Three Essays on Applied International Trade Analysis

by

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A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirement for the Degree of
Doctor of Philosophy

Auburn, Alabama
August 6, 2016

Keywords: fish, supply, demand, trade, price transmission,
incidence, and welfare

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Abstract

This research which addresses factors that impact the global fish market in terms of price and trade flows is presented through three chapters. The first chapter determines the effects of income and population growth on the world fish price and on welfare in net exporting and net importing regions by using the excess demand-supply model. The simulation results suggest that both income and population growth cause fish price to increase by between 0.25% and 1.20%. As a result of higher price, the welfare in the net exporting countries increases and welfare in the net importing regions decreases. However, the overall net gains to producers and consumers in the two regions combined are positive. The second chapter ascertains potential factors triggering FDA's import refusals within three categories of food, drugs, and cosmetics during the period of 2002 to 2013. Results from the panel dynamic GMM model suggest that FDA's decisions are not only influenced by a product's quality and safety but also by a number of other factors. These factors include lobbying pressure, economic development, FDA's human resource capacity, and reputation of neighboring countries. In addition, this chapter also supports the work of former researchers by indicating that US import refusals are dependent on past history. The last chapter analyzes effects of exchange rate on the international price of shrimp and trade flows and includes price transmission elasticity tests. Results from both the Fully Modified OLS and autoregressive Distributed Lag Models indicate that omission of transportation costs in LOP tests causes estimated elasticity of price transmission (EPT) to be underestimated by 30%, and also causes over-rejection of the LOP. The excess supply-demand model of US shrimp import indicates understated EPTs, and this causes exchange rate pass-through to be understated. Similarly, an increase in transportation costs has the same effect on US price and import quantities as does a depreciating US dollar. Moreover, under policy effecting analysis, most of the incidence of a change in exchange rate and transportation costs is borne by foreign producers, because the import demand elasticity is relatively larger than the export supply elasticity.

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Chapter 1

Effects of Income and Population Growth on Fish Price and Welfare

Abstract

An excess supply-demand model is used to determine the effects of income and population growth on the international price of fish, and on welfare in net exporting and importing regions. Stochastic simulations of the model suggest fish price increases by between 0.25% and 1.07% for each 1% increase in world income, and by between 0.30% and 1.20% for each 1% increase in world population. Combining these elasticity estimates with the actual growth in income and population for 1999-2013, results suggests income and population growth together caused the world price of fish to rise by between 1.0% and 4.1% per year, for a best-bet estimate of 2.1% per year. The actual average annual rise in fish price over the last 12 years was 0.9%. This suggests supply growth due to aquaculture moderated to a significant extent price pressure due to demand growth. Higher fish prices increase welfare in net exporting countries at the expense of welfare in net importing countries. However, our results suggest net gains to producers and consumers in the two regions combined are positive.

Key words: fish price, fish trade, welfare

JEL Code: F1

Introduction

The surge in world food prices that began in 2003 has been the subject of much analysis and debate in the scholarly literature (Headey and Fan 2008, Ivanic and Martin 2008, de Hoyos and Medvedev 2011, Headey 2014). What has received less attention, but in some ways is more profound, is the increase in fish price (figure 1). Trend regressions show an average annual rate of increase in the real price of fish of 1.4% between 1990 and 2002 and 0.9% between 2003 and 2014 (table 1). Real food and meat prices, by contrast, show no trend in the 1990-2002 period, and an average annual increase of 1.3% and 1.1%, respectively, in the 2003-2014 period. In essence, the rapid rise in food and meat prices in the surge period has been largely cancelled by declines, resulting in an average annual rate of increase only moderately above the rate of increase in fish price.

That the real price of fish in world markets has increased steadily over the last two and half decades is a boon to fisherman, to fish farmers, and to small coastal communities in the United States and elsewhere where fishing is a traditional way of life. For fish consumers, however, the rise in price is less of a good thing, especially for the urban poor in less developed countries such as Bangladesh where consumers rely on fish for the lion's share of their animal protein intake.[1] In these countries, a rise in fish price can increase the incidence of undernutrition, but also poverty (Headey *et al*. 2015).

The purpose of this research is to determine the effects of income and population growth on the international price of fish. A secondary goal is to determine how such price changes affect the welfare of producers and consumers in net exporting and importing countries of fish. Income and population growth have been long recognized as major drivers of fish demand

[1] According to FAO Globefish, Bangladesh consumers rely on fish for 56.2% of their animal protein intake (http://www.globefish.org/total-fish-consumption-per-capita-kg-and-fish-contribution-to-total-proteins-percent.html). Other counties where fish account for more than 50% of animal protein intake include Cambodia, Sierra Leone, Indonesia, Ghana, Sri Lanka, French Guiana, British Virgin Islands, Guadeloupe, and the Maldives.

(World Bank 2013; FAO 2014). Yet research to determine their effects on price is limited. Studies based on inverse demand systems have quantified the effects of changes in fish supply on price (e.g., Barten and Bettendorf 1989; Eales Durham and Wessells 1997; Holt and Bishop 2002; Nielsen *et al*. 2012; Moore 2015). However, such studies are region and species specific and thus do not address global and aggregate impacts. Global price determination is considered in the IMPACT model developed by the International Food Policy Research Institute that serves as the basis for the World Bank's *Fish to 2030* report (World Bank 2013). Global price determination is also considered in the FAO Fish Model developed jointly with the Organization for Economic Cooperation and Development that serves as the basis for FAO's outlook report on fisheries and aquaculture. But neither of these models isolates the effects of income and population growth on fish price, the major focus of the present study.

The next section discusses the model and relevant data. The model is then calibrated and simulated to gauge the extent to which observed increases in population and income have affected fish price over the last 15 years. The welfare effects of price increases are measured in the next section. The paper concludes with a discussion of key findings and implications.

Model

A unique aspect of fish as a food commodity is that it is highly traded. For example, the proportion of the world's fish production traded internationally in 2013 was 37% (FAO Globefish 2014). This suggests there are large regional imbalances in supply and demand that must be resolved through the price mechanism (Anderson 2003, World Bank 2013, p. xiv). Accordingly, to model fish price we adopted a simple two-country excess supply and demand framework similar to the one used by Chambers and Just (1979) to analyze the effects of currency devaluation on agricultural trade. An advantage of this framework is that countries that are net exporters of fish can be clearly distinguished from countries that are net importers of fish.

This is useful because some countries that are considered major exporters (importers) of fish are actually net importers (exporters) when imports and exports are combined to determine the trade balance. For example, China commonly is cited as the world's largest exporter of fish. In reality, as shown in table 1, it is a net importer of fish. The reason, of course, is that China is also a major importer of fish, and when fish for non-human consumption are included in the trade flows (as is the case in our data), China becomes a net importer. Correctly classifying countries as net importers and net exporters is important because it changes somewhat the stylized fact that fish in world markets flow from the "poor" South to the "rich" North (e.g., Nhuong *et al*. 2011 and references therein). Although there is some truth to this characterization, a perusal of table 1 will show some rich Northern countries in the net exporter category (e.g., Norway, Iceland, Canada) as well as some poor Southern countries in the net importer category (e.g., Nigeria, Egypt, Ghana). Consequently, the income gaps between the categories are not as large as might be supposed, an issue addressed later.

The basic model consists of two structural equations and a clearing condition

(1) $D = D(P, Y_m, N_m) \qquad \frac{\partial D}{\partial P} < 0,\ \frac{\partial D}{\partial Y_m} > 0,\ \frac{\partial D}{\partial N_m} > 0$

(2) $S = S(P, Y_x, N_x) \qquad \frac{\partial S}{\partial P} > 0,\ \frac{\partial S}{\partial Y_x} < 0,\ \frac{\partial S}{\partial N_x} < 0$

(3) $D = S = Q$

where D is the world's excess demand for fish taken to be a function of the market price of fish P and the levels of income Y_m and population N_m in the net importing region. S is the world's excess supply of fish taken to be a function of the market price of fish P and the levels of income Y_x and population N_x in the net exporting region. Q is the quantity of fish traded. The excess demand curve is downward sloping, and shifts to the right with increases in income and population in the net importing region. The excess supply curve is upward sloping, and shifts to the left with increases in income and population in the net exporting region. The model abstracts from transportation costs and other barriers to trade, and assumes that, in equilibrium, the law of one price holds and fish is a homogeneous commodity. Cross-price effects, which play a central role in Chamber and Just's (1979) model, are ignored. A justification for this is the fish are a staple commodity that will be little affected by the prices of related commodities in international trade, at least as a first approximation.

Taking the total differential of equations (1) – (3) and converting partial derivatives to elasticities yields

(4) $D^* = \eta_P P^* + \eta_Y Y_m^* + \eta_N N_m^*$

(5) $S^* = \varepsilon_P P^* - \varepsilon_Y Y_x^* - \varepsilon_N N_x^*$

(6) $D^* = S^* = Q^*$

where the asterisk (*) denotes proportionate change (e.g., $P^* = dP/P$); η_P (< 0), η_Y (> 0) and η_N (> 0) are elasticities of excess demand with respect to fish price, income in the net importing region, and population in the net importing region, respectively; and $\varepsilon_P(> 0)$, $\varepsilon_Y(> 0)$, and $\varepsilon_N(> 0)$ are elasticities of excess supply with respect to fish price, income in the net exporting region, and population in the net exporting region, respectively. Equations (4) – (6) constitute an equilibrium displacement model or EDM. For a good discussion of EDMs, including their limitations, see Piggott (1992), Davis and Espinoza (1997), and Wohlgenant (2011). Note that an increase in income or population in exporting countries causes the excess supply curve to shift to the left. The reason is that fish consumption in those countries increase with increases in income or population, which reduces the quantity of fish that enters international trade, *ceteris paribus*.

The model contains two endogenous variables (P^* and Q^*) and four exogenous variables (Y_m^*, Y_x^*, N_m^*, and N_x^*). At issue is the effect of isolated changes the exogenous variables on fish price. To determine that, we solve equations (4) - (6) simultaneously to yield the reduced-form equation

(7) $$P^* = \left(\frac{\eta_Y}{\varepsilon_P - \eta_P}\right) Y_m^* + \left(\frac{\varepsilon_Y}{\varepsilon_P - \eta_P}\right) Y_x^* + \left(\frac{\eta_N}{\varepsilon_P - \eta_P}\right) N_m^* + \left(\frac{\varepsilon_N}{\varepsilon_P - \eta_P}\right) N_x^*.$$

Income and population growth increase price. And this is true regardless of its source. Two useful principles can be deduced from the reduced form. First, the relative responsiveness of fish price to income and population growth in net exporting and importing countries depends strictly on the relative size of the structural elasticities η_Y and ε_Y and η_N and ε_N, as the numerators in equation (7) are identical across all shift variables. Second, a shift in a less elastic supply or demand curve always results in a larger price effect than a shift a more elastic supply or demand curve. Stated differently, the flatter the excess supply and demand curves for fish are in the world market, the smaller the price effects of income and population growth, *ceteris paribus*.

The price of fish is relatively stable (figure 1). For example, the standard error of the trend regression for fish (0.030) is one third the standard error for meat (0.097), and one-fifth the standard error for food (0.110) (table 1). A stable world price suggests the excess supply and demand curves are relatively flat. Insight into why this might be so can be obtained by considering the following analytical expressions for ε_P and η_P (derived in the appendix):

(8) $$\varepsilon_P = \frac{\bar{\varepsilon}_P - (1-k_x)\bar{\eta}_P}{k_x} > 0$$

(9) $$\eta_P = \frac{\tilde{\eta}_P - (1-k_m)\tilde{\varepsilon}_P}{k_m} < 0.$$

In these expressions, $\bar{\eta}_P (< 0)$ and $\bar{\varepsilon}_P\ (> 0)$ are the *domestic* demand and supply elasticities for fish with respect to price in the net exporting region; $\tilde{\eta}_p (< 0)$ and $\tilde{\varepsilon}_P\ (> 0)$ are the corresponding elasticities in the net importing region; k_x is the share of domestic production in the net exporting region that is exported; and k_m is the share of domestic consumption in the net importing region that is imported. For given values of the domestic supply and demand elasticities, the excess supply and demand curves flatten as trade share decreases (smaller k_x and k_x). Our analysis based on data for 2000-2011 indicates $k_x = 0.19$ and $k_m = 0.12$ (table 2). These *net* trade shares are sufficiently small to suggest that the excess demand and supply for fish in international markets are elastic, an issue to be addressed in more detail later.

