Efficacy of U.S. Antidumping Duties: The Case of Freshwater Crawfish Tail Meat

by

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Abstract:

Quantity-dependent and price-dependent Rotterdam conditional demand systems are estimated using annual data for 1990-2014 to determine whether an antidumping duty levied by the United States on crawfish imports from China was effective in protecting the domestic industry. Results from the quantity-dependent system suggest the duty was ineffective. The hypothesis that the duty had no effect on the demand for domestically-produced crawfish could not be rejected at any reasonable probability level. Results from the price-dependent model, on the other hand, provides some weak evidence that the duty may have been effective. The hypothesis that the duty had no effect on the domestic price of crawfish is rejected at the 10% probability level, but not the 5% level. The 90% confidence interval associated with the estimated parameter for the duty period suggests the effect of the duty on the domestic price of crawfish ranges from 5.1% to 63.78%.

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List of abbreviations

AD	Anti-dumping duty
CPA	Crawfish processors Alliance
CVD	Countervailing duty
DOC	Department of Commerce
GATT	General Agreement of Tariff and Trade
LTFV	Less Than Fair Value
RTAA	Reciprocal Trade Agreement Act
USITC	United states International trade commission
D	Demand curve before antidumping duty
D'	Demand curve after antidumping duty
S	Supply curve before antidumping duty
S'	Supply curve after antidumping duty
p_{us}	Domestic crawfish price before antidumping duty
p'_{us}	Domestic crawfish price after antidumping duty
q_{us}	Quantity demanded of domestic crawfish before antidumping duty
q'_{us}	Quantity demanded of domestic crawfish after antidumping duty
$p_{m,d}$	Demand price of imported crawfish before antidumping duty
$p'_{m,d}$	Demand price of imported crawfish after antidumping duty

$p_{m,s}$ Supply price of imported crawfish before antidumping duty

$p'_{m,s}$ Supply price of imported crawfish after antidumping duty

I. Introduction

The crawfish industry is one of the fast growing industries in the United States. In 1990, U.S. crawfish commercial landing was 7.5 million pounds with a value of 4 million US dollars, while in 2014, the production was 13 million pounds with a value of 16 million US dollars (NMFS, 2016).Table. 1 shows U.S production, imports and value shares of crawfish.

There are two major commercial forms of crawfish: whole crawfish and tail meat. Fresh whole crawfish is consumed near the production areas and the rest is either frozen or processed and peeled to be sold as fresh or frozen tail meat. U.S. imports whole frozen crawfish and tail meat from different countries like China, Spain, Singapore, Australia and some other countries. China is the major exporter of crawfish to the United States. In 2014, imports from China were 91 % of the total value and quantity of crawfish imports and 53 % of the total supply of crawfish in the U.S. (NMFS, 2016).

In 1996, the crawfish processors alliance (CPA) filed a petition claiming that crawfish tail meat imported from China is sold at a less than fair value (LTFV). The United States International Trade Commission (USITC) found that the claim is true and the Department of Commerce (DOC) indicated that the crawfish tail meat processing industry is materially injured due to the low priced crawfish tail meat imports from China, so antidumping duty (AD) on the crawfish tail meat imports from China was imposed with a rate from 91% to 201 % to protect the domestic industry (USITC, 1997).

An anti-dumping duty is imposed by an importing country as a means of protection to the domestic producers when the imported product is sold at an unfair price. AD is supposed to protect the domestic producers by raising the price of the imported good so that the domestic price remains competitive.

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The USITC reviewed the investigations in 2003, 2008 and 2013 and it found that the material injury will continue to the crawfish tail meat industry if the antidumping tariff is eliminated. So the duty was renewed every time.

This paper uses the direct and inverse Rotterdam demand system models to evaluate the effectiveness of the antidumping duty imposed by the U.S. government by measuring the effect of the AD on the domestic price and quantity consumed.

II. Literature Review

The International trade movement has been growing especially after the General Agreement on Tariffs and Trade (GATT). In the report prepared by the United States International Trade Commission (USITC), Baldwin (2009) mention that the US trade policy history passed through different events that aimed to increase the openness of international trade starting from the Reciprocal Trade Agreements Act (RTAA) to the most recent multilateral and bilateral agreements such as NAFTA and CAFTA and other agreements passing by GATT and some negotiations for tariff reductions and increasing nontariff barriers.

It is arguable whether trade liberalization is beneficial to a country. For example, Baldwin (2009) indicates that benefits from trade liberalization to the U.S. economy exceed the drawbacks. In the agriculture sector, Benson, Marchant and Rosson (1996) state that trade liberalization led to an increase in the prices of some agricultural products as a result of entering new export market but also caused decline in the price of other goods due to import competition.

There are some incidents where the government of the United States sees that importing certain goods might be harmful for its domestic industry due to selling the imported goods at unfair prices so it tries to protect the domestic producers by imposing non-tariff restrictions on

the imports of that good to raise the price of it. These restrictions are countervailing duties (CVD), safeguards and antidumping duties.

