the domestic price of crawfish, and an increase in the supply of trout, clam, and pork typically reduced the domestic price of shrimp. Each model showed different relationships between domestic prices of these three goods and other aquaculture and meat products.

Table 1. The relationship of direct price flexibilities to indirect price flexibilities

Type		Direct Price Flexibility	Indirect Price Flexibility
Equation		$F_{di}{}^{a} = \frac{\Delta\% P^{b}}{\Delta\% M^{c}} \cdot \frac{M}{P}$	$F_{ii}{}^{d} = \frac{1}{\varepsilon_i^e} = \frac{1}{\frac{\Delta\% M}{\Delta\% P} \cdot \frac{P}{M}}$
Model I	Functional Form	$LnP = \beta_0 + \beta_1 LnM + \beta_2 LnY^{f}$	$LnM = \alpha_0 + \alpha_1 LnP + \alpha_2 LnY$
	Catfish Crawfish Shrimp	β_1: -0.02093 β_1: 0.01993 β_1: -0.05660	α_1: -0.56140 α_1: 0.37015 α_1: -1.50932
Model II	Functional Form	$LnP = \beta_0 + \ln \beta_1 LnM + \ln \beta_2 LnX + \beta_3 LnY$	$LnM = \alpha_0 + \alpha_1 LnP + \alpha_2 LnY$
	Catfish Crawfish Shrimp	β_1: -0.02376 β_1: 0.01044 β_1: -0.13696	α_1: -0.56140 α_1: 0.37015 α_1: -1.50932
Model V	Functional Form	$LnP = \beta_0 + \beta_1 LnM + \sum_i \beta_i \ln X^{g}{}_i$	$LnM = \alpha_0 + \alpha_1 LnP + \sum_j \alpha_j \ln P^{h}{}_j$
	Catfish Crawfish Shrimp	β_1: 0.00626 β_1: 0.00541 β_1: 0.08387	α_1: 0.37266 α_1: 0.99294 α_1: 2.09983

[a] Direct price flexibility of imported good *i*
[b] Price of imported good *i*
[c] Imported good *i*
[d] Indirect price flexibility of imported good *i*
[e] Supply elasticity of imported good *i*
[f] Disposable personal income
[g] Other related goods
[h] Prices of other related goods

Table 2. Regression analysis and estimated direct price flexibilities

Type of Regression		OLS		SUR	
		Coefficients	t-value	Coefficients	t-value
Catfish	R^2	0.5935		0.5990	
	β_0	19.98138	16.90**	19.87338	16.99**
	β_1	-0.02093	-2.52**	-0.02229	-2.68**
	β_2	-1.53807	-12.86**	-1.52657	-12.90**
Crawfish	R^2	0.1746		0.2362	
	β_0	-2.26927	-1.35	-0.82957	-0.43
	β_1	0.01993	2.54**	0.032438	3.05**
	β_2	0.33636	1.99*	0.191056	0.98
Shrimp	R^2	0.3278		0.6978	
	β_0	7.51200	7.89**	7.88477	1.66
	β_1	-0.12094	-3.79**	-0.06586	-2.78**
	β_2	-0.41684	-3.71**	-0.52548	-1.12

Inverse demand function: $LnP = \beta_0 + \beta_1 LnM + \beta_2 LnY$

* Statistically significant at 0.05

** Statistically significant at 0.01

Table 3. Regression analysis and estimated direct price flexibilities

Type of Regression		OLS		SUR	
		Coefficients	t-value	Coefficients	t-value
Catfish	R^2	0.6198		0.6589	
	β_0	19.98693	17.42**	19.56156	17.23**
	β_1	-0.02376	-2.93**	-0.02923	-3.49**
	β_2	0.11710	3.36**	0.13920	3.58**
	β_3	-1.61034	-13.65**	-1.58157	-13.49**
Crawfish	R^2	0.2117		0.2205	
	β_0	-3.03009	-1.79	-2.44638	-1.38
	β_1	0.01044	1.35	0.01332	1.66
	β_2	-0.00809	-1.98*	-0.00938	-1.96*
	β_3	0.41955	2.47*	0.36095	2.03*
Shrimp	R^2	0.3324		0.3500	
	β_0	7.24160	7.35**	7.57193	6.67**
	β_1	-0.13696	-3.88**	-0.10521	-2.01*
	β_2	0.01120	1.07	0.01048	0.27
	β_3	-0.38412	-3.30**	-0.45	-3.11**

Inverse demand function: $LnP = \beta_0 + \beta_1 LnM + \beta_2 LnX + \beta_3 LnY$