Trade shares are also important determinants of the excess supply and demand elasticities with respect to income and population. To see this, consider the following analytical expressions for the elasticities in question (see appendix for derivation):

(10) $\varepsilon_Y = \frac{(1-k_x)\bar{\eta}_Y}{k_x} > 0$

(11) $\eta_Y = \frac{\tilde{\eta}_Y}{k_m} > 0$

(12) $\varepsilon_N = \frac{(1-k_x)\bar{\eta}_N}{k_x} > 0$

(13) $\eta_N = \frac{\tilde{\eta}_N}{k_m} > 0.$

In these expressions, $\bar{\eta}_Y$ (> 0) and $\bar{\eta}_N$ (> 0) are *domestic* demand elasticities for fish with respect to income and population, respectively, in the net exporting region; and $\tilde{\eta}_Y(> 0)$ and $\tilde{\eta}_N(> 0)$ are the corresponding elasticities for the net importing region. Excess supply and demand elasticities with respect to income and population are inversely related to trade share. This is especially true for the elasticities corresponding to the net exporting region, as the relevant analytical expressions have trade share in the numerator as well as the denominator (compare equations (10) and (12) with equations (11) and (13)). To illustrate, consider a situation where preferences for fish in net exporting and importing regions are homothetic such that $\bar{\eta}_Y = \tilde{\eta}_Y = 1$. Let trade shares be equal such that $k_x = k_m = 0.20$. In this situation, $\varepsilon_Y = 4$ and $\eta_Y = 5$. The rightward shift in the excess demand curve associated with a 1% increase in income in the importing region is 25% larger than the leftward shift in the excess supply curve associated with a 1% increase in income in the net exporting region. And this is true despite identical preferences for fish in the two regions, and identical trade shares. The upshot is that there is an inherent bias that favors demand shocks originating from net importing counties having a larger effect on price than supply shocks originating from net exporting countries.

Model Calibration

To simulate the model, it needs to be calibrated. For this purpose, we surveyed the empirical literature to determine "best-bet" values for domestic supply and demand elasticities for fish with respect to price, income, and population. These values are then combined with the average trade shares in table 1 to compute the excess supply and demand elasticities using equations (8) – (13). Given the inherent uncertainty in the parameter values so obtained, stochastic simulations are performed under the assumption that each parameter follows a GRK distribution with minimum and maximum values equal to one-half and twice its best-best value. The GRK distribution is an empirical substitute for the triangle distribution that allows observed values to fall below the minimum value and above the maximum value 2% of the time. As such, the GRK distribution avoids the understatement of downside risk inherent in the Triangle distribution (Richardson 2005, Chapter 5).

Focusing first domestic demand elasticities, estimates of own-price and income elasticities for net exporting countries include studies by Rickertsen (1996), Andersen *et al*. (2008), and Dey *et al*. (2008) and for net importing countries include studies by Wellman (1992), Eales *et al*. (1997), Nielsen (1999), ABARE (2000), Asche *et al*. (2005), and Singh *et al*. (2014). Based on a careful review of these studies, we set $\bar{\eta}_P = -0.87$ and $\bar{\eta}_Y = 0.60$ as the best-bet values of these parameters for the net exporting region, and $\tilde{\eta}_P = -1.27$ and $\tilde{\eta}_Y = 1.02$ as the best-bet values for the net importing region. Studies of domestic supply elasticities for fish are relatively scarce and include Kouka and Engel (1998), Dey *et al*. (2004), Kumar et al. (2006), Asche *et al*. (2007), Andersen *et al*. (2008), and Asche (2009). Based on a review of these studies, we set $\bar{\varepsilon}_P = 0.54$ and $\tilde{\varepsilon}_P = 0.50$ as the best-bet value of these parameters.

Estimates of the effects of population size on fish demand are even rarer than supply studies. Cheng and Capps (1998) estimate household size elasticity in the range of range of 0.13 to 0.33 for fresh and frozen seafood in the United States. Similar estimates by Lanfranco *et al*. (2002) for Hispanics indicate a range from 0.10 to 0.36. Salvanes and Devoretz (1997) and Myrland *et al*. (2000) find that household seafood consumption increases with increasing household size but do not provide elasticities estimates. Because of the lack of explicit empirical estimates to indicate the responsiveness of fish demand to population size, we set $\bar{\eta}_N = \tilde{\eta}_N = 1$. This implies a 1% increase in population increases domestic demand for fish by 1% in both the net exporting and net importing regions. The assumption is not inconsistent with most empirical studies of demand in which quantity is defined on a per-capita basis.[2] The parameter values used to simulate the model are summarized in table 3.

Simulation Results

Simulation proceeds in two steps. In the first step, stochastic simulations of equation (7) are performed to develop 90% confidence intervals for the reduced-form elasticities implied by the equation.[3] The simulations are performed using the software SIMETAR with the number of iterations set to 1,000 (Richardson 2005). In the second step, the reduced-form elasticities obtained in the first step are combined with observed changes in income and population in the net importing and exporting regions to determine the actual effects of income and population growth on fish price. The changes in income and population are computed for three five-year

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[2] For example, let the per-capita demand function for fish in the net exporting region be defined as $Q_d/N_x = D(P, Y_x)$. Writing this function in proportionate change form yields $Q_d^* = \bar{\eta}_P P^* + \bar{\eta}_Y Y_x^* + N_x^*$. Clearly, the per-capita specification implicitly assumes the elasticity of total fish consumption in exporting region with respect to population is 1. A similar analysis applies to the demand function of the net importing region.

[3] For a cogent discussion of the advantages and caveats associated with stochastic simulation of equilibrium displacement models, see Davis and Espinoza (1998).

intervals covering the period 1999 to 2013. The separation of growth effects into five-year intervals permits an assessment of how the effects may have changed over time.

Reduced-Form Elasticities

Demand shocks originating in net importing countries have larger effects on world fish price than supply shocks originating in net exporting countries (table 4). Specifically, the 90% confidence intervals for $\frac{P^*}{Y_m^*}$ and $\frac{P^*}{N_m^*}$ are [0.19, 0.83] and [0.20, 0.80], with mean values of 0.41 and 0.40, respectively. The corresponding intervals for $\frac{P^*}{Y_x^*}$ and $\frac{P^*}{N_x^*}$ are [0.06, 0.24] and [0.10, 0.40], with mean values of 0.12 and 0.20, respectively. A 1% increase in income or population in net importing countries has about twice the effect on fish price as a 1% increase in income or population in net exporting countries. Still, the effects overall are relatively modest, as the upper limits of the confidence intervals are less than 1. In other words, the model suggests fish price will increase at a slower pace than income and population in the respective regions.

Combining the estimates, it appears that population growth has a slightly larger effect on fish price than income growth. Specifically, an isolated 1% increase in population worldwide is projected to increase fish price by between 0.30% and 1.20%, with a best-bet estimate of 0.60%. An isolated 1% increase in income worldwide is projected to increase fish price by between 0.25% and 1.07%, with a best-bet estimate of 0.53%. The best-bet estimates suggest fish price will increase at about half the pace of income and population growth worldwide.

Simulated Price Effects

To what extent might income and population growth explain the rise in fish price evident in figure 1? To answer the question, we first computed the level of real income and population in the net importing and exporting regions as shown in table 5. These data confirm that net importing countries are richer than net exporting countries. The aggregate income of net exporting countries is only 60% as large as the aggregate income of net importing countries, and this percentage has changed little over the 15 year study period. Next, we computed percentage changes in real income and population for selected time intervals as shown in table 6. The middle period five-year period 2004-2008 showed faster rates of growth for both income and population than the first and third five-year periods, 1999-2003 and 2009-2013. The one exception is for population in net exporting countries, which grew at a slightly slower rate in the middle period (6.9%) relative to the first (7.3%) and third (7.0%) periods.

Predicted price effects were obtained by multiplying the aforementioned growth rates by the reduced-form elasticities as shown in the last three columns of table 6. Results suggest income growth in net importing countries had the largest cumulative effect on fish price over the 15 year period (14.1%), followed by population growth in net importing countries (8.6%). The price pressure exerted by income and population growth in net exporting countries at 3.8% and 4.3%, respectively, by comparison is relatively modest. Adding these effects together gives a cumulative price effect for the 15-year study period of 30.8%, which equates to an average annual price effect of 2.1%. The 90% confidence interval for this estimate is [1.0, 4.1], which suggests income and population growth, when taken together, increased fish price over the study period by between 1.0% and 4.1% per year.

The confidence interval underscores the caution that must be exercised in basing predictions on point estimates generated from a model of the type used in this study, as they inherently are imprecise. Still, it is interesting to note that the predicted price effect is not out of line with the trend growth in fish price indicated in table 1 (1.4% for the 1990-2002 period, and 0.9% for the 2003-2014 period). That fish price rose more slowly than the best-bet prediction from our model (2.1%) suggests productivity growth in the fish-farming sector was instrumental in moderating the price pressure stemming from income and population growth.[4] Overall, income growth accounted for 59% of the price rise predicted by the model compared to 41% for population growth. Consequently, for the 15 year period ending in 2013 income growth appears to be a more important driver of the observed increase in fish price than population growth, although clearly both played prominent roles.

Welfare Effects

An increase in the price of fish benefits producers at the expense of consumers. The welfare effects in the context of the present model are shown in figure 2. Panel A shows the welfare gain in net exporting countries from a price rise associated with an increase in income or population in net importing countries. Panel C shows the welfare loss in net importing countries from a price rise associated with an increase in income or population in net exporting countries. At issue is whether the gain to the domestic economies in the two regions from a combined 1% increase in income or population is positive or negative. In geometric terms, is quadrilateral *abcd* in Panel A larger or smaller than quadrilateral *efgh* in Panel C?

To answer the question, changes in producer, consumer, and total surplus in the net exporting region were measured using the following formulas:[5]

(14) $$\Delta CS_x = -P^0\bar{Q}_d^0P^*(1+\frac{1}{2}\bar{Q}_d^*)$$

(15) $$\Delta PS_x = P^0\bar{Q}_s^0P^*(1+\frac{1}{2}\bar{Q}_s^*)$$

(16) $$\Delta TS_x = \Delta CS_x + \Delta PS_x.$$

[4] *The Economist* (2013) reports that the quantity of wild fish required to produce one pound of farmed salmon dropped from 10 pounds in the early days of the industry to five pounds today. The farms also became more energy efficient, and disease control improved. Indeed, thanks to productivity gains, the production of farmed fish worldwide now exceeds the production of beef. Meanwhile, due in part to overfishing, wild fish captured globally peaked in the late 1980s at about 90 million tons per year. The production of fish between 2010 and 2012 averaged 153 million tons per year (FAO, 2014, p. 200), which means some 42% of world demand is satisfied by aquaculture.

[5] The formulas assume that supply and demand shifts are parallel. For a general discussion of applied welfare analysis using an EDM, see Alston *et al*. (1995) and Wohlgenant (2011). For a specific application, see Kinnucan and Cai (2012).

where P^0 is price in the initial equilibrium, i.e., before the shift in the excess demand curve due to a given change in income or population; $\bar{Q}_d^0$ is the level of fish consumption in the net exporting region in the initial equilibrium; $\bar{Q}_s^0$ is the corresponding level of fish production; $\bar{Q}_d^* = \bar{\eta}_p P^*$ is the change in domestic consumption in net exporting region associated with the change in price induced by a 1% change in income or population in the net importing region; and $\bar{Q}_s^* = \bar{\varepsilon}_p P^*$ is the corresponding change in domestic production.

A similar set of equations is used to measure the changes in economic surplus in the net importing region induced by a 1% change in income or population in the net exporting region, to wit:

(17) $$\Delta CS_m = -P^0 \tilde{Q}_d^0 P^* (1 + \frac{1}{2} \tilde{Q}_d^*)$$

(18) $$\Delta PS_m = P^0 \tilde{Q}_s^0 P^* (1 + \frac{1}{2} \tilde{Q}_s^*)$$

(19) $$\Delta TS_m = \Delta CS_m + \Delta PS_m.$$

where $\tilde{Q}_d^0$ and $\tilde{Q}_s^0$ are initial equilibrium levels of fish consumption and production in the net importing region; $\tilde{Q}_d^* = \tilde{\eta}_p P^*$ is the change in domestic consumption in net importing region associated with the change in price induced by 1% change in income or population in the net exporting region; and $\tilde{Q}_s^* = \tilde{\varepsilon}_p P^*$ is the corresponding change in domestic production.

In applying equations (14) – (19) the price and quantity variables were set to their sample means for the period 2000-2011. Changes in price were computed using the reduced- form elasticities in table 4, and changes in domestic production and consumption were computed using the appropriate elasticities in table 3. Values are reported in real (2002-04) U.S. dollars. For the time period in question, the average annual real price of fish is $2,328/ton.

Results suggest gains to fish producers from income and population growth outweigh losses to fish consumers (table 7). The price rise associated with a 1% increase in the combined income of net exporting and importing regions decreases consumer surplus in the combined regions by between $36 billion and $153 billion (table 7, row 3). However, the associated gains to fish producers, which are estimated to range from $40 billion to $170 billion (row 6), are sufficient to offset the losses to consumers and provide a net welfare gain to the combined economies of between $4 billion and $17 billion (row 7). A similar result obtains for a 1% increase in population, although the net gains are more modest – between $3 billion and $12 billion (row 14). Thus, it would appear that income and population induced increases in fish price are welfare increasing from a global perspective.

Although global gains are positive, producers gain at the expense of consumers, and these distributional consequences can be important. For example, each 1% increase in income (population) in net importing countries is estimated to reduce consumer surplus in net exporting countries by between $22 billion and $96 billion (row 1) ($23 billion and $93 billion (row 8)). For the poorer countries in this group that also rely on fish for the major share of their protein intake, such losses can take a significant human toll, as noted by Headey (2014) and references therein. A similar inference applies to the effects of income and population growth in net exporting countries on consumers in net importing countries. Here, however, the consequences are less severe owing to smaller effects (compare rows 1 and 2) and the higher average income level of net importing countries as shown in table 5.