AD is the most widely spread method among the non-tariff barriers Zanardi (2004). It is imposed by importing countries that found that an exporting country or a group of countries export a certain good to its market at a significantly low price which is called less than fair value price (LTFV) such that the national industry is materially injured.

With the expansion of the international trade, it is normal that the use of antidumping duties is growing. Blonigen (2003) mentions that from 1980s to the 1990s the number of AD increased from 1600 to 2200 cases with an increase in the number of countries that file AD cases.

In the U.S, since 1916, the year of antidumping law emergence, the number of antidumping tariff was varying. Irwin (2005) states that before 1980, the number of AD imposed was small relative to the number of petitions filed opposite to the recent situation where the number of impositions is higher as a result of filing petitions against multiple sources of one product. He claimed that there is a direct relationship between the number of petitions and the rate of exchange and unemployment. Blonigen (2006) found that the average U.S. Antidumping duties jumped by 45 % from 1980s to 2000.

The effectiveness of AD is arguable among the economists. Zanardi (2004) mentions that theoretical work on antidumping duties reveals that the number of successful cases of AD is very small, and the empirical work shows that antidumping tariff negatively affects consumer welfare with or without positive effects to producer welfare.

For fisheries and agricultural products, the situation is not significantly different from the other goods. However, perishability, seasonality and price volatility are specific characteristics to

of agricultural products that make cases of dumping in agricultural products more than other sectors (Rude and Gervais, 2009).

In their unpublished paper, Baylis, Malhotra and Rus (2009) studied the effectiveness if AD on agricultural products and they found that the success of AD to achieve their goals of producers protection depends on some factors; one of them is how concentrated the imports are i.e. the more concentrated the imports the more effective the AD.

Using residual demand model Kinnucan, Duc and Zhang (2017) found that, when the product is homogenous across the supply sources, the effectiveness of AD duties and the import supply elasticity from un-named countries are negatively related, such that the AD duties are ineffective when the non-named countries have perfectly elastic supply. While AD duties are maximally effective when the named country has perfectly elastic supply, in this case the import supply elasticity of non-named countries has no effect; they concluded that the reason is the trade diversion.

Many studies tested the effectiveness of AD in agricultural goods. Asche (2001) studied the effect of U.S. antidumping tariff imposed on salmon imported from Norway and he concluded that the U.S. salmon farmers didn't gain any benefit from the duty because of the diversion of imports to other exporting countries. Kinnucan (2003) studied the effectiveness of AD imposed upon catfish imports from Vietnam and they found that it didn't benefit the domestic producer as much as it harmed the foreign producers.

There are few studies on the crawfish market. Roberts (2001) states that from 72 to 97 percent of the total crawfish production comes from aquaculture farms and the rest comes from capture fisheries. Due to the seasonality of crawfish production, fresh crawfish is sold during the in season period (from January to June) while during the off-season period frozen crawfish is

sold and about 13 percent of the total production in the U.S. is processed and sold as crawfish tail meat (Reynolds and Su, 2005).Chidmi, Hanson and Nguyen (2012) used a non-linear model to determine the substitution patterns among different types of fish and seafood, they found that crawfish demand is elastic, consumers are very sensitive to price changes and crawfish is weak complement to shrimp while shrimp is a strong complement to crawfish. however, Nguyen, Hanson and Jolly (2013) estimated the demand system for crustacean species, crawfish, crab, shrimp and lobster using LA/AIDS and they found that demand for crawfish inelastic.

Applying OLS method using data from 1989 to 2002 Kennedy and Lee (2008) found that during the time period mentioned, the imports of crawfish and domestic price were increasing together .Moreover, they found that domestic production negatively affects the domestic price. They claimed that the drought that happened at the beginning of the 2000s caused a shortage in the supply of domestic crawfish driving the prices up which induced imports to compensate the shortage in the domestic market but when the domestic supply returned to the previous level of production, surplus happened which caused the drop in the domestic price.

Lee and Kennedy (2008) applied the Differential Inverse National Bureau of Research Model (DINBR) to U.S. imported and domestic crawfish, catfish, shrimp, and oysters to estimate the scale and price flexibility of each good and they found that imported crawfish tail meat has the lowest flexibility coefficient. They also found that domestic and imported crawfish tail meat are substitutes but the cross price flexibility is small.

During analysis of demand system of agricultural and fisheries products, the perishability and seasonality of these product must be taken in consideration because these characteristics make it more reliable to use the inverse demand system because these products have inelastic supply in the short run i.e. the price is determined according to the quantity supplied so inverse

demand model is well applicable to these products. Unlike the direct demand system, in inverse demand system the prices are treated as a function of quantities.

One of the well-known inverse demand models is Rotterdam Inverse Demand Model which developed by Barten and Bettendorf (1989) from the direct Rotterdam demand model which developed by Barten (1964) and Theil (1965) and was named after Theil's city of residence.

