Seafood Import Demand in the Caribbean Region

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Abstract

Cointegration analysis and an Error Correction Model are used to estimate aggregate seafood import demand functions for selected Caribbean countries. The results show that seafood import demand is price elastic. Exchange rate has a negative effect on seafood import quantity. Income and tourist arrivals have positive impacts on seafood imports. Seafood import negatively affects domestic fishery production. Tariff and production support policies reduce seafood imports, and enhance domestic production. Both policies increase producer surplus, but a tariff reduces consumer surplus, and a production expansion policy increases consumer surplus. A production expansion subsidy is a more appropriate policy instrument than a tariff for small open economies, like the Caribbean States, to increase domestic production and generate net economic surplus.

Key words: Seafood, import demand, cointegration, economic surplus

JEL classification: Q17, Q22, C32

Introduction

Caribbean economies are deeply integrated into the global economy and rely heavily on international trade of goods and services for their economic growth and development. Many Caribbean countries depend on imports for food consumption and capital goods (Pollard et al., 2008). The Caribbean region is a net food importer, importing cereals and animal proteins to meet its food demand (McIntyre, 1995). However, recent world food price crises, with international food price index nearly doubling between 2006 and 2008 (World Bank, 2009a), have created uncertainty for regional food security (Caribbean Community Secretariat, 2008). Seafood imports make up a large share of Caribbean seafood consumption and any price changes are bound to affect the economic growth and development of these small nation states and weaken their ability to provide their citizens the animal proteins necessary to maintain a healthy diet. Therefore, it is important to examine the factors influencing seafood import demand, and to evaluate costs and benefits of interventions to promote domestic seafood production in the region.

Caribbean fisheries sector is constituted of traditional artisanal fishers, and more recent fish farmers. Regional fisheries production has been decreasing for the last two decades while seafood imports have increased by 96.4 % during the last 15 years (figure 1). The share of imports in total Caribbean seafood consumption increased from 21% in 1991 to 46% in 2006 (FAO - Food and Agriculture Organization, 2009). The rise of seafood imports can be attributed to several factors, such as increased income, increased tourist revenue, decreased domestic fish production, and increased global integration.

First, inceased income stimulates the demand for seafood imports. Caribbean GDP has been increasing continuously during the last three decades (World Bank, 2009b). Income is a demand shifter, hence higher income increases demand for goods and services. The present study tests the hypothesis that higher income increases the demand for seafood imports in the Caribbean region.

Second, tourist revenue was about U.S.$18.93 billions in 2006, accounting for 24.7 percent of total Caribbean GDP. Tourist revenue has been increasing at a rate of 7.3 percent annually from 1986 to 2006 (Caribbean Tourism Organization, 2009). Tourism affects seafood imports in two ways. Tourists directly increase seafood import demand, and indirecly increase seafood import demand through the enhancement of domestic income and foreign currency earning.

Third, the decrease in domestic fishery production can trigger the rise in seafood imports in the Caribbean. Domestic seafood production in the Caribbean decreased almost 50 percent from 327,091 tons in 1986 to 165,787 tons in 2006 (FAO, 2009). The Caribbean region includes many cultural and institutional diversed small nation states, and it is difficult to initiate a cordinated fishery development plan. The regional governments focus more on tourism development than on agriculture and fishery. As a result, domestic fishery production is declining due to few ongoing fishery investments and increasing competetion for water use for tourism. The present study tests the causal relationship between seafood imports and domestic fish production.

Finally, seafood imports have been increasing with Caribbean states integration into the global economy. The Caribbean states are open economies with an average trade-to-GDP ratio of more than 115 percent in 2002 (Pollard et al., 2008). Trade liberalization was promoted in the region during 1980s as a condition for receiving structural adjustment loans from the World Bank. Since late 1980s, Caribbean countries have also participated in Uruguay Round of negotiations and committed to lower tariffs of their agricultural imports. The outcome of trade liberalization in the Caribbean region is the increase in agricultural imports, and decrease in traditional agricultural exports (Ford and Rawlins, 2007). Hence trade liberalizetion does not necessarily increase food security in the Caribbean.

The present study has three objectives: (1) to examine the effects of import prices, income, tourism, and trade policies on Caribbean seafood import demand; (2) to test the causal relationship between domestic seafood production and imports; and (3) to analyize the effetcs of policy interventions to reduce imports, and increase domestic production on economic surplus. The paper is organized with the following sections: Caribbean seafood imports; theoretical import demand model, empirical method and estimation, policy discussion, welfare analysis, and conclusion.

Caribbean Seafood Imports

Caribbean countries imported an average of 126,398.5 tons of seafood per year, equal to $U.S. 196.32 million per year during the period 1976 to 2006 (FAO, 2009). Seafood imports to the Caribbean include categories, such as fin fish, crustacean and mollusk, fish meal, and other fish products. Imports of fresh and frozen fish, crustacean and mollusk are increasing the fastest, while import of fish meal is declining rapidly. Seafood imports can be classified into high-valued and low-valued groups. High-valued seafood include crustacean and mollusk, with average unit value of $U.S. 5.19 per kilogram, accounting for about 3% of total seafood import volume, and about 10% of total seafood import value. Low-valued seafood products include fin fish, fish meal and other fishery products, with average unit value of U.S. $1.45 per kilogram, accounting for 97% of total imports, and 90% of total import value. Imports of high-valued products have been increasing faster than low-valued products, 595 percent and 11 percent for high- and low-valued products, respectively, between 1976 and 2006 (FAO 2009). Seafood import price is increasing in nominal term, but the real price decreased during the study period. Seafood import has been increasing faster in the group of countries with tourist revenue accounting for more than 20 percent of their total GDP (FAO, 2009).