Concluding comments

The real price of fish in global markets has increased steadily for some 25 years now. Our analysis suggests income and population growth were major contributing factors to the price rise. Income growth is estimated to have increased fish price by an average of 1.2% per year, and population growth by an average of 0.9% per year, for a combined effect of 2.1% per year. The actual annual rate of increase over the last decade was about 0.9%, which suggests supply increases associated with productivity gains in the aquaculture sector moderated the price pressure exerted by income and population growth. To the extent this is true, the projected decline in the annual rate of growth of fish from aquaculture -- from 6.1% in 2003-2012 to 2.5% in 2013-2022 (FAO, 2014, pp. 201-202) -- augers for increased price pressure in the years to come.

Welfare gains from rising fish prices are positive for the world as a whole, but the transfer of surplus from consumers to producers is nontrivial. Point estimates from stochastic simulations of the model indicate that for each 1% increase in income (population), producer surplus in global fish markets increases by $84 billion ($100 billion) and consumer surplus decreases by $76 billion ($94 billion), for a net gain of $8 billion ($6 billion). Thus, while the gains to producers from higher fish prices outweigh losses to consumers, the net gain is modest, less than 10% of the redistributed surplus.

A caveat in interpreting our results is that they rest on the assumption that price transmission from world to local markets is perfect. If price transmission is imperfect, i.e., if a 1% increase in the world price of fish causes the domestic price of fish to rise by less than 1%, the excess demand elasticity η_P will be overstated in absolute value, and the excess supply elasticity ε_P will be understated.[6] Depending on the relative magnitudes of the potential biases, the price effects indicated by the model may overstate or understate actual effects. Sensitivity analysis indicated that the confidence intervals reported in table 4 are not much affected by price transmission elasticities in the range of 0.4 to 1.0. For smaller values of the transmission elasticities, the simulated price effects changed in a non-linear fashion. Thus, this caveat would appear most appropriate in situations where domestic prices are insulated from world prices due to border policies, as might be true for specific countries.

[6] These results are developed in an appendix available upon request from the authors. They extend the analysis of Bredahl *et al*. (1979), which shows $|\eta_P| \to 0$ as the international price transmission elasticity approaches zero.

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Appendix

Table 1. OLS Estimates of the Trend Equation ln PRICE=α+β TIME+ γ TIME·D+u, Annual Data, 1990 – 2014a

Item	α	β	γ	R^2	DW	S. E. of Regression
Food Price	4.56 (75)[b]	0.0054 (0.70)	0.0128 (2.27)	0.72	0.67	0.1104
Meat Price	4.72 (87)	-0.0068 (-0.99)	0.0113 (2.28)	0.38	0.64	0.0974
Fish Price	4.47 (271)	0.0141 (6.86)	-0.0041 (-2.71)	0.85	1.62	0.0298

[a] D is a binary variable that equals zero for 1990-2002 and one for 2003-2014. For a graphical display of the price data and source, see Figure 1.

[b] Numbers in parentheses are *t*-ratios.

Table 2. Fish Production, Consumption and Trade Shares for Net Exporting and Importing Countries, Metric Tons, Annual Average for 2000-2011

Net Exporters				Net Importers			
Country	Production	Net Exports	Export Share	Country	Consumption	Net Imports	Import Share
Peru	7,840,830	2,084,601	0.27	EU	10,727,907	3,504,196	0.33
Norway	3,419,328	1,502,113	0.44	Japan	8,427,287	2,715,307	0.32
Chile	4,894,395	1,168,219	0.24	USA	6,126,019	833,315	0.14
Viet Nam	3,713,745	625,155	0.17	Korea	3,607,136	712,349	0.20
Indonesia	7,850,793	619,899	0.08	China	54,216,336	553,146	0.01
Iceland	1,595,638	578,883	0.36	Nigeria	974,407	351,735	0.36
India	6,894,129	543,567	0.08	Ukraine	614,710	338,733	0.55
Argentina	935,858	468,292	0.50	Egypt	1,221,045	243,176	0.20
Russian	3,667,060	461,929	0.13	Côte d'Ivoire	303,999	241,475	0.79
Morocco	998,614	356,957	0.36	Australia	465,705	211,936	0.46
Ecuador	613,734	312,479	0.51	Ghana	589,512	199,186	0.34
Faroe Islands	556,639	298,408	0.54	Hongkong	352,675	185,447	0.53
Namibia	500,272	294,953	0.59	Brazil	1,210,516	142,767	0.12
Taiwan	1,314,498	282,389	0.21	Malaysia	1,768,645	140,570	0.08
New Zealand	606,676	274,364	0.45	Cameroon	263,075	133,997	0.51
Myanmar	2,498,435	259,211	0.10	Singapore	137,239	129,734	0.95
Thailand	3,638,847	250,501	0.07	Saudi Arabia	198,692	122,533	0.62
Canada	1,216,388	148,667	0.12	Belarus	132,450	121,789	0.92
Greenland	208,684	119,691	0.57	Dominican	121,788	105,886	0.87
Pakistan	583,706	114,476	0.20	Sri Lanka	390,730	70,711	0.18
ROW	8,477,238	1,160,827	0.14	ROW	9,321,426	867,594	0.09
Total	62,025,506	11,925,582	0.19	Total	101,171,299	11,925,582	0.12

Source: FAO, 2015. ROW = Rest of World. Note: based on the original data, net exports fell short of net imports by 1.2%. Thus, to get the numbers to balance so that net exports = net imports, net exports for ROW were adjusted upward slightly.

Table 3. Parameter Values Used to Calibrate the Model

Parameter	Definition	Value
k_m	Share of fish consumption in net importing region that is imported	0.12
k_x	Share of fish production in net exporting region that is exported	0.19
$\tilde{\varepsilon}_P$	Domestic supply elasticity for net importing region	0.50
$\bar{\varepsilon}_P$	Domestic supply elasticity for net exporting region	0.54
$\tilde{\eta}_P$	Domestic demand elasticity for net importing region	-1.27
$\bar{\eta}_P$	Domestic demand elasticity for net exporting region	-0.87
$\tilde{\eta}_Y$	Domestic income elasticity for net importing region	1.02
$\bar{\eta}_Y$	Domestic income elasticity for net exporting region	0.60
$\tilde{\eta}_N$	Domestic population elasticity for net importing region	1.00
$\bar{\eta}_N$	Domestic population elasticity for net exporting region	1.00

Source: Best-bet values based on empirical estimates in the literature and authors' computations.

Table 4. Reduced-Form Elasticities

Item	Price with respect to Income (P^*/Y_i^*)			Price with respect to Population (P^*/N_i^*)		
	5% Limit	Mean	95% Limit	5% Limit	Mean	95% Limit
Net Importers	0.19	0.41	0.83	0.20	0.40	0.80
Net Exporters	0.06	0.12	0.24	0.10	0.20	0.40
Combined Effect	0.25	0.53	1.07	0.30	0.60	1.20

Note: elasticities are based on the GRK stochastic distribution.

Table 5. Real Income and Population in Net Exporting and Importing Countries of Fish, Five-year Intervals, 1999-2013

Item	Net Exporting Countries	Net Importing Countries	Ratio
Per Capita Income (in USD)[a]			
1999-2003	6,210	7,062	0.88
2004-2008	6,972	7,858	0.89
2009-2013	7,201	8,123	0.89
Population (in millions)			
1999-2003	2,396	3,647	0.66
2004-2008	2,571	3,846	0.67
2009-2013	2,748	4,050	0.68
Total Income (in billion USD)[a]			
1999-2003	14,879	25,755	0.58
2004-2008	17,925	30,222	0.59
2009-2013	19,788	32,898	0.60

[a]Expressed in constant 2005 dollars.

Table 6. Predicted Effects of Income and Population Growth on International Fish Price, Five-Year Intervals, 1999-2013

Causal Factor	Observed Change (%)	Predicted Price Effect[a]		
		5% Limit	Mean	95% Limit
Income – Importing countries:				
1999 – 2003	8.8	1.7	3.6	7.3
2004 – 2008	15.8	3.0	6.5	13.1
2009 – 2013	9.7	1.8	4.0	8.1
Cumulative effect	34.3	6.5	14.1	28.5
Average annual effect	2.3	0.4	0.9	1.9
Income – Exporting countries:				
1999 – 2003	7.0	0.4	0.8	1.7
2004 – 2008	13.8	0.8	1.7	3.3
2009 – 2013	11.0	0.7	1.3	2.6
Cumulative effect	31.8	1.9	3.8	7.6
Average annual effect	2.1	0.1	0.3	0.5
Population – Importing countries:				
1999 – 2003	6.9	1.4	2.8	5.5
2004 – 2008	8.1	1.6	3.2	6.6
2009 – 2013	6.5	1.3	2.6	5.2
Cumulative effect	21.5	4.3	8.6	17.3
Average annual effect	1.4	0.3	0.6	1.2
Population – Exporting countries:				
1999 – 2003	7.3	0.7	1.5	2.9
2004 – 2008	6.9	0.7	1.4	2.8
2009 – 2013	7.0	0.7	1.4	2.8
Cumulative effect	21.2	2.1	4.3	8.5
Average annual effect	1.4	0.1	0.3	0.6
Combined average annual effect:				
Income	--	0.6	1.2	2.4
Population	--	0.4	0.9	1.7
Income + Population	--	1.0	2.1	4.1

Table 7. Effects of a 1% Increase in Income and Population on Economic Surplus

		Welfare Gain (billion USD)		
Causal Factor	Row	5% Limit	Mean	95% Limit
Income:				
$\frac{\Delta CS_x}{Y_m^*}$	1	-22	-48	-96
$\frac{\Delta CS_m}{Y_x^*}$	2	-14	-28	-56
$\frac{\Delta CS}{Y^*}$	3	-36	-76	-153
$\frac{\Delta PS_x}{Y_m^*}$	4	27	59	120
$\frac{\Delta PS_m}{Y_x^*}$	5	12	25	50
$\frac{\Delta PS}{Y^*}$	6	39	84	170
ΔTS_Y (rows 3 + 6)	7	**3**	**8**	**17**
Population:				
$\frac{\Delta CS_x}{N_m^*}$	8	-23	-47	-93
$\frac{\Delta CS_m}{N_x^*}$	9	-24	-47	-94
$\frac{\Delta CS}{N^*}$	10	-47	-94	-187
$\frac{\Delta PS_x}{N_m^*}$	11	29	58	116
$\frac{\Delta PS_m}{N_x^*}$	12	21	42	83
$\frac{\Delta PS}{N^*}$	13	50	99	199
ΔTS_N (rows 10 + 13)	14	**3**	**5**	**12**

Note: Welfare gains are based on the following initial equilibrium values: P^0 = \$2,328/metric ton, $\bar{Q}_d^0$ = 50,099,924 metric tons, $\bar{Q}_s^0$ = 62,025,506 metric tons, $\tilde{Q}_d^0$ = 101,171,299 metric tons, and $\tilde{Q}_s^0$ = 89,245,718 metric tons. See text for details.

Appendix Table: Data Sources

No.	Item	Source
1	Food, meat, and fish price indices (2002-04 = 100)	FAO Globefish
		http://www.globefish.org/fao-fish-price-index-jan-2015.html
		https://www.google.com/?gws_rd=ssl#q=annual+food+price+index+fao
2	Fish production, consumption, and trade quantity	FAO FishstatJ
		http://www.fao.org/fishery/statistics/software/fishstatj/en
3	GDP per capita (constant USD, 2005 =100)	The World Bank
		http://data.worldbank.org/indicator/NY.GDP.PCAP.KD
4	Population, total and growth	The World Bank, 2015
		http://data.worldbank.org/indicator/SP.POP.TOTL