* Statistically significant at 0.05

** Statistically significant at 0.01

Table 4. Regression analysis and estimated demand elasticities

Type of Regression		OLS		SUR	
		Coefficients	t-value	Coefficients	t-value
Catfish	R^2	0.1874		0.2126	
	β_0	-26.73300	-1.13	-16.6434	-0.71
	β_1	-0.01328	-0.02	0.20918	0.39
	β_2	-1.50686	-2.33*	-1.72333	-2.78**
	β_3	1.54084	1.95	1.09808	1.43
	β_4	3.93684	1.47	4.13023	1.57
	β_5	0.96751	0.40	0.78756	0.33
	β_6	-3.44734	-3.13**	-3.30844	-3.12**
	β_7	3.02309	1.67	2.10938	1.19
Crawfish	R^2	0.1546		0.4631	
	β_0	-109.74312	-2.21*	-19.6842	-4.53**
	β_1	-3.25963	-2.98**	0.10507	1.07
	β_2	-2.26597	-1.72	-0.14321	-1.28
	β_3	5.36634	3.45**	-0.06278	-0.45
	β_4	7.01879	1.38	-0.08938	-0.19
	β_5	7.58999	1.57	1.36826	3.11**
	β_6	-7.89023	-3.46**	-0.55991	-2.90**
	β_7	8.26524	2.17*	2.62635	8.14**
Shrimp	R^2	0.5358		0.8359	
	β_0	-9.64363	-1.47	-19.6842	-4.53**
	β_1	0.25460	1.63	0.10507	1.07
	β_2	-0.39826	-2.25*	-0.14321	-1.28
	β_3	-0.44035	-2.03*	-0.06278	-0.45
	β_4	1.06258	1.46	-0.08938	-0.19
	β_5	1.08251	1.61	1.36826	3.11**
	β_6	-0.24664	-0.82	-0.55991	-2.90**
	β_7	1.20980	2.44*	2.62635	8.14**

Ordinary demand function: $LnC_i = \beta_0 + \beta_1 LnP_1 + \beta_2 LnP_2 + \beta_3 LnP_3 + \beta_4 LnP_4 + \beta_5 LnP_5 + \beta_6 LnP_6 + \beta_7 LnY$

Where

P_1: Crawfish price

P_2: Catfish price

P_3: Shrimp price

P_4: Chicken price

P_5: Beef price

P_6: Pork price

* Statistically significant at 0.05

** Statistically significant at 0.01

Table 5. Regression analysis and estimated supply elasticities

Type of Regression		OLS		SUR	
		Coefficients	t-value	Coefficients	t-value
Catfish	R^2	0.0390		0.2499	
	β_0	5.70137	9.69**	5.64134	10.03**
	β_1	0.07336	0.60	0.06489	0.56
	β_2	0.04662	2.52*	0.04613	2.55
Crawfish	R^2	0.1897		0.7123	
	β_0	11.61601	4.68**	8.98277	5.34**
	β_1	-4.42193	-2.02*	-4.64169	-3.23**
	β_2	-0.53543	-3.48**	-0.19509	-1.75
Shrimp	R^2	0.1420		0.9392	
	β_0	-4.2935	-1.44	8.28336	8.48**
	β_1	1.10562	1.95	0.05222	0.33
	β_2	1.11011	5.15**	0.06197	0.83

Domestic production function: $LnS_i = \beta_0 + \beta_1 LnP + \beta_2 LnM$

* Statistically significant at 0.05

** Statistically significant at 0.01

Table 6. Regression analysis and estimated direct price flexibilities for catfish

Type of Regression	OLS		SUR	
	Coefficients	t-value	Coefficients	t-value
R^2	0.6813		0.8302	
β_0	2.21817	0.33	26.85023	6.97**
β_1	-0.00659	-0.64	0.00781	0.99
β_2	0.00687	1.19	-0.00909	-1.36
β_3	0.00626	0.69	-0.00841	-0.92
β_4	-0.13076	-2.40*	0.03786	0.90
β_5	0.07438	0.67	-0.26855	-3.33**
β_6	0.00666	0.22	-0.02412	-0.40
β_7	0.00512	0.17	-0.07433	-3.06**
β_8	-0.00282	-0.31	-0.01042	-1.04
β_9	-0.04200	-0.66	0.08287	1.30
β_{10}	0.06533	0.59	-0.16284	-2.20*
β_{11}	0.00779	0.14	0.03896	1.12
β_{12}	0.06461	0.97	0.03128	0.44
β_{13}	-0.09791	-2.71*	-	-
β_{14}	0.42935	1.48	0.31534	1.78
β_{15}	-0.16324	-1.92	0.00667	0.08
β_{16}	0.39789	1.62	0.11691	0.39
β_{17}	0.12544	0.99	0.01015	0.13
β_{18}	-0.23481	-1.17	-0.01716	-0.09
β_{19}	-0.30272	-0.39	-2.21579	-4.88**

Inverse demand function:

$$LnCARP =$$
$$\beta_0 + \beta_1 LnCRIM + \beta_2 LnCRDP + \beta_3 LnCAIM + \beta_4 LnCADP + \beta_5 LnSHIM + \beta_6 LnSHDP + \beta_7 LnTRIM$$
$$\beta_8 LnTRDP + \beta_9 LnCLIM + \beta_{10} LnCLDP + \beta_{11} LnOYIM + \beta_{12} LnOYDP + \beta_{13} LnCHIM + \beta_{14} LnCHDP +$$
$$\beta_{15} LnBEIM + \beta_{16} LnBEDP + \beta_{17} LnPOIM + \beta_{18} LnPODP + \beta_{19} LnDPI$$