The main goal of developing Rotterdam demand model was testing the utility maximization theory restrictions, however it has proved its applicability in many applied consumer demand research. Rotterdam demand model uses the differential approach procedure by taking the total differential of the demand function and then introducing restriction on it using the utility maximizing theory Clements and Gao (2015).

Many studies used direct Rotterdam demand model to analyze the demand system of different product and also to determine the effect of some demand shifters like preferences, advertising or product recall, etc. see Parks (2016), Marsh, Schroeder and Mintert (2004) and Kinnucan et al. (2001). Following Barten and Bettendorf (1989), who applied the Rotterdam inverse demand model to determine the demand system of some kinds of Belgian sea fresh fish, some studies used that model to determine the quantity and scale elasticities of fish and aquaculture products. For example, Chiang, Lee and Brown (2001) and Eales (1997).

III. Theoretical Framework

Dumping means selling an imported product at a price less than the fair market value. Less than the fair value price means it is either less than the production costs or less than the product's price at the exporters' country. When the price of a source differentiated product is lower than

the domestically produced one, the demand and the price of the domestic product decreases, given the supply curve is upward sloping. The purpose of antidumping duty is to increase the price and demand of the domestically produced product through raising the price of the imported good, thus decreasing the demand of it. When that happens, the demand for the domestic good increases which, given upward sloping supply, causes the price of the domestic good to increase. Thus, domestic producers are protected and experience a welfare gain from the duty.

What are the different scenarios? In one extreme case, where the import supply curve is perfectly elastic (horizontal), the domestic price of the imported product rises by the full amount of the duty and domestic buyers bear the full incidence. This is shown in figure 1 where the upward shift in the (horizontal) supply curve associated with the duty causes the domestic price of the duty product to rise by the full amount of the duty-induced shift. The higher price for the imported product increases the demand for the domestically-produced product, which, depending on the slope of the supply curve for the domestically-product, causes its price to rise by the per-unit amount of the duty. In this case, the antidumping duty is 100% effective.

In the other extreme case, where the import supply curve is perfectly inelastic (vertical), the domestic price of the duty product does not change at all, while the import supply price falls by the full amount of the duty and the foreign suppliers bear the full incidence of the duty. This is shown in figure 2 where the import supply curve is fixed and the import demand curve shifts downward by the full amount of the duty making the import supply price of the duty product falls by the full amount of the duty leaving the domestic market unchanged. In other words, the foreign exporters bear the full incidence of the duty by selling the same amount of the product at a price less than usual by the full amount of the duty. In this case, the antidumping

duty fails to increase the price of the dutied good so the price and the demand of the domestically produced product stay the same.

IV. Model Specifications

4.1. Rotterdam Demand System Model:

Assuming that U.S crawfish, imports from China and Rest of The World (ROW) are in a weakly separable group, the conditional Rotterdam demand system has the following form:

(1) $\bar{s}_i dlnq_i = \alpha_i + \sum_{j=1}^{3} \theta_{ij} dlnp_j + \theta_i DlnQ + \varepsilon_i$

Where q_i and p_i are the consumption per capita and the nominal price of good i; $DlnQ = \sum_{i=1}^{n} \bar{s}_i dlnq_i$ is the "Divisia Volume Index"; $\bar{s}_i = (s_{i,t} + s_{i,t-1})/2$ is the average budget share of product i of two successive points of time ; $s_{i,t} = \frac{p_i q_i}{y}$ is the budget share of good i at time t ; $y = \sum_{i=1}^{n} p_i q_i$ is the total expenditure; $\theta_{ij} = \eta_{ij}^* s_i$ is the budget share weighted Hicksisan elasticity of product i with respect of product j; s_i is the average budget share of good i over the time period used in the study; $\theta_i = \eta_i^y s_i$ is budget share weighted income elasticity of product i; ε_i is the error term and α_i is the intercept.

Antidumping tariff has been imposed by the U.S. since 1997 on the crawfish tail meat imports from China with a rate of 91% to 201%. To estimate the effect of that tariff, a dummy variable was introduced to the model:

(2) $\bar{s}_i dlnq_{i,t} = \alpha_i + \sum_{j=1}^{n} \theta_{ij} dlnp_{j,t} + \theta_i DQ_t + \gamma_i T_t + \varepsilon_{i,t}$

Where T is a dummy variable which equals one for the tariff period (from 1997 to 2014) and zero otherwise, and $\frac{\gamma_i}{s_i} = \tau_i$ is the proportionate effect of the antidumping tariff on the demand for good i

4.1.1. Hypothesis

(3a) $H_N: \gamma_1 = 0$ (AD duty is ineffective at increasing demand for good 1)

(3b) $H_A: \gamma_1 > 0$ (AD duty is effective).

For an AD to be effective in the sense that it increases the welfare of domestic producers, it must cause the price of the domestically produced good to rise. Asserting a zero effect in the null hypothesis implies that we are not prepared to accept the conclusion that the duty was effective unless there is strong evidence in the data to support the claim. The null hypothesis can be tested using a standard one-tail t-statistic. The critical t-value for rejecting the null at the 10 percent probability when the degrees of freedom are 19 is 1.328. In other words, the null hypothesis can be rejected if $t \geq 1.328$ or if $p \leq 0.10$.