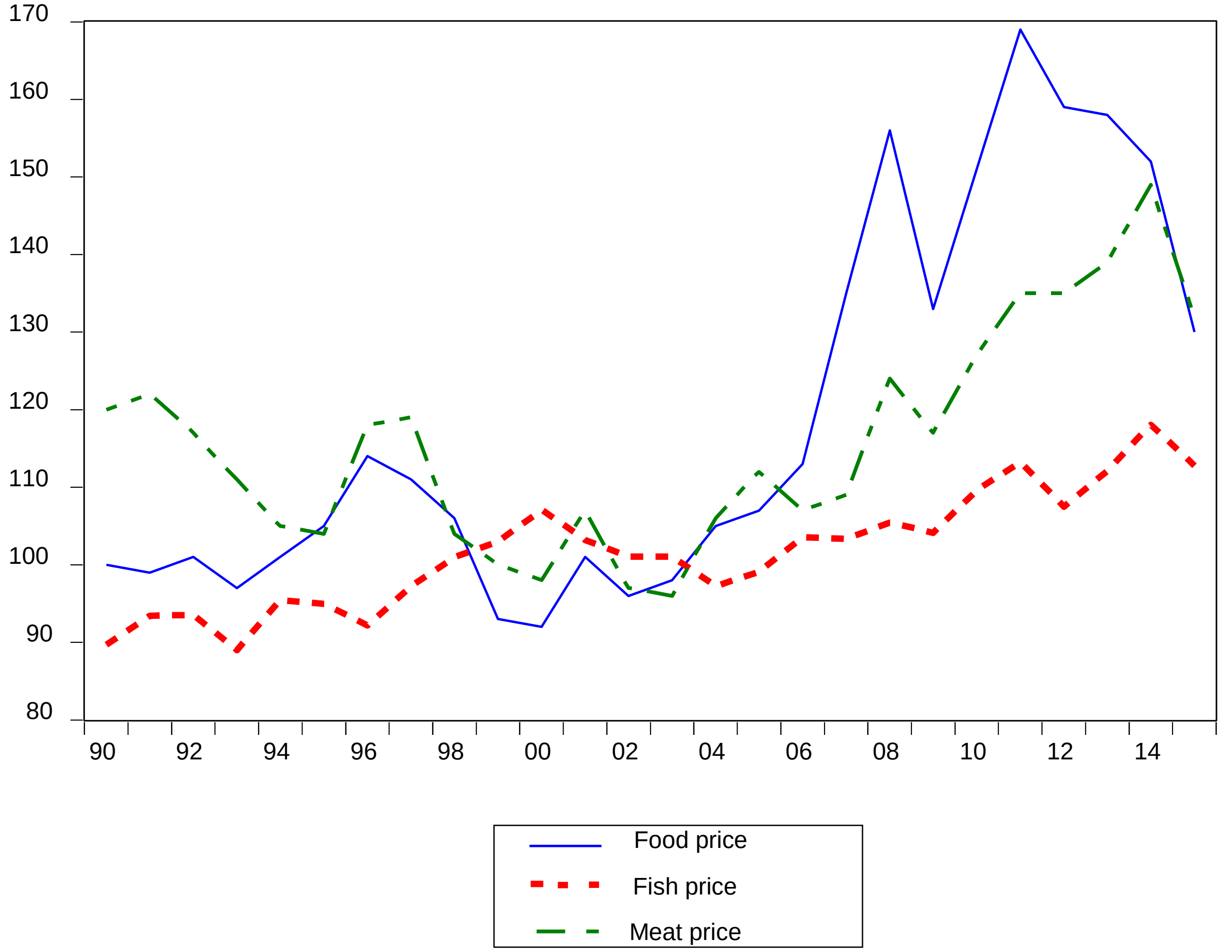

Figure 1. Real International Price of Food, Meat and Fish, 1990 – 2015

(Note: The 2015 price is for January. All prices are deflated by the Manufacturers Unit Value Index developed by the World Bank. The MUV Index is rescaled so that that 2002-04 = 100 instead of 2010 = 100. See appendix table for data sources.)

Figure 2. Welfare Effects of Income and Population Growth in World Fish Markets

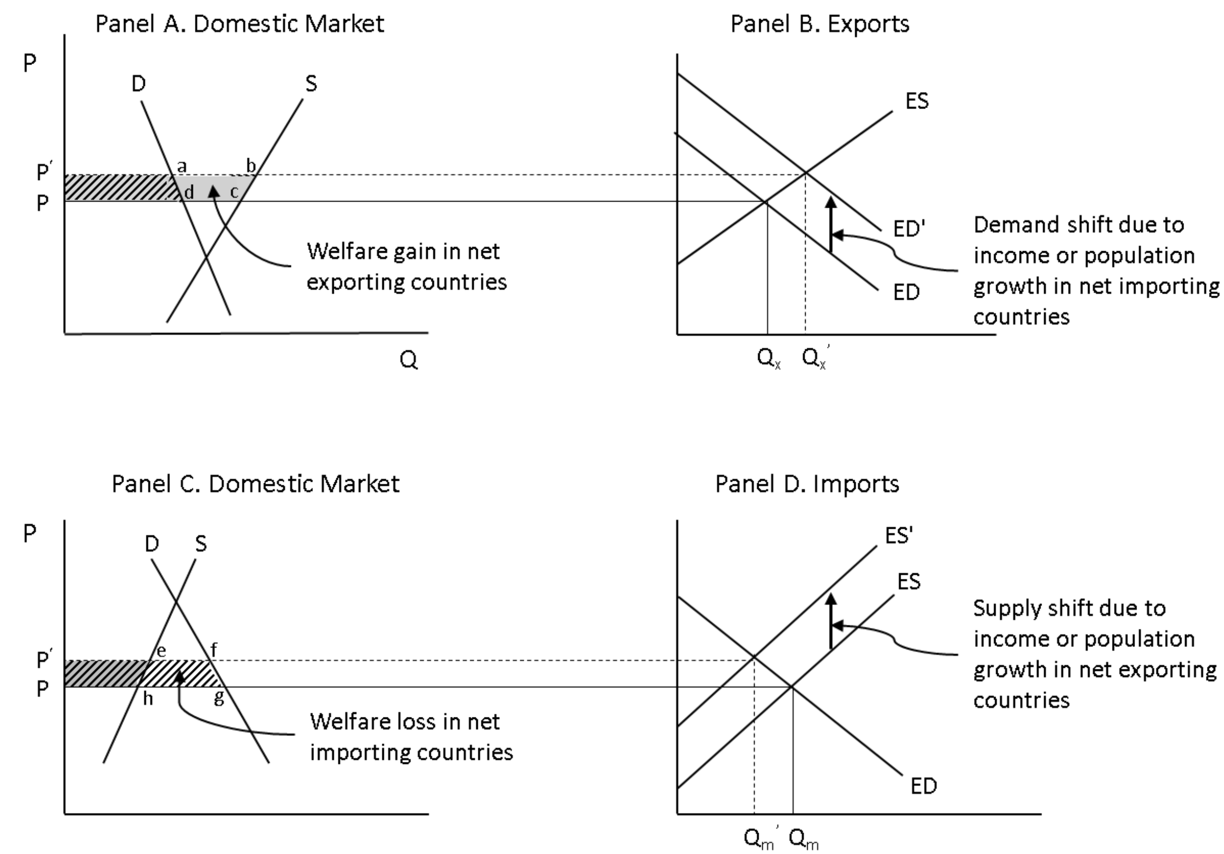

Figure 2. Welfare Effects of Income and Population Growth in World Fish Markets

Appendix. Derivation of Analytical Expressions for Excess Demand and Supply Elasticities

Net Importing Region

Let the structural model for the net importing region be defined as follows

(A1) $Q_d^* = \widetilde{\eta}_P P^* + \widetilde{\eta}_Y Y_m^* + \widetilde{\eta}_N N_m^*$ (domestic demand)

(A2) $Q_s^* = \tilde{\varepsilon}_P P^*$ (domestic supply)

(A3) $Q_m^* = \varepsilon_P P^*$ (import supply)

(A4) $Q_d^* = k_m Q_m^* + (1 - k_m) Q_s^*$ (market clearing)

The excess demand curve for the net importing region is obtained by dropping equation (A3) (to treat P^* as temporarily exogenous) and solving the remaining equations simultaneously for Q_m^* in terms of the exogenous variables to yield

(A5) $Q_m^* = \left(\frac{\widetilde{\eta}_P - (1-k_m)\tilde{\varepsilon}_P}{k_m}\right) P^* + \left(\frac{\widetilde{\eta}_Y}{k_m}\right) Y_m^* + \left(\frac{\widetilde{\eta}_N}{k_m}\right) N_m^*.$

Letting $Q_m^* = D^*$ and changing notation, equation (A5) can be written more simply as

(A6) $D^* = \eta_P P^* + \eta_Y Y_m^* + \eta_N N_m^*$

where

(A7) $\eta_P = \frac{\widetilde{\eta}_P - (1-k_m)\tilde{\varepsilon}_P}{k_m} < 0$

(A8) $\eta_Y = \frac{\widetilde{\eta}_Y}{k_m} > 0$

(A9) $\eta_N = \frac{\widetilde{\eta}_N}{k_m} > 0$

are excess demand elasticities expressed in terms of domestic demand and supply elasticities and import share.

Net Exporting Region

Let the structural model for the net exporting region be defined as follows

(A10) $Q_d^* = \bar{\eta}_P P^* + \bar{\eta}_Y Y_x^* + \bar{\eta}_N N_x^*$ (domestic demand)

(A11) $Q_s^* = \bar{\varepsilon}_P P^*$ (domestic supply)

(A12) $Q_x^* = \eta_P P^*$ (export demand)

(A13) $Q_s^* = k_x Q_x^* + (1 - k_x) Q_s^*$ (market clearing)

The excess supply curve for the net exporting region is obtained by dropping equation (A12) (to treat P^* as temporarily exogenous) and solving the remaining equations simultaneously for Q_x^* in terms of the exogenous variables to yield

(A14) $$Q_x^* = \left(\frac{\bar{\varepsilon}_P - (1-k_x)\bar{\eta}_P}{k_x}\right) P^* - \left(\frac{(1-k_x)\bar{\eta}_Y}{k_x}\right) Y_x^* - \left(\frac{(1-k_x)\bar{\eta}_N}{k_x}\right) N_x^*.$$

Letting $Q_x^* = S^*$ and changing notation, equation (A14) can be written more simply as

(A15) $$S^* = \varepsilon_P P^* - \varepsilon_Y Y_m^* - \varepsilon_N N_m^*$$

where

(A16) $$\varepsilon_P = \frac{\bar{\varepsilon}_P - (1-k_x)\bar{\eta}_P}{k_x} > 0$$

(A17) $$\varepsilon_Y = \frac{(1-k_x)\bar{\eta}_Y}{k_x} > 0$$

(A18) $$\varepsilon_N = \frac{(1-k_x)\bar{\eta}_N}{k_x} > 0$$

are excess supply elasticities expressed in terms of domestic demand and supply elasticities and export share.

Chapter 2

Triggering Factors for US Import Refusals

Abstract

Antifreeze in toothpaste and melamine-tainted infant formula have raised concerns about the quality and safety of imports into the US to unprecedented levels. However, the Food and Drug Administration (FDA) cannot inspect all imports, so their inspections are path-dependent (Baylis et al., 2009) and targeted based on risk (Elder, 2013). This research investigates potential factors triggering FDA's import refusals within the three categories of food, drugs, and cosmetics during the period from 2002 to 2013. Triggering factors are differentiated by: 1) FDA's human resource; 2) product-specific characteristics; 3) economic and political pressures in the US and exporting countries; and 4) spillover effects among exporting countries. Number of refusals and refusal ratio are used as the dependent variable in a two-stage least-square estimator of the panel dynamic GMM model. Factors related to FDA's human resource; including FDA annual staff numbers, FDA foreign offices, and historical compliance, all have significant influence on refusals. Determination of spillover effects indicates that lagged refusals and refusals from a highest-violated country caused significant influence on rejections from their neighbor country in a region.

Key words: Refusals, influent factors, food, drug, and cosmetics.

JEL code: F5

Introduction

Imports are becoming a more significant proportion of the US economy, which grew approximately 7% annually for the period from 2002 to 2013. During this period, imported food accounted for 17 percent of total consumption per capita, 40 percent of all drugs were imported, and 80 percent of the active pharmaceutical ingredients in drugs consumed in the United States were imported (FDA, 2014). However, the recent issues of antifreeze in toothpaste and melamine-tainted infant formula have raised concerns about the quality and safety of imports into the US to unprecedented levels. Considered as one of the world's most efficiently working systems in terms of imported-product approval and regulation, FDA is responsible for ensuring that merchandise entering the US market is wholesome, safe, and produced under sanitary conditions (FDA, 2012). Tasked with an enormous job, FDA is responsible for monitoring imports from over 300,000 facilities from more than 130,000 importers in 150 different countries whose products enter the United States through over 300 ports of entry. Because of the tremendous volume of imported products, limited time and human resources, and financial constraints, FDA can only physically examine less than 1% of all regulated products, although 100% of imported food products are electronically examined and 100% of drug products are reviewed at an additional level before reaching US borders. Therefore, FDA's inspections have become path dependent (Baylis, Martens, and Nogueira, 2009) and targeted based on risk (Elder, 2013). For example, frozen fish from Norway has never been a problem, so it would be considered low risk, while seafood from China, has been a persistent problem indicating high risk (Knox, 2007).

The FDA, the USDA Food Safety and Inspection Service (FSIS), and the Environmental Protection Agency are three agencies who take responsibility to ensure the safety of imported products for domestic consumption. FDA regulates $2 trillion of imported goods including food (except meat, poultry, and processed eggs), animal feed, human and veterinary drugs, vaccines and other biological products, cosmetics, and medical devices. Although FDA frequently upgrades their regulations to keep Americans safe and healthy but the number of refusals didn't change much over the last decade. Refusals ranged 18,663 per year for the period from Jan. 2002 to Apr. 2014 except in 2011 when they rose to 85,000 (appendix figure 1). The research question is the degree to which refusals change as a result of improvements or declines in imported product's safety, industry compliance, and other factors. Thus this paper investigates potential factors triggering FDA's import refusals within the three categories of food, drugs, and cosmetics during the period from 2002 to 2014.

Although exporters are interested in the reasons for FDA’s import refusals, the literature in this area is still limited and has only been studied in recent years. Because of limited and biased data, previous researchers could only investigate in some particular aspects. Most of these authors focused on product-specific refusals such as seafood (Anders and Westra, 2011), fish and seafood (Grant and Anders, 2010), different kinds of food (Baylis, Martens, and Nogueira, 2009; Jouanjean, Maur, and Shepherd, 2012; Nakuja, 2012), or food in general (Buzby and Regmi, 2009).