* Statistically significant at 0.05

** Statistically significant at 0.01

Table 7. Regression analysis and estimated direct price flexibilities for crawfish

Type of Regression	OLS		SUR	
	Coefficients	t-value	Coefficients	t-value
R^2	0.4685		0.4709	
β_0	-17.19413	-1.84	0.31825	0.06
β_1	0.01074	0.75	0.02742	2.65**
β_2	-0.00302	-0.38	-0.02773	-3.16**
β_3	-0.00257	-0.21	0.02981	2.48*
β_4	0.01932	0.26	0.06399	1.16
β_5	0.14119	0.91	0.07556	0.72
β_6	-0.04364	-1.05	-0.00337	-0.04
β_7	-0.04966	-1.18	-0.01478	-0.46
β_8	0.00443	0.35	0.01316	1.00
β_9	0.02254	0.26	0.14132	1.69
β_{10}	0.22420	1.45	-0.15403	-1.59
β_{11}	0.01565	0.21	-0.01633	-0.36
β_{12}	0.19484	2.11*	-0.01258	-0.13
β_{13}	-0.10003	-2.00	-	-
β_{14}	-0.70504	-1.75	-0.44596	-1.92
β_{15}	-0.01376	-0.12	0.01035	0.10
β_{16}	0.32434	0.96	0.14656	0.37
β_{17}	-0.22622	-1.28	-0.32554	-3.12**
β_{18}	-0.56590	-2.04	-0.20818	-0.80
β_{19}	2.18822	2.03	0.52098	0.88

Inverse demand function:

$$LnCRRP =$$
$$\beta_0 + \beta_1 LnCRIM + \beta_2 LnCRDP + \beta_3 LnCAIM + \beta_4 LnCADP + \beta_5 LnSHIM + \beta_6 LnSHDP + \beta_7 LnTRIM$$
$$\beta_8 LnTRDP + \beta_9 LnCLIM + \beta_{10} LnCLDP + \beta_{11} LnOYIM + \beta_{12} LnOYDP + \beta_{13} LnCHIM + \beta_{14} LnCHDP +$$
$$\beta_{15} LnBEIM + \beta_{16} LnBEDP + \beta_{17} LnPOIM + \beta_{18} LnPODP + \beta_{19} LnDPI$$

* Statistically significant at 0.05

** Statistically significant at 0.01

Table 8. Regression analysis and estimated direct price flexibilities for shrimp

Type of Regression	OLS		SUR	
	Coefficients	t-value	Coefficients	t-value
R^2	0.7765		0.6502	
β_0	-15.62031	-3.05**	7.24527	2.16*
β_1	-0.00369	-0.47	0.00879	1.28
β_2	0.00531	1.21	-0.00594	-1.02
β_3	-0.01548	-2.25*	-0.01001	-1.25
β_4	-0.00653	-0.16	0.08732	2.39*
β_5	0.12084	1.43	-0.15159	-2.16*
β_6	-0.04027	-1.76	-0.01135	-0.22
β_7	-0.00254	-0.11	-0.04574	-2.16*
β_8	-0.00933	-1.34	-0.00485	-0.56
β_9	-0.00776	-0.16	0.09227	1.66
β_{10}	0.12764	1.51	-0.13968	-2.17*
β_{11}	0.00883	0.21	0.02649	0.87
β_{12}	-0.01996	-0.39	0.02255	0.36
β_{13}	0.01875	0.68	-	-
β_{14}	-0.39261	-1.78	-0.16645	-1.08
β_{15}	-0.05913	-0.92	0.01103	0.16
β_{16}	0.42246	2.27*	-0.41682	-1.59
β_{17}	-0.38378	-3.97**	-0.31050	-4.47**
β_{18}	0.02986	0.20	0.38408	2.21*
β_{19}	1.75045	2.96**	-0.07390	-0.19

Inverse demand function:

$$LnSHRP =$$
$$\beta_0 + \beta_1 LnCRIM + \beta_2 LnCRDP + \beta_3 LnCAIM + \beta_4 LnCADP + \beta_5 LnSHIM + \beta_6 LnSHDP + \beta_7 LnTRIM$$
$$\beta_8 LnTRDP + \beta_9 LnCLIM + \beta_{10} LnCLDP + \beta_{11} LnOYIM + \beta_{12} LnOYDP + \beta_{13} LnCHIM + \beta_{14} LnCHDP +$$
$$\beta_{15} LnBEIM + \beta_{16} LnBEDP + \beta_{17} LnPOIM + \beta_{18} LnPODP + \beta_{19} LnDPI$$

* Statistically significant at 0.05

** Statistically significant at 0.01

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