Import Demand Model

The "imperfect substitute" approach to international trade is widely used to estimate aggregate import demand. The key assumption is that imported goods are not perfect substitutes for domestic goods. Murray and Ginman (1976) argued that estimation of traditional import demand has an identification problem that can be solved by assuming infinite world supply elasticity. Recent empirical studies on import demand found in Tveteras and Asche (2008), Erkel-Rousse and Mirza (2002), Pattichis (1999), Sawyer and Sprinkle (1996), Ligeon et al. (1996). Erkel-Rousse and Mirza (2002) suggest that most import price elasticities are underestimated due to misspecification and measurement error when using import unit value for import price. Tveteras and Asche (2008) addressed the issue of exchange rate pass-through in commodity markets, using multivariate cointegration framework. Pattichis (1999) analyzed the import demand of maize, milk powder, butter, and rice in Cyprus, using cointegration time-series technique and unrestricted error correction model (ECM). Sawyer and Sprinkle (1996) found that import demand models have been always estimated with a ratio of import price over domestic price. The price ratio helps to avoid multicollinearity. However, the price ratio specification assumes that import demand function is homogenous in prices, or coefficients of import price and domestic price must be the same in magnitude and opposite in sign. Ligeon et al. (1996) assess catfish import into the U.S. with a traditional import demand function using a ratio of imports over domestic production as the dependent variable.

The motivation of international trade is to seek economic efficiency through specialization and division of labor. People trade goods and services because they face different relative prices for the same goods and services. There are many factors determining relative prices, such as, resource endowment and factor productivity, market structure, exchange rate, and trade barriers. However, relative import price can be used to explain the above factors. Import demand is part of the total demand, and equal to domestic demand minus domestic supply. Hence, the dynamics of import demand depend on the dynamics of domestic demand and domestic supply. The import demand function is defined as:

$$M(P) = D(P, Y(P)) - S(P) = M(P, Y) \quad (1)$$

where, M is import quantity, D is domestic demand, S is domestic production, Y is domestic real income, and P is product price. Expected effect of price (P) on import quantity is negative, $\partial M/\partial P = \partial D/\partial P + (\partial D/\partial Y) * (\partial Y/\partial P) - \partial S/\partial P < 0$. Since, $\partial D/\partial P < 0$, price increases lower quantity demanded; $\partial D/\partial Y > 0$, income increase results in an increase in demand, and $\partial Y/\partial P < 0$, higher prices make consumers poorer, hence $(\partial D/\partial Y)*(\partial Y/\partial P) < 0$; the third term is the supply relationship $\partial S/\partial P > 0$, hence $- \partial S/\partial P < 0$. The expected effect of income (Y) on import quantity (M) is positive, if import is a normal good, $\partial M/\partial Y = \partial D/\partial Y > 0$, and negative if import is an inferior good, $\partial M/\partial Y = \partial D/\partial Y < 0$. However, the "imperfect substitution" trade theory rules out the case of inferior good imports, and the expected sign of income effect on import should be positive (Narayan and Narayan, 2005). Following Khan and Ross (1977), the import demand equation is linearized as such:

$$M^*_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + \varepsilon_t \qquad (2)$$

where, M^*_t is market equilibrium import quantity at time t. Whenever there are shocks in the market, imports will adjust toward the equilibrium quantity (M^*_t). However, there are costs involved in the adjustment from actual import quantity (M_t) to the desired equilibrium quantity (M^*_t). In addition, importation of goods requires time to make contracts, to produce goods, to transport products, and to deliver the imports to consumers. Hence, imports have a delayed responsiveness to any market changes. Khan and Ross (1977) proposed a partial adjustment import demand model in which the change of imports at time t (ΔM_t) is related to the difference between equilibrium demand for import at time t (M^*_t) and actual imports at time t-1 (M_{t-1}):

$$\Delta M_t = \gamma \, (M^*_t - M_{t-1}) \qquad (3)$$

where, $\Delta M_t = M_t - M_{t-1}$, γ is the coefficient of adjustment ($0 \leq \gamma \leq 1$). Substitute (2) into (3), and solve for M_t to obtain:

$$M_t = \gamma\alpha_0 + \gamma\alpha_1 P_t + \gamma\alpha_2 Y_t + (1-\gamma) M_{t-1} + \gamma\varepsilon_t \qquad (4)$$

The equation (4) is a 'dynamic' import demand function. The empirical estimation of (4) can be in linear or log-linear specification, and determined by Box-Cox test for functional form. Previous empirical estimations of import demand often used relative price. The relative price is the ratio of import price in domestic currency over prices of domestically produced goods and services. The specification conforms to the neoclassical trade theory of comparative advantage. Since, import price is not available, the current study uses import unit value. The empirical import demand model is:

$$M_t = M\left(\frac{e * P_{im}^{usd}}{P_d}, M_{t-1}, Y_t\right) \qquad (5)$$

where, P_{im}^{usd} is import unit value in U.S. dollars. Exchange rate (e) is introduced to transform import unit value into local currency. The exchange rate is the price of foreign currency ($*) in terms of domestic currency ($), $e = \$/\$^*$. Therefore, local currency is equal to exchange rate times foreign currency, $ = e$*. Seafood import price can be expressed in domestic currency as $e * P_{im}^{usd}$. P_d is price level of domestic goods and services. The measurements of P_d vary across studies. Legion et al. (1996) used domestic catfish price for P_d in an estimation of catfish import demand; Narayan and Narayan (2005) used price of domestic goods and service for P_d. In this study, consumer price index (CPI) is used for P_d to represent domestic price level of goods and services. The empirical import demand equation is specified as:

$$\log(M_t) = a_0 + a_1*\log(P^{usd}_{im\ t}/CPI_t) + a_2*\log(e_t) + a_3*\log(M_{t-1}) + a_4*\log(Y_t) + u_t \quad (6)$$