In general, most papers were based on historical data to describe simple trends in FDA’s refusals in specific food sectors such as vegetables and vegetable products, fishery and seafood products, and fruits and fruit products. Buzby, Unnevehr, and Roberts (2008) used FDA’s Import Refusal Reports from 1998 through 2004 to examine FDA’s refusals of food offered for importation into the United States. The authors created tabulations of refusals by industry group and violation code, in which they particularly focused on “adulteration” violations. They determined that import refusals highlight food safety problem that appear to occur in trade where the FDA has focused on alerts, examinations, and other monitoring efforts. Moreover, the data showed that some food industries and types of violations are consistent sources of problems both over time and in comparison with previous studies.

Using the same dataset and method, Buzby and Regmi (2009) classified import refusals by food industry group, type of violation, and country from 1998 to 2004. Their study found that low-income countries share the highest number of violations and the most refusals per billion dollars of US food imports. The implication from this study is that low-income countries may not have as effective food safety standards, practices, and regulations as the middle-income and high-income countries. Therefore, in order to approve more food exported to the US from these countries, it is necessary for them to improve their food safety procedures and techniques. In addition, if relying on the data for a short period only (Sep. 2006 to Oct. 2007), India, China, and Mexico were the leading violators in terms of FDA’s refusals, with fishery/seafood products, vegetables/vegetable products, and spices/flavorings having the largest share of refused shipments because the products were filthy (Allen et al., 2008). From these descriptive/analysis studies, with the exception of food quality, the factors which influenced the number of food import refusals to the US depended on the food industry groups, country development status, and refusal history.

Because of the complexity and limitation of the refusal data from the FDA for all products imported from different countries, some earlier studies targeted only a particular product or specific country. Emphasizing the most highly-traded commodities with the most violations, Anders and Westra (2011) investigated trends and patterns in U.S import detentions and refusals of seafood products from 2000 to 2010. Their research was also conducted via tabulations of the FDA's refusal data. Their results are consistent with the statement by Buzby and Regmi (2009), that lower-middle income seafood exporting countries account for higher levels of shipment detentions and refusals. As an important source of food imports into the United States, China accounts for the highest number of import refusals from FDA. Therefore, analyzing the FDA refusals of food shipments from China is a typical case for other countries (Gale and Buzby, 2009). These two authors have tabulated the number of refusals of food shipments from China by year, product category, and type of violation in order to characterize potential safety problems in food imports. The result of their statistical description shows that FDA refusals of food shipments from China peaked in early 2007, including mostly fish and shellfish, fruit, and vegetable products.

With more comprehensive investigations, quantitative methods are applied in order to determine the relative importance of factors that influence import refusals. Grant and Anders (2010) also focused on US import refusals and detections in fishery and seafood. Instead of just tabulating historical data, these authors went further by applying the standard gravity model to analyze the potential reorientation of fishery and seafood trade conditional on the refusals imposed by FDA for the time period 1996-2006. Therefore, the new variable added to the conventional gravity model is frequency of FDA refusals. This allows for testing as to whether FDA refusals occurring in the US impact fishery and seafood trade patterns throughout the rest-of-world market. Their results showed that FDA import refusals are significantly correlated with higher exports to markets other than the United States. However, this study had some limitations, such as, it did not consider the spurious relationship of countries exporting both to the US and rest-of-world markets simultaneously. In addition, the authors did not incorporate other information contained in the FDA database such as the value of the refused shipments, the reason for the adulteration, and a shipment originated from a developed or developing country.

Baylis, Martens, and Nogueira (2009) econometrically analyzed the determinants of US import refusals. In their study, imported-food refusals are subject to experience in trade with the US and political or economic pressure. Specifically, the number of refusals is explained by a set of variables including whether the product was refused by EU, perishable product, high-risk product (meat and seafood), new exporter, WTO member, lobbying expenditures, percentage change in price, change in employment, and domestic trade protection (antidumping). The authors determined that six of these nine factors were highly correlated with the number of import refusals. Generally, domestic interests may be influencing the direction and stringency of import food inspections but newer exporters get fewer refusals than established ones. However, their paper did not mention any statistical techniques to test the results. In addition, the risk variable represented by meat and seafood was not consistent because seafood refusals come from FDA, whereas FSIS is responsible for the safety of all other imported meat (except game and exotic meats), poultry, and processed egg products. On the other hand, Jouanjean, Maur, and Shepherd (2012) investigated spillover effects on probability and number of refusals under owner reputation, sector reputation, and neighbor reputation. In fact, in their paper they developed the intuition in Baylis, Martens, and Nogueira (2009) via extending reputation of food itself, related-food products, and sectors. The authors determined that history of compliance of a product itself, related products, and a neighbor country's products have significant effects on both probability and number of refusals. In addition, import quantity, tariff rate, and per capita income are associated with refusals and refusal probability. Although the paper did not mention use of statistical tests for results' accuracy, the conditional fixed effects logit and fixed effect negative binomial models are not the best choice for this type of panel database. One recent study on this topic investigated political influence of the US Food Safety Modernization Act (FSMA) on fruit and vegetable trade (Nakuja, 2012). In this study, the cause-effect relationship between political influence and import refusals was tested for three major exporters to the US: Mexico, Canada, and China. Unemployment rate and antidumping activity were used as proxy variables for political influence, and country-specific exports and alerts are control variables. The author identified that the domestic politics and sector unemployment rate motivated import refusals only from the major exporters of fruits and vegetables into the US market (Mexico and

Canada). Conversely, these variables are not statistically significant with respect to the import refusals from China because China is a relatively smaller exporter of fruit and vegetables in comparison to Mexico, Canada, and Peru. Although Nakuja reviewed significant literature, his result is not convincing since the model eliminated major variable controlling product quality and safety affect refusals. In addition, the endogeneity of import value could affect the model because exchange rate, import price, distance, and trade agreements play a role in import quantity between countries.

Overall, the previous researchers have investigated the domestic political and economic pressure on FDA’s import refusals. However, beside the technical issues related to choosing a model, these researches did not consider variables for product quality and safety as FDA’s target as well as capacity of inspection system. Therefore, together with updating the new data, our paper investigates triggering factors for FDA’s refusals under four groups: 1) FDA's human resource and financial capacity; 2) product-specific characteristics; 3) economic and political pressures in the US and exporting countries; and 4) spillover effects among exporting countries. Moreover, it contributes a major part to the general literature of all categories of FDA refusals including food, drugs, and cosmetics. Accounting for approximately 60% of FDA refusals, the violations of drugs and cosmetics examined in this paper will provide an overall picture of a cause-effect relationship. Because of typical features of panel data, a dynamic panel data model is a more accurate choice for analyzing the data used in this study. The ratio of refusals to import value is used as the dependent variable in order to reduce endogeneity in the model. However, this paper also covers analyses using the number of refusals as a dependent variable in order to compare the results to those of former studies and to help choose the more consistent model.

Model and data

In this paper, we focused on investigating the trigger factors of FDA import refusals from the top-twenty countries which accounted for the major refusals (approximately 81% of total refusal) by FDA for the period 2002 to 2013. Because the collected dataset is panel data (combined cross-sectional of 20 countries and time series of 12 years) with potential issues of autocorrelation, fixed effects/random effects, heteroskedasticity, and endogenous regressors, the linear dynamic panel data (DPD) and negative binomial estimators are more preferable.

The DPD model contains one or more lagged dependent variables as explanatory variables.

A number of DPD estimators are proposed and reviewed to implement with different characteristics. Overall, these estimators are divided into two groups; (1) instrumental estimators, and (2) direct bias correcting estimators (Behr, 2003), in which, the class of instrumental estimators use the lag levels or lag differences as instruments to prevent the bias resulting from correlation between explanatory variables and the error term or endogeneity of dependent and independent variables. These estimators were initially mentioned by Anderson-Hsiao (1981) based on a variation form of the original equation. In 1991, Arellano and Bond exploited additional moment restrictions, based on the Anderson-Hsiao estimator, to enlarge the set of instruments called least square dummy variable (LSDV) estimator and generalized method of moments (GMM) estimator. In addition, the Blundell and Bond (2000) estimator used the information contained in differences instead of instruments to improve the estimation, which was fundamentally based on the instrumental variable (IV) estimation once it uses all available lags at each period as instruments for the equation in the first difference. Recently, the system GMM estimator has been proposed as more effective since both the lags of the level and first difference are instruments.

Bias correction in the DPD model is developed to correct the bias on original estimators related to weakly exogenous regressors and time-dominant data of the LSDV estimator. This approach is initially mentioned by Nickell (1981) to show the inconsistence for first order autoregressive within a fixed time period and infinitive individual dataset. In 1995, Kiviet derived an approximation formula for the bias of the ordinary LSDV estimator in the first-order stable dynamic panel data model with normal disturbances and a scalar covariance matrix. Other methods to correct the bias or inconsistence of dynamic panel data estimators have been investigated by Hansen (2001) and Hahn, Kuersteiner, and Hyeon (2004). Bun and Carree (2005) derived the bias-corrected estimator for finite number of time periods and larger number of cross-section units under the assumption of homoscedasticity or to extend the framework of both time-series and cross-section heteroscedasticity disturbances. Because all LSDV, IV, and GMM estimators are dealing with bias and inconsistence, Everaert and Pozzi (2007) corrected the LSDV estimator using an iterative bootstrap algorithm.

Suppose the dynamic panel model for refusals of a country *i* for year *t* (R_{it}) is characterized by the presence of a lagged dependent variable among the explanatory variables as:

$R_{it} = \gamma R_{i,t-1} + \beta X'_{it} + \alpha_i + \mu_{it}$

i = 1,…, 20 (cross-sectional dimension) and *t* = 1, ..., 12 (time dimension) (1)

where, R_{it} is a scalar dependent variable, X_{it} is a K x 1 vector of independent variables, $R_{i,t-1}$ is the lag of scalar dependent variable, μ_{it} is a two-way error component model in which $\mu_{it} = \eta_i + \lambda_t + v_{it}$; η_i is individual effects and λ_t is time effects, both are constant for given *i* over *t* and for given *t* over *i*, respectively; v_{it} represents the unobserved random shocks over *i* and *t*; and both η_i and λ_t are assumed to follow either the fixed effects (FE) model or the random effects (RE) model.

The assumptions in this model are (1) the model is full rank in regression analysis: $rank\left(E\left(X_{i,t}X'_{i,t}\right)\right) = K$, (2) explanatory variables are strictly exogenous: $E\left(\varepsilon_{i,t}/X_{\iota,\tau}\right) = 0\ for\ all\ (i,t,\iota,\tau)$, and (3) there is no serial correlation in the error terms: $E\left(\varepsilon_{i,t}\varepsilon_{\iota,\tau}/X\right) = 0 \text{ for } (\mathrm{i},\mathrm{t}) \neq \text{all } (\iota,\tau)$

The models with number of refusals and ratio of refusal are the dependent variable formed as following:

$$\text{Refusal}_i = \alpha + \beta_0\text{Refusal}_{i,\,t-1} + \text{Staff}_i.\beta_1 + \text{Inspt}_{it}.\beta_2 + \text{FSMA}_{it}.\beta_3 + \text{FSMAType}_{it}.\beta_4 + \text{FDAFPO}_{it}.\beta_5 + \text{Dtype}_{it}.\beta_6 + \text{GDP}_{it}.\beta_7 + \text{ltttradet}_{it}.\beta_8 + \text{Unempt}_{it}.\beta_9 + \text{AD}_{it}.\beta_{10} + \text{llobbyt}_{it}.\beta_{11} + \text{Countryi}_{it}.\beta_{12} + \text{lExport}_{it}.\beta_{13} + \text{Corrupt}_{it}.\beta_{14} + \text{Scandal}_{it}.\beta_{15} + \text{Spillover}_{it}.\beta_{16} + \text{WTO}_{it}.\beta_{17} + \text{English}_{it}.\beta_{18} + \text{Fretrade}_{it}.\beta_{19} + \text{Bitrade}_{it}.\beta_{20} + \mu_{it} \quad (5)$$

The simplest model to deal with this panel data is the within-group estimator characterized by the coefficient of the lagged dependent variable and it is downward biased. This bias only disappears after increasing the time series dimension (Santos and Barrios, 2011). In order to deal with inconsistency of the within group estimator, the instrumental variable (IV) of either the dependent variable is lagged two periods or its first differences are recommended. However, like the fixed effects model, the coefficients of time-invariant regressors are not estimable by differencing. As a result, only the coefficients of time-varying regressors will be identified. Therefore, the two-stage least square estimation or one-step GMM using dynamic panel estimator is applied in this paper.

Overall, for the time small and individual large data, GMM performs better than LSDV (Bun and Carree, 2005). In addition, the data for this paper does not necessarily follow a conventional assumption that regressors strongly exogenous. This data show two features of endogenous variables and lagged dependent variables as regressors. Therefore, panel GMM provides consistent estimates when OLS does not. However, the dynamic panel GMM estimator is used to control for endogeneity and autocorrelation issues. Particularly, the two-stage least square estimation or one-step GMM implies that a model can be obtained in the two stages which (1) predictors of regressors are yielded from instruments, and (2) the dependent variable is estimated relying on the predictors of regressors.