4.1.2. Estimation

Elasticities are calculated from the coefficients as follow:

(4a) $\eta_i^y = \frac{\theta_i}{s_i}$ Expenditure (income) Elasticity

(4b) $\eta_{ij}^* = \frac{\theta_{ij}}{s_i}$ Hicksian Own and Cross Price Elasticities

(4c) $\eta_{ij} = \eta_{ij}^* - s_i \theta_i$ Marshallian Elasticities

(4d) $\tau_i = \gamma_i / s_i$ Tariff Effect.

4.2. Rotterdam inverse demand system (RID):

With the same assumption of weak separability, the form of RID is as follow:

(5) $\bar{s}_i d\ln\pi_i = \beta_i + \sum_{j=1}^{n} \delta_{ij} d\ln q_j + \vartheta_i DQ_i + \mu_i$

where $\pi_i = p_i/y$ is the normalized price of good i; $\vartheta_i = f_i s_i$ is the budget share weighted scale elasticity of good i; $\delta_{ij} = f_{ij}^* s_i$ is the budget share weighted compensated quantity elasticity of good i with respect to good j; β_i is the intercept and $\mu_{i,t}$ is the error term. After introducing the AD effect as a dummy variable the model will be:

(6) $\quad \bar{s}_{i,t} d\ln\pi_i = \beta_i + \sum_{j=1}^{n} \delta_{ij} d\ln q_{j,t} + \vartheta_i DQ_{i,t} + \emptyset_i T_{i,t} + \mu_{i,t}$

where $\frac{\emptyset_i}{\bar{s}_i} = \tau'_i$ is budget-share weighted proportionate effect of the antidumping duty on the price of good i .

4.2.1. Hypothesis

(7a) $\quad H_N: \phi_1 = 0 \quad$ (AD duty is ineffective at increasing the price of good 1)

(7b) $\quad H_A: \phi_1 > 0$ (AD duty is effective).

As mentioned previously, we cannot accept the claim that the duty was effective in raising the domestically produced product unless we have strong evidence. One tailed test used because according to the economic theory, antidumping duty is expected to raise the price of the domestic product.

4.2.2 Estimation

Scale and quantity elasticities are calculated form the coefficients as follow:

(a) $\quad f_i = \dfrac{\vartheta_i}{s_i}$ $\qquad\qquad$ Scale elasticity

(b) $\quad f_{ij}^* = \dfrac{\delta_{ij}}{s_i} + \dfrac{s_j}{f_i}$ $\qquad$ Hicksian own and cross price flexibilities

(c) $\quad f_{ij} = f_{ij}^* - s_i f_i$ $\qquad$ Marshallian flexibilities.

(d) $\quad \tau'_i = \emptyset_i/s_i$ $\qquad\qquad$ Proportionate Tariff Effect on the Price.

Estimation of the direct and inverse models' elasticities and flexibilities is done by seemingly unrelated regression after dropping one equation (ROW) from the system to avoid singularity. The dropped equation's coefficients are calculated relying on the general restrictions:

1- Symmetry: $s_i \eta_{ij}^* = s_i \eta_{ji}^*$ and $s_i f_{ij}^* = s_i f_{ji}^*$.

2- Homogeneity: $\sum_{j=1}^n \eta_{ij}^* = 0$ and $\sum_{j=1}^n f_{ij}^* = 0$.

3- Cournot: $\sum_{i=1}^n \eta_{ij}^* = 0$ and $\sum_{i=1}^n f_{ij}^* = 0$.

4- Engle: $\sum_{i=1}^n \beta_i = 1$ and $\sum_{i=1}^n f_i = 1$.

5- $\sum_{i=1}^n \tau_i = 0$ And $\sum_{i=1}^n \tau'_i = 0$.

V. Data description

Annual data of the United States crawfish domestic landing and imports quantities and values in the period from 1990 to 2014 are collected from National Marine Fisheries Service (NMFS). Imported crawfish data are divided into imports from China and imports from the rest of the world. Prices data are obtained by dividing the total value by the total quantity. Quantities are converted from kilograms units into pounds. Prices are represented in dollars per pound. Table.2 shows data summary statistics.

5.1 Data limitation

Data of Crawfish tail meat prices and consumption is not available so data of total crawfish value and consumption is used in the current research.

VI. Results:

Results obtained from running direct and inverse Rotterdam models using annual data of the period from 1990 to 2014 are shown in Tables 3 and 4.

From the two models, it seems that Rotterdam inverse demand model has better fit to the data; the system weighted R-square is 0.979, most of the coefficients of the model were significant at the conventional levels of significance and the signs of demand estimates are consistent with the theory. That might be because inverse demand model assumes that supply is fixed which is true for perishable goods like crawfish.

6.1. Demand estimates:

Flexibility estimates of the Rotterdam inverse demand system model are presented in Tables 5 and 6.