The sign of the parameter a_1 is expected to be negative, according to demand theory. The parameter a_2 is expected to be negative because an increase in exchange rate, equivalent to a depreciation of domestic currency, makes imports more expensive to domestic buyers, and lowers imports. The parameter a_3 should be positive and smaller than 1, since $a_3 = 1 - \gamma$, where $0 < \gamma < 1$. The parameter a_4 is expected to be positive, as discussed above. The error term (u_t) is white noise.

Tourism's Effects

Tourism is an important economic sector in the Caribbean. Discussion of the linkage between tourism and agriculture are found in Momsen (1998) and Torres (2003). The potential effects of tourism on seafood import can be determined in several ways. First, tourism itself can increase demand for seafood imports, since tourist arrivals generates further demand for goods and services, such as hotel, transportation, food as well as seafood products. Second, a rise in tourist arrivals may increase income of local people, and in turn, stimulates demand for imported seafood. Third, tourism brings more foreign currency into local economies, causes an appreciation of the domestic currency, and encourages imports. An empirical model can be designed to test different effects of tourism on seafood imports:

$$\log(M_t) = a_0 + a_1*\log(P^{usd}_{im\ t}/CPI_t) + a_2*\log(e_t) + a_3*\log(M_{t-1}) + a_4*\log(Y_t) +$$

$$a_5*\log(Tour_t) + u_t \quad (7)$$

The expected sign of parameters a_5 is positive. In summary, tourism by all means will have a positive effect on seafood imports.

Domestic Production versus Imports

In a partial equilibrium trade model, import is equal to domestic demand minus domestic supply. Therefore, import and domestic production have a direct, negative relationship. A concern of the present study is the causal direction in the relationship between seafood imports and domestic fish production.

Caribbean seafood imports increased in the last 15 years (FAO, 2009). The expansion of seafood imports can be explained by three different market forces. The first market force can be an increase in domestic demand. The increase in domestic demand shifts the excess demand curve outward. Higher excess demand will cause import volume and import price to increase. In this case, domestic demand and domestic supply will both increase. The second market force of an increase in seafood imports can be a decrease of domestic supply. Inward shift of domestic supply curve shifts the excess demand curve outward. As a result, import volume and import price will both increase. Domestic quantity and domestic supply both will decrease. The third market force of an increase in seafood import can be an increase of world supply, equaling to a shift out of excess supply.

In this case, import volume increases, import price decreases, domestic demand increases and domestic supply decreases.

Domestic fishery production in the Caribbean has been decreasing in the last two decades (FAO 2009). Decreasing domestic fish production can be a result of over exploitation, resource depletion, poor investment and management of fishery resources, and competition for resources and water use from tourism. One opposing argument is that the reduction in domestic production is the reason causing seafood imports to increase. A seafood import demand function with domestic production as an independent variable can be employed to test the relationship between imports and domestic production.

$$\log(M_t) = a_0 + a_1*\log(P^{usd}_{im\ t}/CPI_t) + a_2*\log(e_t) + a_3*\log(M_{t-1}) + a_4*\log(Y_t) + a_5*\log(Tour_t) + a_6*\log(Q_d) + u_t \qquad (8)$$

The expected sign of a_6 is negative. The causality test will be employed to confirm a hypothesis that the behavior of domestic production series can explain the behavior of seafood import series, and vice versa.

In addition, relationship between domestic production and import can be examined when investigating the relationship between domestic production and import price. If import is a substitute for domestically produced product, import price will positively affect domestic production. In other words, there should be a long-term equilibrium relationship between domestic production and import price.

Data and Variable

Data for seafood import volumes, and values into Caribbean countries were collected from FAO Fishstat Database (FAO, 2009). Data on GDP and population were collected from World Development Indicator (WDI) database (World Bank, 2009). Data on CPI and exchange rates were collected from the International Financial Service (IFS) database (IMF, 2009). Data on domestic fishery production (Q_d) were from FAO Fishstat Database (FAO, 2009). Data on tourism arrivals to Caribbean countries were collected from the Caribbean Tourism Organization's database. Caribbean countries covered in the present study are Aruba, Antigua and Barbuda, Bahamas, Barbados, Cayman Islands, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Netherlands Antilles, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Virgin Islands (U.S.). All data are available in annual basis for the study period of 1976 to 2006, and the summary of the variables are presented in table 1.

Empirical Analysis

A time series variable is stationary when its stochastic properties, such as mean, variance and covariance between its observations, are invariant with respect to time (Kennedy, 2008). It is well known that ordinary least squares (OLS) method using nonstationry time-series data produces spurious regressions (Granger and Newbold, 1974). Granger (1981), Engle and Granger (1987) introduced the concept of cointegration, and a method to estimate economic models with cointegrated nonstationary time-series data. If a group of economic time series data have an equilibrium or economic relationship, they can not move independently from each other (Ender, 2004); in other words, those economic time series should be cointegrated. Engle and Granger (1987) proved that a group of time-series variables are cointegrated when (i) all the variables are integrated to the same oder d; and (ii) there exists at least one linear combination of variables that is integrated to the order d-b, where b > 0. The cointegration method allows us to find the long-term equilibrium relationship among nonstationary economic variables. In the short-term, any diviation from the equilibrium will die out gradually. The error-correction model estimates short-term dynamics of variables that are influenced by deviations from the long-run equilibrium in previous periods (Engle and Granger, 1987).