FDA plays a critical role in ensuring the safety and efficiency of imported food, medical, and cosmetic products. Therefore, FDA staff numbers and their experience play an important role in operating the system and implementing inspections; and consequently, affect the number of refusals. It is assumed that the higher the working staff numbers are for the FDA, the greater the number of inspections performed and the larger the number of violations identified. As a result, staff numbers or number of inspections can contribute to the number of refusals. On the other hand, FDA's annual budget will impact whether it can sustain and expand its mission of protecting and promoting the health and well-being of the American people (DHHS, 2014). With limited funding or budget cuts, FDA could reduce imported inspections and staffs presence overseas. Because the appearance of a violation may be based on the testing of foreign samples, fewer inspections may imply that the number of refusals may also be reduced. Overall, number of employees, inspections, and the budget scenario of FDA can all cause collinearity in the model. Test results and chosen variables will be presented in the results and discussion. Moreover, FDA regulations, programs, and innovations would have a strong effect on its operational system efficiency, specifically on import refusals. Up to now, hundreds of rules and regulations have been issued to upgrade FDA's authority to deal with not only fast-growth globalization and imports, but also with rapid development of many domestic products. This research focuses on only two recent laws that improve FDA's position in dealing with these issues. The first law is The FDA Food Safety Modernization Act (FSMA), established in early 2011, considered as the first overhaul of food safety laws in more than 70 years. Although this Act strengthens FDA's powers to prevent, detect, and respond to food safety issues, it nevertheless affects the budget and inspectors for drugs and cosmetics. The relationship between the FSMA and refusals is expected to be positive once the scan system is improved and more inspections are conducted. However, if the inspectors and the funds are controlled, there could be more concentration on food safety, with less FDA resources allocated to drug and cosmetics.

Consequently, fewer inspections for drugs and cosmetics could decrease the total number of refusals. Overall, the total refusals may increase or decrease or remain stable, depending on FDA resource allocation. In order to eliminate inaccurate influence of this program on drug and cosmetic refusals, the dummy variable for before and after this program will be used to interact with whether refusals are related to food, drug or cosmetics. Another significant change for FDA came in late 2008 or early 2009, when the agency established representative offices in particular countries or regions beside its main office in the homeland country. One of the major activities of FDA's foreign offices is to ensure product quality and safety and conduct foreign inspections in order to prevent problems before they occur, thereby preventing products that do not meet FDA requirements from reaching any of the US ports of entry (FDA, 2012). FDA's overseas staff can often obtain information that is more complete, accurate, timely, and robust than information obtained from US locations and sources. The presence of these foreign offices obviously reduces the violations from exporting countries in those cases where FDA inspectors work efficiently in these countries to improve the safety of imported food and medical products. Countries and regions where FDA has established oversea offices include Mexico, China, India, the Middle East, Europe, and Latin America. This variable is dummied as one if the FDA opens an office in a specific country and zero otherwise. This variable indicates not only the relationship between import refusals and whether an FDA foreign office exists or not but also the efficiency of these offices in providing information to support FDA's strategy.

Although there is no available variable representing the quality of imported products, the proxy indicators nevertheless can determine whether FDA rejects merchandise due to its quality violations. The FDA data from 1998 to 2004 show that the top imported food categories refused due to safety and other violations were vegetable and vegetable products, fishery and seafood products, and fruits and fruit products. These products were refused due to such risks of perishable, contaminated, and mainly imported from developing countries. This paper does not go into detail of these products, instead it classifies the imported merchandise into three major categories of food, drugs, and cosmetics. Although drugs and cosmetic products have some similar features in terms of transportation risks and potential contamination, food, medical, and cosmetic products, obviously, have different features in terms of quality measurement and storage conditions. Hence, a dummy variable for the three cases of food, drug, and cosmetics is applied to identify whether the refusals or ratio of refusal is different among these types of products. Food, for example, is expected to have a higher number refusals or ratio of refusals compared to medical and cosmetic products, because not only is food the higher imported proportion but also the most perishable and most likely to be contaminated. Another proxy indicator for product quality is past import refusals from a specific country. Because of limited resources, FDA now detains or refuses to import certain products based on past history (Becker, 2008). Therefore, the correlation between past and present import refusals named as owner reputation (Jouanjean, Maur, and Shepherd, 2012) is expected to be positive. In other words, any country with history of compliance will have fewer refusals and vice versa.

This research also intends to quantify the economic and political pressures applied in the US and exporting countries, and how these impact number of refusals and ratio of refusals. In particular, Gross Domestic Production (GDP) per capita and total import value are representive of the domestic economic status of a country. Although GDP per capita is not an accurate indicator for economic growth, it is assumed to have a positive correlation with import refusals. GDP growth leads to an increase in imports because of higher domestic demand and the higher import causes higher refusals. Even though GDP per capita and import value would be collinear, the import value is still measured in this model to identify the hidden pressure of domestic economic policy on FDA inspections. If FDA is influenced to protect the domestic economy or domestic manufactures, then a specific country's imports into the US could be restricted by increasing refusal to protect domestic production. The sign of refusal-ratio and import-value coefficient is expected to be positive. On the other hand, the correlation between domestic politics and import demand or trade policy have been mentioned by Helpman (1995), Goldberg and Maggi (1999), and Lopez and Matschke (2005), and impact of political pressure and import refusals have been investigated. A positive correlation between political pressure and number of refusals has been tested in the food industry by Baylis, Martens and Nogueira (2009) and Nakuja (2012). This study is extended to examine the effect of domestic politics on ratio of refusals, with unemployment rate, the US-antidumping user, and lobbying expenditure used as proxy variables for political pressure. Unemployment rate is one of the major indicators that reflects the economic and political policies in every country. Wherever a country experiences growth in unemployment rate, the government will change trade policy to protect its domestic industry. It is hypothesized that such a rise in unemployment rate will be associated with an increase in import refusals. Antidumping cases are usually initiated by producers of products in the US that are experiencing a loss of market share or profits due to lower priced imports of foreign like products. Such cases are usually initiated by domestic groups pressuring politicians to impose import restrictions; hence it gives the effect on industry-specific international trade. The dummy variable used to estimate the effect of antidumping on import refusals is equal to one if an antidumping case was filed against a country in the previous year. This coefficient is expected to be negative within antidumping cases. Finally, the rent-seeking interested group may lobby the US government to minimize the amount of imports into the US, which would cause rising import refusals. We would expect greater lobby expenditure by a specific industry to result in higher import refusals. The lobby expenditure is measured as the amount of money spent on the food and medical and cosmetic industries. In order to figure out the influence of lobby expenditure in each industry, this variable is interacted with a dummy variable representing type of products. The coefficients will explain whether lobby spending on food and medical and cosmetic industries affect the food-imported refusals or medical and cosmetics-imported refusals, respectively.

Some studies have found that an exporting country's economic growth can influence import refusals (Baylis, Martens, and Nogueira, 2009; Grant and Anders, 2010; Jouanjean, Maur, and Shepherd, 2012). This study measures this effect via proxy variables, including country-income classification (high, low, or middle), exporting value, and corruption perceptions index. Theoretically, an exporting with lower income should have more import refusals. Such a trend in reflected in developing countries since many of them have no extensive food safety systems, and do not have the appropriate infrastructure in place to develop such a system so they can not comply with export acquirements. On the other hand, safety regulations could in fact benefit producers in developing countries by forcing technological progress and learning through the implementation of stricter standards, thereby, creating a competitive advantage that could lead to gains in international trade. Hence, the correlation between import refusals and a country's income is expected to be negative. The richer countries will get fewer rejections. Export value for a country also has potential to affect the number of import refusals, because it can be assumed that the higher the value of a country's exports to the US, the greater the number of refusals that would be issued. Hence, the expected sign of this factor is positive. In order to eliminate the multicolinearity issue in the model, the ratio of exporting value to GDP is used for a consistent comparison among countries. Getting a high ratio implies that a country has more experience in exporting into the US market, and that it could identify a strategy to reduce import refusals. This coefficient is assumed to be negative. Another indicator for the exporting country's economic development is corruption perception index (CPI). This index scores countries based on how corrupt a country's public sector is perceived to be. The rank is scaled from 0 to 100, where 0 means that a country is perceived to be highly corrupt and 100 means that a country is perceived as being very clean. The cleaner country would be expected to have less import refusals.

There is little information in the literature about spillover effects of import refusals. Baylis, Martens, and Nogueira (2009) are the first researchers to analyze this effect. The authors presumed that if EU countries find a product-country pair violation, the FDA would see this as cause for increased vigilance in their inspections. The latest research on a sector-spillover effect and a neighbor-spillover effect was conducted by Jouanjean, Maur, and Shepherd (2012). The probability of refusals and number of refusals for a particular product or a given product from a particular country might be more likely if their closely related products or neighboring exporters of the same product has a history of non-compliance. In this study I use two proxy variables of spillover effects. The first one is the China imported food scandal in 2008, and the second is past refusals of the most influential countries in the world free zone convention to include India, China and South East Asia, Middle East, North and South America, Russia and Central Asia, Europe, and Africa. One of the top food scandals that shocked the world occurred in 2008 when high levels of the industrial chemical melamine was found in powdered and ordinary milk from leading companies across China. The scandal sparked worldwide food safety concerns. As a result, FDA issued an alert which called for "detention without physical examination of all milk products, milk derived ingredients and finished food products containing milk from China due to the presence of melamine and/or melamine analogs". Therefore, a test of the effects of this scandal on import refusals since FDA would be expected to take a more serious look at these imported products is implemented. The dummy variable equals to one for every country after 2008, is used to to test whether the scandal about unsafe food from China impacted import refusals from other countries. This variable may not only present the spillover effect from China into other countries but also show whether a food scandal can cause changes in refusals of drugs and cosmetics. On the other hand, the lag refusal of the most effective-neighbor country is assumed to have a positive relationship with country-specific refusals. In this case, the most effective-neighbor country is a country that got the highest number of refusals in the same free zone convention. We assume that imports from a country are less likely to be rejected if its neighbor has a history of compliance.

We also control other factors that have potential influence on the number of import refusals or ratio of import refusals. One possible factor that can change the number of refusals is experience of the exporting country. It is assumed that new exporters may have more difficulty meeting US import standards than traditional more experienced exporters. This variable is represented by the number of years that a country has been a member of the World Trade Organization (WTO), and it is expected to have a positive effect sign. Inaccurate labeling and a manufacture's lack of proper registration are common violations diagnosed by the FDA. Labeling mistakes usually show a lack of clear English labeling to identify the ingredients, nutritional information, weight, etc. Such mistakes accounted for 22% of 2007-08 violations from China. Whereas, lack of proper registration generally occurs when a manufacture fails to file information on its scheduled process, or fails to register its plant with FDA if they produce low-acid canned food. Hence, exports from English-speaking countries might be less likely to be rejected because the exporters can more easily interpret and meet US English requirements. A dummy variable equals one if the exporter is an English-speaking country, and it is expected to be a negative effect. Lastly, imports from countries that have a free trade or bilateral trade agreement with the US are less likely to have their products rejected because the exporters have more experience in exporting into the US. They have also investigated the processes and information they need to know to meet the US import requirements.

Since all above explanatory variables are inserted into a model the multicolinearity may be an issue. The model is tested to determine a set of significant variables in terms of both statistics and reality.

Data

Monthly data are more appropriate to reflect changes in FDA policies related to quality or safety scandals. However, some macro indicators are not available for monthly (GDP, CPI, lobby expenditure, antidumping, and FDA budget), so the SPLINE method for transferring annual data into monthly data was applied. Consequently, a multicolinearity error exists in the model. Therefore, this paper uses annual data instead of monthly data for the analyses and results are presented in the next part.

Data from the FDA website listed total refusals of 290, 200 for a period from Jan. 2002 to Dec. 2013, in which, the number of refusals by the top-20 countries was 228,968. In particular, the drug refusals accounted for 55.36%, food refusals accounted for 39.59%, and the last 5.05% was cosmetics refusals. Number of FDA employees was collected from FedScope, US Office of Personnel Management from 2002 to 2013 annually. The inspection observations were also collected from this website, where FDA's Office of Regulatory Affairs was the lead office for all field activities including inspections. Observations for annual inspection observations were available only for a period from 2006 to 2013. The former years, from 2002 to 2005 were traced based on refusals because both refusals and inspections reflect the producers' compliance values for FDA's annual budget allocation. Outlays of the US Department of Health and Human Services (HHS), were collected from the HHS annual budget reports from 2002 to 2013. In addition, information on the Food Safety Modernization Act and FDA's foreign offices were also obtained from FDA's website.