The own price Marshallian flexibilities absolute value of U.S. domestic crawfish, imports from China and imports from the rest of world are 1.04, 0.986 and 0.179 respectively, which means that if the supply of crawfish increased by 10% then the prices should goes down by 10.4 % for domestic crawfish, 9.86% for imports from China and 1.7% for ROW, holding other factors constant.

Cross price flexibilities have a negative sign which indicates that the three goods are substitutes.

Signs of the three Scale elasticities are negative, their absolute values are 1.10, .815 and 2.01 for US domestic crawfish, imports from China and imports from ROW respectively, which means that if the total supply of crawfish increased by 10%, the price of U.S product falls by 11% While Chinese product falls by 8% and the crawfish from ROW lowers by 20.1%

Most results from Direct Rotterdam Demand System are not significant; however the demand estimates are reported in Tables 6 and 7.

6.2. Antidumping Tariff Effects

The Antidumping tariff was imposed by the U.S. government on the crawfish tail meat imports from China in order to protect the domestic industry from the low prices of the imports by allowing the domestic price to be higher as well as the quantity sold.

In the two models, antidumping tariff variable is introduced as a dummy variable. Results from the inverse demand model indicate that null hypothesis that the antidumping duty has had no effect on the price of the domestically produced product cannot be rejected at 5% significance level but can be rejected at 10% level of one tailed test. That means the anti-dumping tariff may have raised the domestic price by 34.0 %. But with one tailed test, we can say that we do not have a strong evidence to reject the null hypothesis. On the other hand, the null hypothesis that antidumping duty has had no effect on the quantity consumed of the domestically produced crawfish cannot be rejected at conventional significance levels (1%, 5% and 10%).

VII. Conclusion

Results obtained from Rotterdam inverse demand model are consistent with the theory of demand. The compensated own quantity elasticities of the U.S crawfish , Chinese imports and ROW imports are all negative values where the absolute value of U.S. crawfish own quantity elasticity is the highest followed by crawfish imported from China. The compensated cross quantity elasticities indicate that the three products are substitutes; the cross quantity elasticity of the imports from ROW with respect to domestically produced crawfish is the highest absolute

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value of 1.07 which means that for a 10% increase in the domestically produced crawfish, the price of imports from ROW drops by 10.7%.

Marshallian own quantity elasticities of the U.S crawfish , Chinese imports and ROW imports are all negative; the uncompensated own quantity elasticity of U.S. crawfish is the highest followed by crawfish imported from China. Uncompensated Cross quantity elasticities indicate that the three products are substitutes; the cross quantity elasticity of imports from China and the rest of world is the highest absolute value of 1.92, which means that for a 10% increase in the crawfish imports from China, the price of crawfish from the rest of the world drops by 19.2% keeping the scale effect constant.

Scale elasticities of the three goods are consistent with theory and the scale flexibility of the ROW crawfish imports is the highest among the three products with an absolute value of 2.01 which indicates that if the total quantity of crawfish increased by 10%, the price of crawfish from ROW falls by 20.1%. Meanwhile, most of results obtained from the Rotterdam direct demand model are insignificant at conventional levels of significance.

The antidumping tariff imposed by the U.S. does not have a significant effect on the quantity consumed of the domestically produced crawfish. However, at 10% level of significance, it may have caused increase in the price of domestically produced crawfish by 34%; this effect is not statistically significant at 5% significance level. That might be due to mismeasurement of data or because of the tariff avoidance trials by the Chinese exporters.

Market advertising is a suggested approach to solve the problem of dumping and might be more effective than antidumping tariff.

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Appendix A

Table 1: U.S. production and imports values and value shares

year	U.S production (mill USD)	Total imports (mill USD)	Value shares (%)		
			U.S.	China	ROW
1990	4.07	0.063	98.48	1.02	0.499
1991	6.03	0.238	96.20	3.77	0.028
1992	16.10	1.29	92.60	6.87	0.529
1993	19.99	1.87	91.45	8.32	0.237
1994	29.97	3.75	88.88	11.12	0.000
1995	11.52	9.07	55.95	43.35	0.696
1996	9.94	4.80	67.44	32.54	0.016
1997	12.86	3.61	78.07	21.93	0.000
1998	14.39	9.67	59.81	37.45	2.74
1999	10.48	5.68	64.86	31.09	4.05
2000	0.68	12.03	5.38	70.64	23.99
2001	8.64	45.36	16.00	81.19	2.80
2002	8.07	23.67	25.42	72.13	2.44
2003	4.85	50.15	8.81	89.86	1.33
2004	4.95	39.31	11.18	83.68	5.14
2005	8.46	17.05	33.17	59.64	7.19
2006	1.45	24.56	5.57	85.07	9.36
2007	9.26	42.80	17.79	79.87	2.34
2008	9.71	16.74	36.70	47.81	15.49
2009	15.55	71.91	17.78	71.51	10.71
2010	13.97	85.15	14.09	81.57	4.34
2011	9.91	23.56	29.61	54.73	15.66
2012	5.00	95.11	4.99	86.22	8.79
2013	16.49	90.29	15.44	77.77	6.79
2014	16.09	83.79	16.11	76.56	7.33