Unit-root Tests

A time-series variable is integrated to the order d when its d^{th} difference is stationary. In economics, most macroeconomic variables are integrated to the order 1. Therefore, the present study employs Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) to check first difference stationary, or unit root, among investigated time series variables. The general form of ADF test is:

$$\Delta y_t = a_0 + \gamma y_{t-1} + \sum_{i=2} \beta_i \Delta y_{t-i+1} + a_1 t + \varepsilon_t \qquad (9)$$

We first check the null hypotheis of $\gamma = 0$, using critical value of tau (τ_τ) = - 3.60 at sample size = 25. Then we test another null hypothesis of $a_0 = \gamma = a_1 = 0$, using the critical value of phi (Φ_2) = 5.68. If we fail to reject both null hypotheses above, the series (y_t) has unit root. The results are presented in table 2, showing that all variables have unit root. Since all variables are integrated to the same order 1, we can conduct a cointegration test, then estimate the long-term equilibrium relationship among the variables.

Cointegration Test and Long-term Equilibrium

Engle and Granger (1987) have proposed a two-step method to test cointegration in a single-equation model. The basic of Engle-Granger method is based on testing for unit root in cointegrating regression residuals. However, there are some limitations to the Engle-Granger method. First, OLS method for cointegrating regression requires us to choose a regressand among the variables, the estimation of cointegrating parameters is sensitive to the choice of the regressand. Second, when there are more than two variables, the number of cointegrating relationships can be more than one, which the OLS method for cointegrating regression will not be able to estimate all these relationships, and can produce inconsistent estimates of these multiple sets of cointegrating parameters (Kennedy, 2004). In dealing with the above issues in Engle-Granger method, Johansen (1988) has developed a method to test cointegration in multiple-equation models. The Johansen method views all variables as being endogenous, and forming a vector autoregressive (VAR) equation to test for cointegration. The Johansen cointegration test is developed from a vector autoregressive model:

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} + A_3 Z_{t-3} + \dots + A_m Z_{t-m} + \varepsilon_t \qquad (10)$$

Substacting each side of (9) by Z_{t-1} and going through a series of manipulationa to obtain:

$$\Delta Z_t = \Pi\, Z_{t-1} + \sum_{i=1}^{m-1} \Gamma_i\, \Delta Z_{t-i} + \varepsilon_t \qquad (11)$$

where:

$$\Pi = - I + A_1 + A_2 + \ldots + A_m$$

$$\Gamma_i = - \sum_{j=i+1}^{m} A_j$$

The rank of a matrix is the number of its characteristic roots that differ from zero. Therefore, the rank of matrix Π is equal to the number of independent cointegrating vectors of Z variables. Johansen and Juselius (1990) developed a maximum likelihood method to test the number of estimated cointegrating vectors and to estimate those cointegrating vectors. However, multiple cointegrating vectors cause difficulties to identify the true economic equilibrium relationship among variables. More than one cointegrating relationship does not mean that there is more than one long-term equilibrium position, but meaning that there are several sector equilibria in a long-run equilibrium (Kennedy, 2004). Researchers often deal with multiple cointegrating vectors by ignoring those vectors that have no economic meaning.

The results of cointegration test for Caribbean seafood import demand model are presented in table 3. The cointegration rank test starts with null hypothesis of r = 0. Trace statistic rejects the null hypothesis because computed trace statistic of 100.57 is greater than the critical value of 93.92. The second step involves a null hypothesis of r = 1 but the trace test fails to reject the null hypothesis since computed statistics (65.35) is smaller than the critical value (68.68). Therefore, there exists only one cointegrating relationship among variables. The most theoretically sound long-term cointegrating vector is presented in table 4. The long-term equilibrium relatioship among the variable conforms to the theoritical import demand model. Seafood import negatively affects import quantity. A one percent increase in import price will cause import quantity to reduce by 1.72 percent in the long-term. Exchange rate has a negative effect on seafood import as expected. A one percent increase in exchange rate will cause 1.55 percent decrease in seafood imports. Doemstic production has a negative relationship with import quantities. Both income and toursist arrivals have positive effects on seafood imports. Seafood import is income inelastic, 0.22, or seafood import is a normal good. Tourism plays a significant role in seafood importation. A one percent increase in tourist arrivals increases seafood imports by 1.17 percent.