The GDP per capital of the US and exporting countries and exporting-country classification based on country income of high, middle, or low were obtained from the World Bank's World Development Indicators and United Nation Accounts (2014). Annual US total imports in millions of dollars, with seasonal adjustment, were taken from US foreign trade census data on the historical series of international trade in goods and services. we used a US Bureau of Labor Statistics database to obtain annual unemployment rates. Antidumping data are presented as annual-accumulated-antidumping cases given by the Global Antidumping Database, World Bank (2014). Lobby data were sourced from the Center for Responsive Politics. I classified annual lobby expenditure for the food industry and drug and cosmetic industries by filtering the expenditure by industry. The food lobby cost includes expenditures for agricultural service/products, food processing and sales, crop production and basic processing, dairy, livestock, poultry and eggs, and miscellaneous agriculture. The lobby expenditure for health includes pharmaceuticals/heath products, health professionals, hospitals/nursing homes, health services, and other miscellaneous health costs of the drug and cosmetic industry. Spillover effects by region were sourced from the world free zone convention. we obtained information on English-official-language countries from The Nation's Leading English Advocates. Years that exporters have been a member of WTO are obtained from the WTO website, and information on bilateral trade and free trade with the US was collected from the US International Trade Commission and the US International Trade Administration.

Results and discussion

Model tests and bootstrap

Distribution of residuals and plot of residuals for number of refusals and refusal ratio show some distortions and non-white-noise. In addition, the Hausman test shows that data issues related to both fixed effects and random effects exist in both models.

Test for serial autocorrelation by the Wooldridge test shows autocorrelation of number of refusals in the model (in the context of panel data), with the null hypothesis (H_0) indicating that there is no serial correlation in this specification, and the alternative hypothesis indicating a serial correlation with idiosyncratic errors. The Fisher statistic in the model of refusals (model 1) is equal to 43.374 (p=0.000), which implies that the hypothesis of no serial correlation is strongly rejected. Moreover, the test for heteroskedasticity is determined by the Breusch-Pagan test with the null hypothesis indicating homoskedasticity. the model shows the chi square distribution is equal to 5163.76 (p=0.000). Hence, the null hypothesis of non-heteroskedasticity is strongly rejected. In other words, heteroskedasticity exists in this database. In order to manage these issues and bootstrap for model 1, the GMM estimator, developed by Arellano and Bond (1991) and named the two-step GMM estimator, is used to deal efficiently with autoregressive and heteroskedasticity data. This choice also follows recommendations from the literature review, which indicates that the GMM estimator performs well for panels with wider cross-sectional dimensions. On the other hand, the Hausman test identifies endogeneity with the US total import values, total value of country-specific exports, and the FDA's number of staff. The variables of exchange rate and the FDA annual budget serve as instruments. The tests show that all three variables are valid endogenous variables. Therefore, the Dynamic Panel Model of two-step GMM is applied for analyzing factors influent the FDA import refusals and ratio of refusal. Finally, we use the robust option to obtain robust standard errors for the parameter estimates as recommended by Cameron and Trivedi (2009) to control for mild violation of underlying assumptions.

Factors Affecting of number of refusals

The output presented in table 1 in the appendix result from using the estimator Eviews. The two-step Sargan test rejects the validity of the null hypothesis of overidentifying restrictions. Whereas, the two-step Hansen test indicates that the overidentification restrictions are valid. The paper uses the Hansen test instead of the Sargan test to accept the valid instruments. The Hansen test is used because it is more robust than the Sargan test which is not distributed as chi-square under heteroskedasticity, and because the number of instruments is greater than the number of groups. In other words, the heteroskedasticity and many instruments could cause the Sargan test to incorrectly reject the null hypothesis. On the other hand, the Arellano-Bond test for the first-order serial correlation rejects the null hypothesis of no first-order serial correlation, but it does not reject the null hypothesis of there being no second-order serial correlation. These are what we expected from overidentification and autocorrelation diagnostics in the two-step GMM estimation. Moreover, the result of this model is also robust to have consistent standard errors with panel-specific autocorrelation and heteroskedasticity.

Overall, most of the coefficients in the Panel dynamic two-step GMM model have the expected signs and are statistically significant. In particular, the first group of variables that represents effects of exporter's and importer's economic development on the number of import violations. There variables are considered as proxies for product quality as well as its characteristics. A variable used to represent importer economic growth is the US GDP per capita. For this variable, the higher the economic development, the less the number of refusals diagnosed. Although the import proportion increases gradually in comparison to annual American consumption, domestic economic development has a negative effect on refusals. This implies that increased US economic growth does not put more pressure on FDA to better inspect imports or the American importers in order to improve their classification or choose better importers who have less violation. However, this variable is not statistically significant. As expected, the GDP per capita of an exporter has a negative influence on import violations. In particular, the number of refusals is reduced by 0.9% when the GDP per capita of these countries increase by 10%. This makes sense since the standard system of management and more technologically advanced applications in richer countries are better than those in the less developed countries. In other words, those countries with a higher GDP can invest more on exporting in terms of technological improvements, updated legislation, and more financial support to help their exporters do a better job of complying with FDA regulations and requirements. This result is consistent with the conclusions of Baylis et al. (2009) and Buzby and Regmi (2009), and indicates that lower-income countries do not have as extensive or effective food safety standards, practices, and regulations in place as the US or other more-developed countries. Another statistically significant factor that supports this result is country-income classification. This coefficient shows that high-income countries got 1.46% less rejections than the low-income countries. However, the difference in violations between low-income countries and the upper-average-income countries is not statistically significant. More important, both GDP per capital variable and country income classification in the model cause an issue with multicollinearity. Therefore, the country classification variable has been removed from the model because the GDP per capita can represent for country classification. The estimation output also shows that the index of corruption perceptions of export countries generates a positive effect on violations, although it is not significant in statistical terms. Another variable that effected import refusals, as we expected in terms of magnitude and sign, is export value for exporters. The coefficient indicates that a 10% increase in export values causes the rejection numbers to increase by 0.26%. This implies that when the export of a country grows into the US market that would be a pressure on the US production. As a result, the inspection will increase and the violation is more detected. Although a country exports more into the US market would put more emphasis on understanding US import requirements in order to reduce the risk of rejections. In other words, a country with more export has a competitive advantage in exports in comparison to countries with less export. However, the result shows that the more export into the US market the more rejections is revealed.

The second group of variables is presenting for capacity and principle of the agent that is responding to issue refusal once the importing products do not comply with the US safety and quality requirements. These variables are the FDA human and financial resources, number of employees, establishment of an FDA office in a particular country, and implementation of the Food Safety Modernization Act, all present impacts on number of annual refusals, and some are statistical significant. For instance, the more staffs are employed, the more refusals are issued. It implies that the FDA would be expected to implement more inspections as more employees are hired. More inspections would be expected to lead to more rejections. The elasticity indicates that if FDA’s staff increases by 1%, the number of refusals would grow by 0.86%. With more technicians for each inspection site, FDA could be more efficient and generate a larger archive due to shorter-time investigations. They could also inspect a larger proportion of imported goods and diagnose more violations. The statistical data show that the number of FDA employees rose 2.78% annually for a period from 2002 to 2013, whereas the number of inspections grew by 2.25% each year on average from 2008 to 2013. The analysis presented in this paper does not cover the influence of inspections on refusals, because the statistical data for inspections before 2008 is not available. The FDA could use more inspectors because of the increased volume of FDA-regulated products in both domestic and foreign markets during recent years. However, information presented in this paper is limited to the effect of FDA staff numbers on refusal quantity efficiency, without any detailed analysis of product variety or expert demand of specific industry inspections. In addition, the FDA examination process shows that not all violated products go to inspection or refusals only after inspecting. The refusals can be issued without inspection if the FDA obviously realizes the violation of imports through initial evaluation.

Recently, the US significantly expanded imports of goods and services from around the globe, and FDA set up inspection offices in the top exporting countries. This is viewed as an essential manner to better collaborate with foreign government counterparts to prevent unsafe problems before actual goods reach the US market. A dummy variable is used for two cases where FDA post is established in a specific export country, and for the main office in the US. The number of import refusals decreases when FDA establishes a representative office, regardless of whether it is in the US or in the export country. This variable is statistically significant at the 5% level. In other words, the FDA office existing in a particular country contributes to reduce import violation. In particular, the presence of FDA representatives in a foreign country contribute to diminished violations from that country by 37% per year. This result proves the efficiency and necessity for having an FDA office located in an export country.

On the other hand, the FSMA that was recently signed into law resulted in significant effects on import refusals, but only for food products and not for drugs and cosmetics. This program proves to have significant impacts once it was applied in a broader scope in 2011. Specifically, the program causes the number of violation diagnoses from foods, cosmetics, and drugs to increase by 21%, 47%, and 53%, respectively. Although this Act may provide lagged effects and have not implemented completely , it shows initially significant effects right after it is implemented. In addition, up to the latest data available in 2013, this program has been implementing for only two years. Hence, this paper does not mention any lagged effects from this program. The effects of this program on refusals of drugs and cosmetics, however, imply that although FDA establishes a special Act that targets a particular product, the program also influences other products and causes changes in the overall operation of the FDA system. Moreover, FDA apparently does not allocate more resources just for the imported food program, but simultaneously concentrates more on cosmetics and drugs as well. As a result, when this program is implemented, more violations are diagnosed and more products are rejected. As unexpected, FDA funding provides a negative effect on the number of refusals. Eventhough the FDA budget increased gradually from 2002 to 2013, at an average of 8% per year, this growth does not show a statistically significant influence on the number of import rejections. This funding growth may have been offset by inflation or increased wages that did not allow FDA to hire more employees, or encourage current employees to work more efficiently. However, the number of staffs variable and budget variable has multicollinearity in the model and FDA budget is valid instrument for number of staffs. Therefore, the FDA budget is removed off the model and played as an instrumental variable.

A group of proxy variables used to represent product quality, overall, has expected effects in terms of size and significance. The number of violations is different among food, drug, and cosmetic imports, with food rejections higher than drug rejections by 14%, and cosmetic imports violated less than food imports by 46%. Obviously, these results support the assumptions that higher-risk food products have more violations because they are more perishable and more easily contaminated once in transport in comparison to cosmetics and drugs. Cosmetics being rejected less than drugs could imply that cosmetics are not as likely to cause serious injury or death as drugs or food. Thus, the requirements and inspection levels for these products are not as tight as for drugs. For instance, FDA does not require the cosmetic firms to register their establishments, file cosmetic product ingredients, or have a registration number for cosmetics imported into the United States.

More important, regression result also supports the former conclusion that FDA refusals is historical path. Particularly, at the 1% level of significance, a 10% growth in past import refusals has a 16.6% positive effect on current refusals for cosmetics. This result indicates that FDA may rely somewhat on a product’s compliance history profile to refuse a particular product. Under this hypothesis, if a product in a specific country had a good compliance last year, it would be at less risk for rejection in the current year. This output agrees with the literature review that rejections can be path dependent because FDA has limited resources.

The next factor group studies are the factors representative of US political pressures on FDA's import rejections, provides expected signs and statistical significance. The first variable, that shows a positive effect and is statistical significant at the 10% level, is annual US unemployment rate. A 10% growth in unemployment rate causes the refusal numbers to increase by 0.92%. Obviously, the significance of this factor proves that domestic economic and political circumstances can influence FDA actions. According to our analysis, when unemployment rate is higher, the government would encourage domestic enterprises to employ more US workers. In order to create more US jobs, these enterprises would need to be protected via reduction in competition from export products. As a result, import restrictions would be applied to reduce foreign exports and this would simultaneously increase the possibility of import rejections. Another political factor that influences import violations is US annual lobby expenditures from different industries. This variable is interactive with the type of industry, so we examine whether lobby from the food industry impacts food rejections or whether lobby from the drug and cosmetic industry causes changes in refusal numbers for these products. The analysis indicates that lobby in the food industry and in the drug and cosmetic industry cause positive effects on import refusals for both industries. This can be explained by the fact that domestic industries lobby government to seek more protectionism and this happens via minimizing the mount of imports accepted into the country. The greater the lobby expenditure, the more congress reacts to protect domestic producers, sometimes via imposing illegitimate, overly strict, or excessively costly standards to eliminate foreign competition. As a result, the model used indicates that import refusals would rise by 1% when lobby expenditure for food industry increases by 1%. The last political factor that shows a statistically significant affect on import refusals is US implementing antidumping with their trade partners. The principle of how antidumping protects domestic producers is not much different from industry lobby payments. Countries with more antidumping implemented by the US Department of Commerce, the International Trade Commission (ITC), and US Customs and Border Protection, leads FDA to inspect more of their imports or spend more time on the inspections of their products. This results in a greater portion of a country's product being refused for import.

Turning to the group of factors representative for spillover effects, this research finds that not all signs and magnitudes are statistically significant from the1% to 10% level. Particularly, the dummy variable for the China food scandal in 2008 causes a positive effect on import rejections just only in 2008 but the number of refusals reduced in the later years. By comparison with refusals before and after, the violation number in this year was higher than other years by 21.9%. Because of the fast response of food, drug and cosmetic industries to scandal and the high flexibility of FDA to unsafe events, the food scandal is most pronounced the same year because FDA immediately decides to reject every import product related to melamine-contaminated milk. However, just one year after the scandal, the refusals are reduced substantially. This occurs because import countries concentrate more on either following US import standards or because they are so alarmed by the high possibility of rejections they improve their own production technology. However, this variables is not statistical significant. It implies that the food scandal in 2008 did not significantly affect the US import violation. It is reasonable when this scandal only occurred in the food industry and the FDA's regulations and principles are well prepared and consistent. However, since 2008 was also a year of global economic crisis, imports and exports from many countries also changed. Figure 1 & 2 shows the US imports from these countries decreased in 2008 to 2009,

Another statistically significant variable is neighbor refusal effects. This effect is examined by using the correlation of refusals between a country and refusals of their highest-rejected neighbor country in the same global economic region. This variable is statistical significant at a 1% level and positive. It implies that when the refusals from most violated country in a region increase by 1%, the imports by neighbor country is likely rejected by 0.3%.