Table 2: Summary statistics

Variable	N	Mean	Std Dev	Minimum	Maximum
U.S. consumption of domestically produced crawfish (lbs/person)	25	0.054	0.038	0.001	0.191
U.S. consumption of crawfish imported from China (lbs./person)	25	0.028	0.021	0.00003	0.060
U.S. consumption of crawfish imported form ROW (lbs./person)	25	0.002	0.002	0	0.006
Domestic crawfish price ($/lb)	25	0.788	0.306	0.402	1.74
Chinese crawfish price ($/lb.)	25	3.06	1.21	1.45	5.60
ROW crawfish price ($/lb.)	25	3.31	1.97	0.950	8.07

Table 3: Estimated coefficients of Rotterdam demand system model (1=U.S., 2=China,

3=ROW; t-ratio in parentheses)

Equation	Intercept	$dlnp_1$	$dlnp_2$	$dlnp_3$	DQ_i	T_i	DW
1	0.083	-0.186	0.151	0.035	0.396	-0.149	2.03
	(0.77)	(-1.84)	(1.50)	(1.57)	(3.57)	(-1.22)	
2	-0.070	--	-0.125	-0.025	0.604	0.130	1.98
	(-0.65)		(-1.17)	(-0.90)	(5.38)	(1.06)	
3	-0.013	--	--	-0.010	0.00008	0.019	

System weighted R^2 = 0.978

Table 4: Estimated coefficients of Rotterdam inverse demand system model (1=U.S., 2=China, 3=ROW; t-ratio in parentheses)

Equation	Intercept	$dlnq_1$	$dlnq_2$	$dlnq_3$	DQ_i	T_i	DW
1	-0.135	-0.045	0.057	-0.012	-0.465	0.145	2.62
	(-1.64)	(-1.82)	(2.65)	(-1.75)	(-6.21)	(1.55)	
2	0.129	--	-0.067	0.010	-0.429	-0.156	2.56
	(1.90)		(-3.34)	(1.79)	(-7.04)	(-2.03)	
3	0.006	--	--	0.002	-0.106	0.011	

System weighted $R^2 = 0.97$

Table 5: Estimated compensated and uncompensated elasticities (1=U.S., 2=China, 3=ROW)

| Equation | τ_i | Compensated | | | Uncompensated | | | s_i | η_i^y |
		$\eta_{i,1}^*$	$\eta_{i,2}^*$	$\eta_{i,3}^*$	$\eta_{i,1}$	$\eta_{i,2}$	$\eta_{i,3}$		
1	-0.355	-0.441	0.358	0.083	-0.837	-0.137	0.033	0.421	0.942
2	0.248	0.286	-0.238	-0.048	-0.193	-0.838	-0.108	0.526	1.139
3	0.359	0.659	-0.477	-0.182	0.658	-0.478	-0.182	0.053	0.002

Table 6: Estimated compensated and uncompensated Flexibilities (1=U.S., 2=China, 3=ROW)

| Equation | τ'_i | Compensated | | | Uncompensated | | | s_i | f_i |
		$f^*_{i,1}$	$f^*_{i,2}$	$f^*_{i,3}$	$f_{i,1}$	$f_{i,2}$	$f_{i,3}$		
1	0.344	-0.572	-0.688	-0.166	-1.04	-1.27	-0.224	0.421	-1.10
2	-0.296	-0.235	-0.556	-0.324	-0.578	-0.986	-0.367	0.526	-0.815
3	0.205	-1.07	-0.865	-0.073	-1.91	-1.92	-0.179	0.053	-2.01

Table 7: Description of Variables

Variable	Description	unit
q_i	Consumption per capita of domestic crawfish, imports from China and imports from ROW, i=1,2,3	Lb.
P_i	Nominal price of domestic crawfish, imports from China and imports from ROW, i=1,2,3	U.S dollar/lb.
S_i	Budget share of domestic crawfish, imports from China and imports from ROW, i=1,2,3	
$DQ_{i,t}$	Divisia volume	
T	Dummy variable ,one for years at which tariff are imposed and zero otherwise	

Appendix B:

Rotterdam direct demand system derivation:

Let $\bar{q}_i = q_i(p_1, p_2, \ldots, p_n, y)$ (1)

be the demand equation for good i, $i = 1,2, \ldots, n$. where p_i is the price of good i and $y = \sum_{i=1}^{n} p_i q_i$ is total expenditure. Equation (1) is obtained from maximizing the utility function.

$u(q_1, \ldots, q_{n)}$, subject to the budget constraint $y = \sum_{i=1}^{n} p_i q_i$.