Error-correction Model and Short-term Dynamics

Error correction mechanisms have been used widely in economics. Some early studies on error correction mechanism can be found in Sargan (1964) and Phillips (1957) (Engle and Granger, 1987). The main idea of the error correction mechanism is that a proportion of disequilibrium from one period is corrected in the next period. The general form of an ECM model is:

$$\Delta x_t = \pi_0 + \pi\ x_{t-1} + \pi_1\ \Delta x_t + \pi_2\ \Delta x_{t-1} + \ldots + \pi_P\ \Delta x_{t-P} + \varepsilon_t \qquad (12)$$

where, $x_t = (x_{1t}, x_{2t}, x_{3t}, \ldots x_{nt})$, Δ is the difference operator, π_0 is a vector of intercepts, π is error correction (n x n) maxtrix, π_i is the coefficient (n x n) matrix. The estimate of error-correction model is presented in table 5. The results show that short-run dynamics of all investigating variables are exemplifying import demand theory. Import price negatively affects import quantity demanded. Import demand elasticity is 1.25 in the short-term. The effect of exchange rate in the short-term is smaller than that in the long-term. A one percent increase in exchange rate causes Caribbean seafood imports to decrease by 0.71 percent in short-run and 1.55 percent in the long-run. Domestic production has a negative impact on import. If domestic production increases by one percent, import quantity will decrease by 0.32 percent in the short-run, and 0.83 in long-run. Income and the number of tourist arrivals do not have significant effects on seafood import in the short-term.

Effect of Import on Domestic Production

The results in previous sessions show a negative relationship between domestic production and seafood imports. We suspect a causal relationship between imports and domestic production. The hypothesis is that increasing seafood imports into the Caribbean region is a reason for the decreased production. The data on seafood imports show that real seafood import price was decreasing over the study period, at the same time, seafood import volume was increasing. The data suggest that there is an outward shift in seafood world supply to the Caribbean (figure 2), which causes import price and domestic production to decrease. Granger causality tests confirm that seafood import has a causal effect to domestic production.

Import price should have a positive relationship with domestic seafood production. In partial equilibrium trade models, import is a substitute for domestic production. A higher import price lowers seafood import quantity demanded, and stimulates domestic production. In the theory of the firm and the law of one price, import price is assumed to equal to domestic product price. CPI is proxy for input price level. Profit maximizing firms will end up with a supply function which has a positive relationship with product price and negative relationship with input price. The estimate of domestic seafood supply elasticity is 0.463 (table 6). In conclusion, the present study confirms that imports and domestic production have a negative relationship, and seafood import expansion causes domestic production to decrease.

Policy Discussion and Welfare Analysis

Seafood imports increase the dependence of Caribbean region on foreign fish production. On average, the region spends about $U.S. 196.3 million per year on seafood imports. In addition, seafood imports compete with and take over the market of domestically produced seafood. The Caribbean needs to promote its fishery sector to reduce levels of imports, minimize market risks and enhance its food security. There are two possible policies to promote domestic fisheries, such as import restriction and domestic production support. The first option relates to trade policies such as exchange rate manipulation, tariff and non-tariff trade barriers. The second policy option relates to production expansion policies, such as extension services and information diffusion, credit and input subsidy programs. The partial equilibrium trade model allows us to analyze the welfare changes of each policy option mentioned above. With the use of a partial equilibrium displacement model we evaluate the effects of directed policies on the Caribbean fisheries sector. The structural equations in the partial equilibrium trade model are generalized as:

$$D^* = -\eta_d P_d^* \quad \text{(Domestic demand)} \qquad (13)$$

$$S^* = \varepsilon_d P_d^* + \varepsilon_a A^* \quad \text{(Domestic supply)} \tag{14}$$

$$M^* = \varepsilon_m P_m^* \quad \text{(World supply)} \tag{15}$$

$$P_d^* = P_m^* + t^* \quad \text{(Prices equation)} \tag{16}$$

$$D^* = k_d S^* + k_m M^* \quad \text{(Partial equilibrium of trade)} \tag{17}$$

where, (*) is the symbol for percentage change of the variables, D is domestic demand, S is domestic supply, P_d is domestic price, M is import, P_m is import price, A is a supply shifter, variable t is import tariff, k_d is the share of domestic supply in total consumption, and K_m is the share of imports in total consumption. To substitute D* from (13) and S* from (14) into (17) yields:

$$-\eta_d P_d^* = k_d (\varepsilon_d P_d^* + \varepsilon_a A^*) + k_m M^* \tag{18}$$

We can specify import demand function as $M^* = - \eta_m P_m^* = - \eta_m (P_d^* - t^*)$ where η_m is import demand elasticity. The equation (18) can be transformed to:

$$-\eta_d P_d^* = k_d (\varepsilon_d P_d^* + \varepsilon_a A^*) - k_m \eta_m (P_d^* - t^*) \tag{19}$$

Domestic demand elasticity (η_d) is not estimated directly in the present study, but it can be derived from (19) as:

$$\eta_d = (- k_d \varepsilon_d + k_m \eta_m) - \varepsilon_a A^*/P_d^* - k_m \eta_m t^*/P_d^* \tag{20}$$

Technology (A) and tariff (t) are exogenous factors in the system from (13) through (17). Price changes do not affect supply shifter and tariff, $\partial A/\partial P_d = 0$ and $\partial t/\partial P_d = 0$. Therefore, the terms $A^*/P_d^* = (\partial A/\partial P_d)^*(P_d/A)$ and $t^*/P_d^* = (\partial t/\partial P_d)^*(P_d/t)$ are equal to zero. So, domestic demand elasticity is:

$$\eta_d = - k_d \varepsilon_d + k_m \eta_m \tag{21}$$

Form previous sections, $\eta_m = 1.72$, $\varepsilon_d = 0.463$, $k_d = 0.661$, $k_m = 0.339$, hence η_d is 0.277. The supply shifter elasticity (ε_a) is assumed to be equal to 1.0 for convenience in simulation. The world seafood supply elasticity (ε_m) is assumed to be infinity, since Caribbean countries are small, open economies.

The average import tariff on seafood product to the Caribbean region is 35 percent (Ford and Rawlins, 2007). The effects of a tariff are described in the figure 3. A tariff increase is equal to an upward, vertical shift up of the excess supply curve. The predicted effects are domestic price increasing, import price decreasing, domestic production increasing, domestic demand and import decreasing. The changes in economics surplus of producers and consumers are computed as:

$$\Delta PS = P_d S_0 P_d^* (1 + S^*/2)$$

$$\Delta CS = - P_d D_0 P_d^* (1 + D^*/2)$$

where, ΔPS and ΔCS are the changes of producers' surplus and consumers' surplus; S_0 is initial supply quantity, assumed equal to average domestic production, 246,615.1 tons; P_d^* is percentage change in domestic price; S^* is percentage change in domestic supply; D^* is percentage change in domestic demand. The effects of a tariff increase of one percent are simulated in two scenarios, $\varepsilon_m = 2$, and ε_m = infinity (table 8). In case of $\varepsilon_m = 2$, a one percent increase in tariff (t) will cause 0.54 percent increase in domestic price and 0.46 percent decrease in import price. Producer surplus increases by $U.S. 2.06 million a year. Consumer surplus decreases by $U.S. 3.11 million a year. Hence, total surplus decreases by $U.S. 1.05 million per annum. In case of ε_m = infinity, a tariff generates more producer surplus, $U.S. 3.84 million a year, but also greater loss of consumer surplus, $U.S. 5.78 million a year. Total surplus decreases $U.S. 1.95 a year.

The effects of supply expansion are described in figure 4. An outward shift of domestic supply cause the excess demand to shift to the left. The excess demand inward shift will reduce import price and import quantity. Domestic price is also decreasing. Lower domestic price causes seafood demand to increase. The changes in economic surplus of producers and consumers are computed as:

$$\Delta PS = P_d\, S\, (P_d^* - V_d^*)\, (1 + S^*/2), \text{ where } V_d^* = - \varepsilon_a^* A/\varepsilon_d$$

$$\Delta CS = - P_d\, P_d^*\, D\, (1 + D^*/2)$$

The effects of a one percent increase in domestic supply, for both scenarios of $\varepsilon_m = 2$ and ε_m = infinity, are presented in table 8. Domestic supply expansion generates higher welfare to producers and consumers, and helps Caribbean countries to save foreign exchange from the purchase of imports. Total economic surplus of a one percent increase in domestic supply is $U.S. 9.31 million a year and $U.S. 8.29 million a year when $\varepsilon_m = 2$, and ε_m = infinity.

Conclusion

The present study has largely accomplished its objectives: (1) to estimate the Caribbean seafood import demand, and to explore factors influencing seafood imports; (2) to examine the causal relationship between seafood imports and domestic seafood production; (3) to analyze economic surplus of optional policies to reduce import and to promote domestic seafood production.

First, seafood import demand function is successfully estimated for the Caribbean market. Seafood import demand elasticity is 1.72. Exchange rates have negative effects on seafood imports, a one percent increase in exchange rate causes 1.55 percent decrease in seafood imports. Income has positive effect on seafood import demand, a one percent income increase cause 0.22 percent seafood import increase. Tourist arrivals have positive effects on seafood imports; a one percent increase in tourist arrivals causes a 1.17 percent increase in seafood imports. Import price is the major factor affecting seafood imports. Second, there is a negative relationship between seafood imports and domestic production. Seafood imports have a significant negative effect on domestic production, transmitted through import price. The study suggests an outward shift of world seafood supply in the Caribbean region. The shift causes import price to decrease, and domestic seafood production to decrease as well. Finally, economic surplus of a tariff and a supply expansion policy have been simulated. Both policies reduce import and enhance domestic production. Both policies increase producers' surplus, but tariff policy reduces consumer surplus, and supply expansion increase consumer surplus. Small open economies, like the Caribbean States, must be selective in the adoption of policy instruments to stimulate domestic production. A production expansion policy is more appropriate and effective than a tariff in expanding production and net economic surplus. However, a production expansion subsidy must be financed from local government funds which are not always available.

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Table 1. Variable description

Variables	Unit	Mean	Minimum	Maximum
Import (Q_{im})	tons	126,398.50	73,440.00	18,9277.00
Import price (P_{im})	$US/kg	1.55	0.82	2.43
Domestic Production (Q_d)	tons	24,6615.10	15,6648.00	32,7091.30
Consumer price index (CPI)	index	58.67	21.06	117.98
Exchange rate (e)	$/$*	83.08	37.50	176.75
GDP	million $US	165,329.20	43,044.16	511,222.00
Tourist arrival (Tour)	million	13.48	5.80	23.17

Table 2. Augmented Dickey-Fuller Test for Unit Roots

Variables	τ	Pr < τ	Φ	Pr > Φ	Conclusion
$\log(Q_{im})$	-2.28	0.4298	2.64	0.6598	I(1)
$\log(P_{im}/CPI)$	-2.86	0.1890	4.09	0.3859	I(1)
log(e)	-2.42	0.3625	3.38	0.5204	I(1)
log(GDP)	-0.72	0.9622	1.78	0.8224	I(1)
log(Tour)	-1.72	0.7146	1.61	0.8544	I(1)
$\log(Q_d)$	-1.37	0.8476	2.14	0.7549	I(1)

Notes: (i) Unit root tests were performed using Proc ARIMA in SAS 9.1; (ii) 95% critical of τ = - 3.60; (iii) 95% critical value of Φ = 5.68.