The total differential of equation (1) is:

$$dq_i = \frac{\partial q_i}{\partial p_1} dp_1 + \frac{\partial q_i}{\partial p_2} dp_2 + \cdots + \frac{\partial q_i}{\partial y} dy \qquad (2)$$

By dividing (2) by q_i and scaling the right hand side of the equation, it can be written as:

$$lnq_i = \sum_{j=1}^{n} \eta_{ij} lnp_j + \cdots + \eta_i^y lny \qquad (3)$$

where $\eta_{ij} = \partial lnq_i / \partial lnp_j$ is marshalian price elasticity of demand for good i with respect to good j, $j = 1,2, \ldots, n$. and $\eta_i^y = \partial lnq_i / \partial lny$ is income elasticity of demand for good i.

The first difference of (3) is

$$dlnq_i = \sum_{j=1}^{n} \eta_{ij} dlnp_j + \cdots + \eta_i^y dlny \qquad (4)$$

By substitution Slutsky equation, $\eta_{ij}^* = \eta_{ij} + s_i \eta_i$, where η_{ij}^* is the Hicksian price elasticity of demand and $s_i = \frac{p_i q_i}{y}$ is the budget share of good i, in equation (4):

$$dlnq_i = \sum_{j=1}^{n} \eta_{ij}^* dlnp_j + \cdots + \eta_i^y (dlny - dlnP) \qquad (5)$$

where $dlnP = \sum_{j=1}^{n} p_j$ is the Stone price index.

Multiplying equation (5) by s_i gives:

$$s_i dlnq_i = \sum_{j=1}^{n} s_i \eta_{ij}^* dlnp_j + \cdots + s_i \eta_i^y dln(y/P) \qquad (6)$$

This can be written as:

$$s_i dlnq_i = \sum_{j=1}^{n} \theta_{ij} dlnp_j + \cdots + \theta_i dln(y/P) \qquad (7)$$

where $\theta_{ij} = s_i \eta_{ij}^*$ budget share is weighted hicksisan elasticity and $\theta_i = s_i \eta_i^y$ is budget share weighted income elasticity.

General restrictions:

6- Symmetry: $s_i \eta_{ij}^* = s_i \eta_{ji}^*$, then $\theta_{ij} = \theta_{ji}$.

7- Homogeneity : $\sum_{j=1}^{n} \eta_{ij}^* = 0$,then $\sum_{j=1}^{n} \theta_{ij} = 0$.

8- Cournot: $\sum_{i=1}^{n} \eta_{ij}^* = 0$, then $\sum_{i=1}^{n} \theta_{ij} = 0$.

9- Engle: $\sum_{i=1}^{n} \eta_i^y = 1$, then $\sum_{i=1}^{n} \theta_i = 1$.

Divisia volume index:

By summing up both sides of equation (7) over i:

$$\sum_{i=1}^{n} s_i dlnq_i = \sum_{i=1}^{n} \sum_{j=1}^{n} \theta_{ij} dlnp_j + \cdots + \sum_{i=1}^{n} \theta_i dln\left(\frac{y}{P}\right). \qquad (8)$$

this can be reduced by cournot restriction to:

$$\sum_{i=1}^{n} s_i dlnq_i = \sum_{i=1}^{n} \theta_i dln(y/P) \qquad (9) \text{ This, by Engle}$$

restriction, can be written as

$$\sum_{i=1}^{n} s_i dlnq_i = dln\left(\frac{y}{P}\right) = DQ. \tag{10}$$

Estimation

The final model estimating equation is:

$$\bar{s}_{i,t} dlnq_{i,t} = \sum_{j=1}^{n} \theta_{ij} dlnp_{j,t} + \cdots + \theta_i DQ_{i,t} \qquad i, j=1,2,\ldots,\text{n}.$$

$t=1, 2, \ldots, m.$

where $\quad \bar{s}_{i,t} = (s_{i,t} + s_{i,t-1})/2 \quad , \qquad dlnq_{i,t} = lnq_{i,t} - lnq_{i,t-1}, \quad dlnp_{i,t} = lnp_{i,t} - lnp_{i,t-1},$

and $DQ_{i,t} = \sum_{i=1}^{n} \bar{s}_i dlnq_{i,t}.$

<u>Inverse demand:</u>

The market inverse demand system can be written as follow:

$$p_i = f_i(q_i, y). \tag{1}$$

$i=1, 2, \ldots, n.$

Where p_i is the n-vector of nominal price, q_i is the n-vector of corresponding normalized quantity, and y is the total expenditure on the sub-group of commodities, $y = \bar{q}_i * p_i.$

Since (1) is homogenous of degree one in income (if all prices and income increased by the same amount w, there will be no change in the consumption, it can be written as:

$$f_i(q_i, wy) = wp_i. \tag{2}$$

Letting $w = 1/y$, then equation (1) can be written as:

$$f_i(q_i, 1) = \tilde{f}_i(q) = \frac{p_i}{y} = \pi_i \quad i = 1, 2, \ldots, n \tag{3}$$

where π_i is normalized price.