Table 3. Cointegration Rank Test

H0: Rank = r	H1: Rank > r	Eigen-value	λ_{Trace}	5% Critical Value
0	0	0.69	100.57	93.92
1	1	0.54	65.36	68.68
2	2	0.40	41.87	47.21
3	3	0.33	26.44	29.38
4	4	0.26	14.45	15.34
5	5	0.16	5.25	3.84

Notes: Cointegration rank test were performed using Proc VARMAX in SAS 9.1

Table 4. Estimates of long-run cointegrating relationship of import demand model

Variables	Cointegrating vector
$\log(Q_{im})_t$	1.00
$\log(P_{im}/CPI)_t$	1.72
$\log(e)_t$	1.55
$\log(Q_d)_t$	0.83
$\log(GDP)_t$	-0.22
$\log(Tour)_t$	-1.17
Constant	-17.09

Notes: (i)Long-term cointegrating relationship is estimated using Proc VARMAX in SAS 9.1; (ii) Using lag oder (P) = 1 in the estimation of cointegrating vector.

Table 5. Estimates of Error-correction Model

Parameter	Estimate	t Value	Pr > |t|
$\Delta\log(P_{im}/CPI)_t$	-1.246***	-5.53	<.0001
$\Delta\log(e)_t$	-0.713	-1.61	0.1207
$\Delta\log(Q_d)_t$	-0.321	-1.10	0.2824
$\Delta\log(GDP)_t$	-0.078	-0.40	0.6954
$\Delta\log(Tour)_t$	-0.294	-0.67	0.507
μ^s_{t-1}	-0.477**	-2.37	0.0264
DW	1.99		

Notes: (i) Error-correction term, $\mu^s_{t,}$ is computed using cointegrating vecctor; (ii) ECM model relationship is estimated using Proc MODEL in SAS 9.1; (iii) * significant at 10%, ** significant at 5%, *** significant at 1%.

Table 6. Estimaltion of Domestic Supply Fucntion

Parameter	Estimate	t-value
intercept	14.156	33.29
$\log(P_{im})$	0.463**	2.37
log(CPI)	-0.489***	-3.92
R^2-adjusted	0.424	
F-value	12.07	
DW	0.736	

Note: * significant at 10%, ** significant at 5%, *** significant at 1%.

Table 7. Estimated parameter in partial trade model

Parameters	Description	Value	Note
η_d	Domestic demand elasticity	0.28	estimated
ε_d	Domestic supply elasticity	0.46	estimated
ε_a	Domestic supply shifter elasticity	1.00	assumed
η_m	Import demand elasticity	1.72	estimated
ε_m	World supply elasticity	2 or $+\infty$	simulated
k_d	Share of domestic production	0.662	estimated
k_m	Share of import volume	0.338	estimated

Table 8. Welfare Analysis of Tariff and Supply Expansion Policies

Variables	Unit	Tariff		Supply expansion	
		$\varepsilon_m = 2$	$\varepsilon_m = +\infty$	$\varepsilon_m = 2$	$\varepsilon_m = +\infty$
P_d*	%	0.538	1.000	-0.524	0.000
P_m*	%	-0.462	0.000	-0.524	0.000
D*	%	-0.149	-0.277	0.145	0.000
S*	%	0.249	0.463	0.757	1.000
M*	%	-0.925	-1.720	-1.048	-1.950
ΔPS	1000 $US/year	2061.67	3838.80	6272.32	8291.14
ΔCS	1000 $US/year	-3112.14	-5784.88	3038.58	0.00
ΔTS	1000 $US/year	-1050.48	-1946.08	9310.89	8291.14

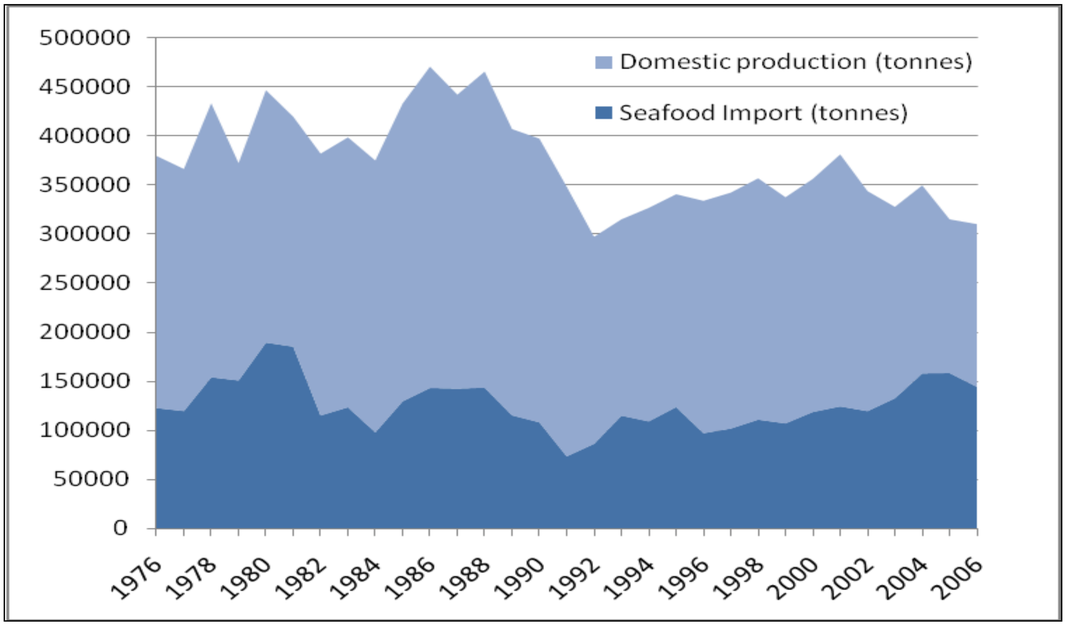

Figure 1. Seafood Import vs. Domestic Production

Source: FAO Fishstat Plus Database, 2009

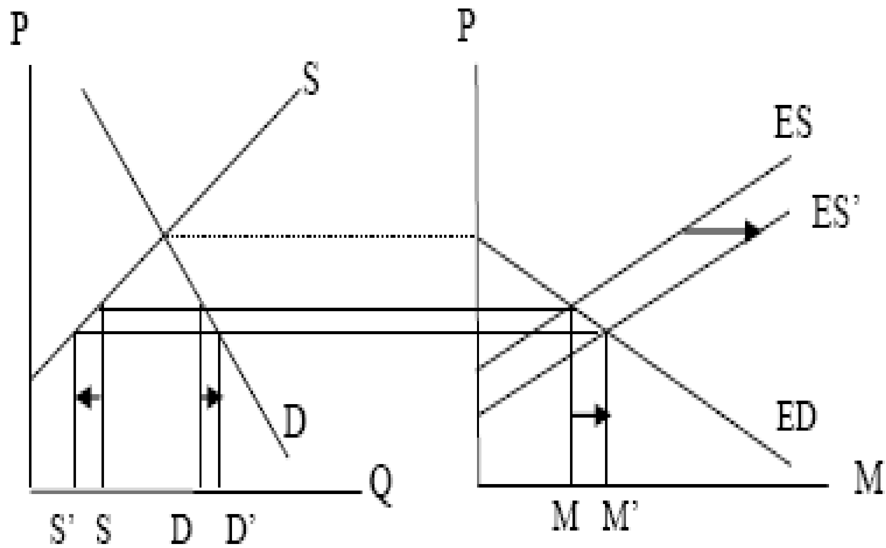

Figure 2. Partial Equilibrium Trade Model

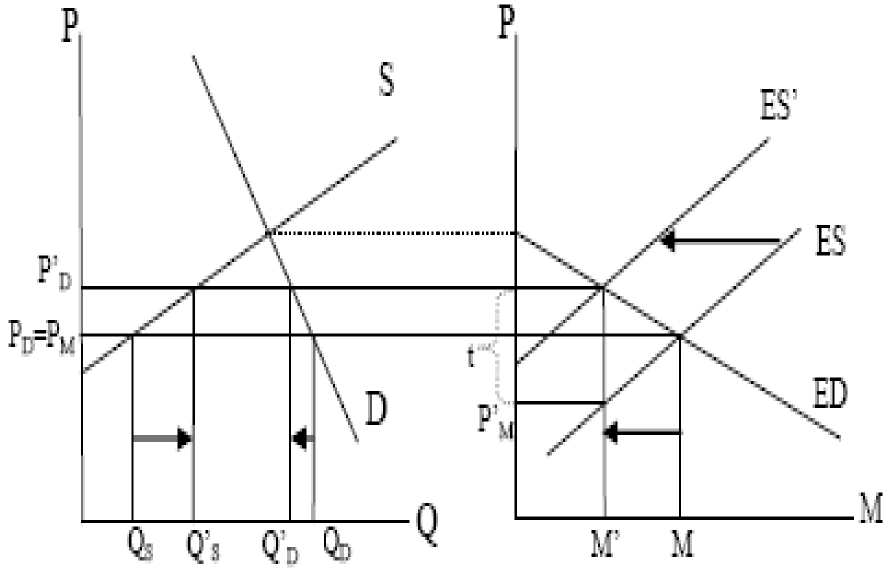

Figure 3. Partial Equilibrium Trade Model with a Tariff's Effects

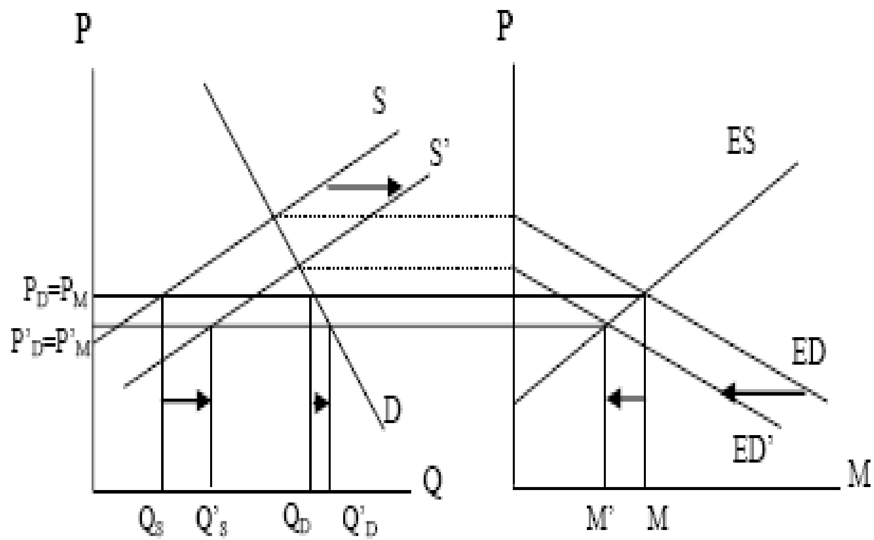

Figure 4. Partial Equilibrium Trade Model with a Supply Expansion's Effects