Quantity Elasticities:

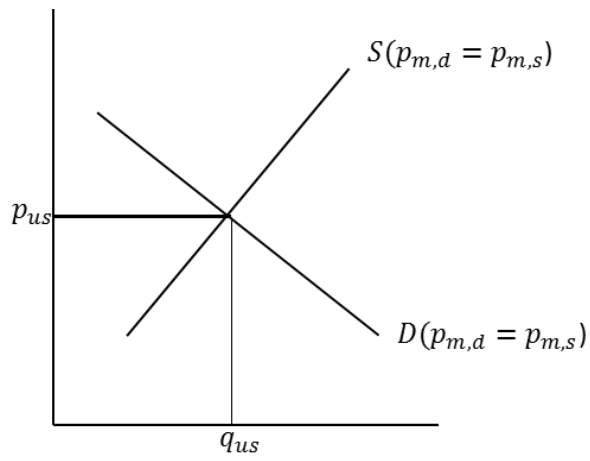Deriving Rotterdam inverse demand equation is analogous to the direct one except for using normalized prices.

$$\bar{s}_i dlnp_i^* = \sum_{j=1}^n \delta_{ij} dlnq_{j,t} + \cdots + \vartheta_i DQ_{i,t} + \emptyset_i T_{i,t}$$

where $\delta_{ij} = F_{ij}^* \bar{s}_i$, F_{ij}^* is the compensated quantity elasticity (flexibility) of good i with respect to good j, $\vartheta_i = F_i \bar{s}_i$ is scale elasticity of good i, $\emptyset_i = \tau'_i \bar{s}_i$, and $\dot{\tau}_i$ is the proportionate effect of antidumping tariff on the price of good i.
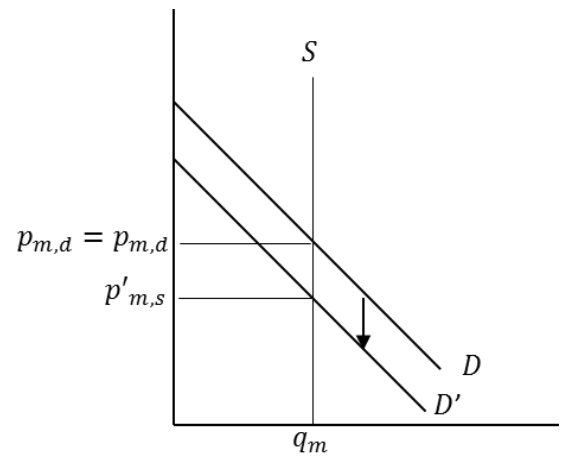
Appendix C:

Domestic Market
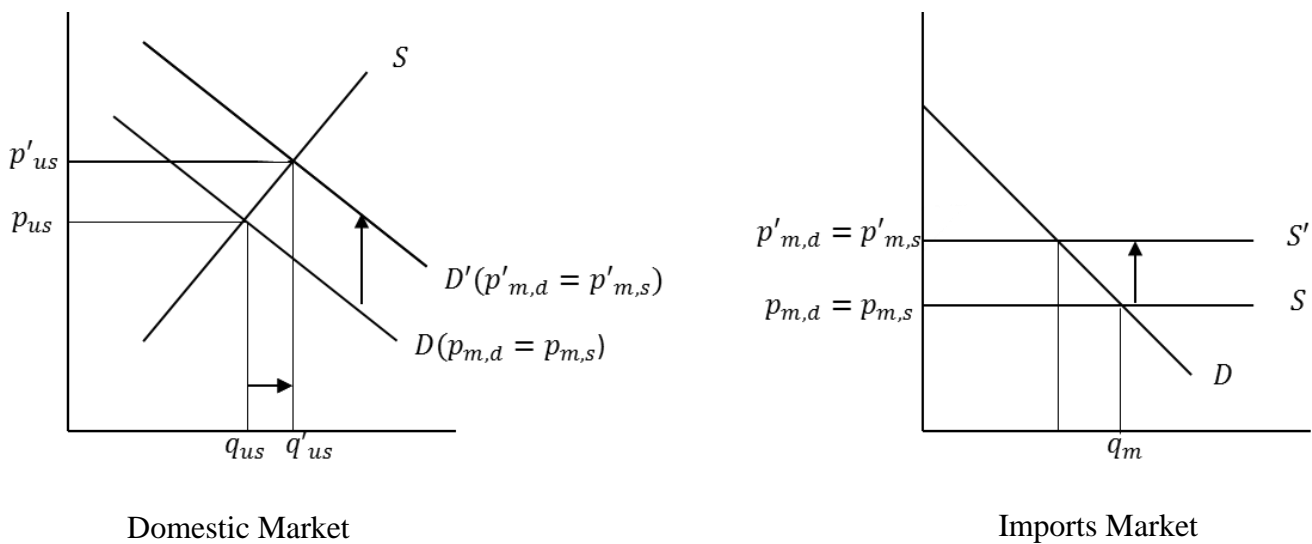
Imports Market

Figure 1. When the supply curve for the duptied product is perfectly elastic the domestic price increases by the full amount of the duty supply curve.

Figure 2. When the import supply curve for the duties product is perfectly inelastic the domestic price is unaffected by the duty