The other explanatory variables related to US import refusals, that resulted in significant effects on import violations, are years a country has been a WTO member, whether a country has signed a free trade agreement with the US, and whether a country uses English as an official language or not. The effect of the WTO member variable is negative, as expected, and statistically significant at the 5% level. The longer a country has membership in WTO, the fewer the number of import refusals. This indicator reveals that the more experience a country has in international trade deals, the less likely the risk of their imports being rejected. On the other hand, any country with English as its official language does not necessarily receive lower rejection numbers. Conversely, this country appears to have a high number of refusals in comparison to a country that does not use English as an official language. A reasonable explanation for this pattern could be because a country uses English does not mean it necessarily follows the US requirements for labeling or product information, and these failures do not account for high in the total refusals either. Country classification by economic regions also has a statistically significant effect on import refusals. The results show that export countries from both the Americas and Caribbean, as well as from the European Union, have more violations in comparison to countries from Asia. However, only difference from American and Caribbean shows statistically significant influence by 9.5% in comparison to refusals from the Asian region. Finally, countries that have signed a free trade agreement with the US receive more import rejections. Evidently, having a signed trade agreement with the US does not mean a country can export their products into the US market any easier. However, the positive effect of increased refusals with these free trade countries could be related to the fact that they export more products into the US market. As a result, the more they export, the greater the number of inspections, which could cause more refused while the overall percentage of refused is still very low.

Triggering factors of refusal ratio

In this part, we also use the similar model with number of refusals. The only difference is dependent variable is refusal ratio. It is a ratio of number of refusal for a country dividing totoal exporting values of this country into the US market. This ratio is used in order to eliminate the biases caused by the endogenous variable of export values. It is expected, that with use of the ratio of refusals instead of refusal numbers, various factors can be more appropriately assessed for their triggering effects. Overall, regression result provides effect signs that are consistent with those of the first model, but the number of statistically significant variables have been dropped some. Specifically, within the group of factors representing FDA human and financial resources, the FDA annual fund allocation, and number of FDA staff personnel, there is no statistically significant effect on the refusal ratio. However, the factor representative of FDA office location, whether in the US or in a specific country, contributes to a increase in import violations. In addition, implementation of the FSMA causes the number of refusals per million of US dollars in export value to increase. These results further support the theory that efficiency of FDA is enhanced by establishment of additional offices to achieve the goal of diminishing violations before products reach the US market. Conversely, FDA's current violation ratio does not relate to its history of compliance and there is no difference of refusal ratio among food, cosmetics, and drugs.

For factors representative of economic and political conditions in the domestic and exporter markets, most variables are consistent with those of the first model in terms of sign effect and statistical significance. Exceptions are the number for antidumping, which does not show a statistically significant impact on ratio of refusal, and the CPI index, which does not adjust the violation per export value. The negative marginal effect of the antidumping variable implies that a country with higher antidumping into the US would have less violation per export value. This means that countries with more antidumping must either lessen their exports into the US market or improve their quality to better follow FDA requirements to avoid risk of rejection.

On the other hand, the variables of spillover effect related to the China food scandal in 2008 do not show any effect on the refusal ratio in 2008. However, the ratio of violation is lessened in 2009, just one year after the scandal occurred, and the other years after 2009 have no significant effects on the ratio. This response is understandable, because right after the food safety scandal, FDA take action to prevent several types of food products from being imported into the US market without a thorough field inspection.

Moreover, the spillover effect of refusal ratio from highest violated country on refusal ratio of a specific country is again statistical and positive. In other words, with a 10% increase in refusal from the neighbor country, the possibility to be rejected of a country is 0.02%. This effect is relatively small but it is a sign to reveal a spillover effect among countries in a region.

Conclusions

The FDA plays an important role in ensuring that imported products are safe and wholesome for American citizens. US imports have increased gradually during recent years and now account for a significant portion of domestic consumption, especially food products. Therefore, FDA inspection and approval procedures for import entrance into the US market, is interest not only to domestic consumers but also to US trade partners. This study has investigated factors that influence FDA's decision to reject or approve a product. The hypothesis is proposed that other than product quality and safety indicators, FDA's decisions may also be influenced by their financial and human resource capacity, by economic and political pressures in the US as well as in the export countries, by compliance history of the product and export country, and by the neighbor country's reputation. The analyses are based on the annual panel data collected from 2002 to 2013 for the top twenty countries with the highest number of rejections by FDA during this period. The number of annual refusals from each country for food, drug, and cosmetics served as the dependent variable in the basic model. In addition, the model is adjusted to use the dependent variable ratio of refusals to million dollars of export value to solve the issues related to endogeneity and make the model more robust. Because autocorrelation occurs in both the model using number of refusals and the ratio of refusals model, the two-step GMM estimation for dynamic panel data is appropriate. Robust techniques are applied for both these models to improve the standard deviation and generate more accurately estimated coefficients. Although there is no indicator to conclude which is the better model, the number of refusals model is more statistical significant and higher explanatory power. In addition, this model is more robust once an export value has a big significant explanatory variable to cause bias of other factors.

Overall, both models provide similar effect signs and statistical significance. The models give proof that FDA's decisions to reject or accept imports depends on four groups of factors. These factors include FDA's human resource and financial capacity, product-specific characteristics, economic and political pressures in the US and exporting countries, and spillover effects among exporting countries. As expected, a greater number of FDA employees and the FSMA program provide a positive influence on violation diagnoses and, thus, more refusals. In addition, whether FDA has other representative offices located in a specific exporting country or in the US itself result in a reduction in violations. Even though, increased FDA annual fund has a negative effect on rejections, this variable is not statistically significant. The only variable representative of product quality shows that total annual refusals are different among food, drug, and cosmetic products, with rejections for food being the highest. This result is not consistent with that of the refusal ratio model. Although US GDP per capita does not impact either refusal number or refusal ratio, the exporter's GDP per capita has a negative effect on import rejection. As expected, the indicator of corruption perception index provides a significant influence on refusal number and refusal ratio. Two factors representative for pressures from US politics on FDA decisions prove to be statistically significant, with positive signs for unemployment rate and domestic lobby expenditures. There are significant spillover effects from neighbor country's refusals. The China food scandal in 2008 did not provide significant impact on number refusal as well as refusal ratio.Other factors, which show a significant impact on FDA's rejections are, trade agreement with the US, English as official language, number of years a country has been a WTO member, and number of antidumping the US had assigned to the exporter. Results also showed that violations are significantly different among economic regions, with EU countries dealing with the lowest rejections and Asian countries the highest. Finally, both number of refusals and ratio of refusals are path dependent.

In this study, as many factors as possible are combined to explain FDA's import rejections. The hypothesis that the factors besides product quality and safety impact FDA's decision to approve or reject imports has been substantiated. In fact, this work shows that, economic and political pressures, and FDA self-capacity all contribute significantly to FDA decisions. The models, both present nearly consistent results. However, the annual data in these models may not accurately reflect past responses of FDA to changes of explanatory factors, especially in reference to food scandals and standards. In addition, food, cosmetic, and drug products all covered in the models may not accurately reflect the difference in import quality because there are other individual features of each type of products contributing to affect FDA inspection procedures. For example, a drug is more likely to deal with patent infringement than food and cosmetics. Therefore, further researches to detail and narrow classify products with similar evaluations for quality are needed.

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Appendix

Table 8. Panel Two-Stage Least Square GMM for Refusal Numbers as Dependent variable

Variable	Model 1	Model 2	Model 3	Model 4
Lag refusal	0.847***	0.746***	0.675***	0.663***
LnUSGDP	-0.090	-0.745**	-0.925	-2.069***
LnUStotal imports	0.005	0.021	0.045***	0.037**
LnexportGDP	-0.063***	-0.061***	-0.062	-0.017
Lnexports	0.072***	0.077***	0.075***	0.060***
Drugs	-0.141*	-0.145**	-0.140**	-0.140**
Cosmetics	0.225	-0.322***	-0.457***	-0.460***
C	1.733	1.001	13.743	13.620
FDAstaff		0.864***	0.449**	1.543*
FDAFPO		-0.026	-0.036	-0.371**
Lnlobby			1.607**	1.003*
AD			0.005***	0.010***
English			0.005***	0.224***
CPI			0.011	0.002
Unemprate			0.199*	0.092*
WTO			-0.018*	-0.031**
Bitrade			0.000	0.000*
Freetrade			0.152**	0.137*
Dummy20082013				-0.219
Dummy2009*usimports				-0.011
Spillover				0.289***
R-square	0.79	0.82	0.83	0.84

Table 9. Panel Two-Stage Least Square GMM for Refusal Ratio as Dependent variable

Variable	Model 1	Model 2	Model 3	Model 4
Lag refusal	0.641***	0.646***	0.648***	0.565***
LnUSGDP	-0.271	-0.658	0.492*	-0.528***
LnUStotal imports	-0.003	-0.003*	0.003*	0.004**
LnexportGDP	-0.015*	-0.016	-0.014***	0.019**
Drugs	-42.256	-0.0434	-0.0760	-0.031
Cosmetics	-0.041	-0.043	-0.0717	-0.038
C	0.439	-0.203*	0.106***	11.688***
FDAstaff		1.315*	1.227***	1.273***
FDAFPO		-0.619*	-0.244***	0.264***
Lnlobby			0.263***	0.246***
AD			0.000	0.000
English			0.011	0.015*
CPI			0.014***	-0.016***
Unemprate			0.028***	0.025***
WTO			-0.001	-0.000
Bitrade			0.000***	0.000***
Freetrade			0.005	-0.009
Dummy20082013				0.006
Dummy2009*usimports				0.002*
Spillover				0.002*
R-square	0.44	0.45	0.47	0.48

Table 10. Descriptive Statistics of the FDA Refusal

Products	Mean	Max	Min.	Sum.	Std. Dev.	Obs.
1	378	1,949	18	90,811	380	240
2	73	563	0	17,507	76	240
3	498	60,379	1	119,421	3,892	240
All	316	60,379	0	227,739	2,262	720

Note: 1: food, 2: cosmetics, 3: drugs

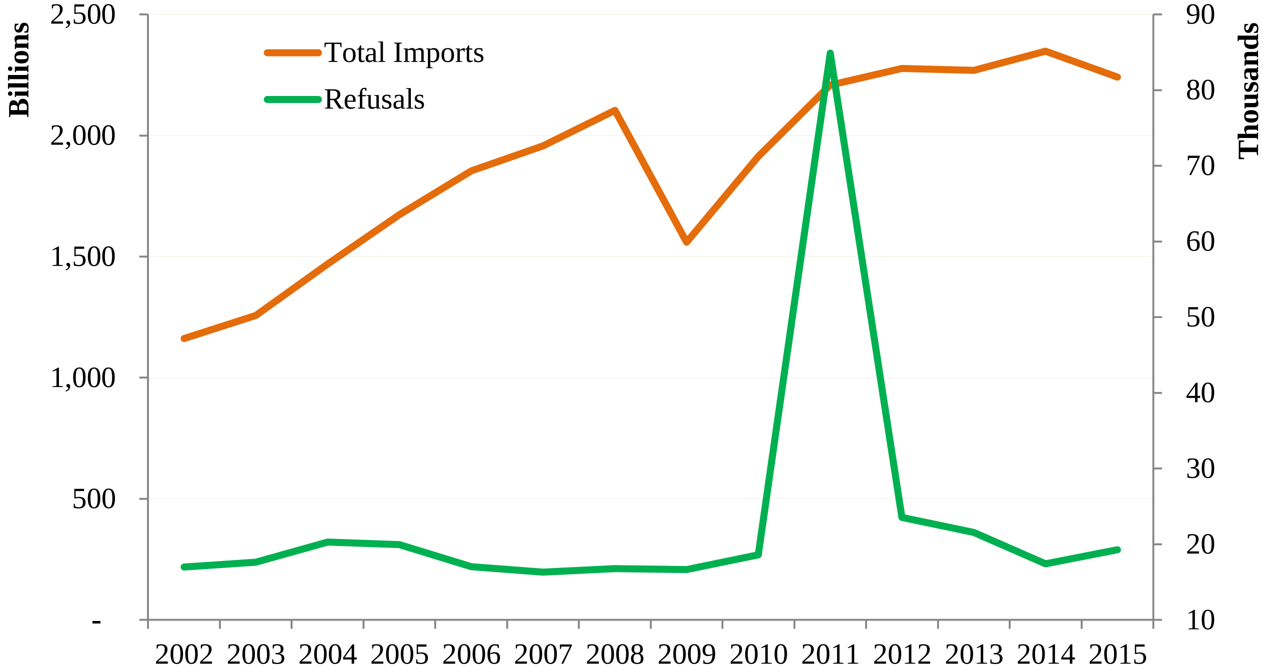


Figure 3. The US Total Imports and Refusals from Top-Twenty Countries

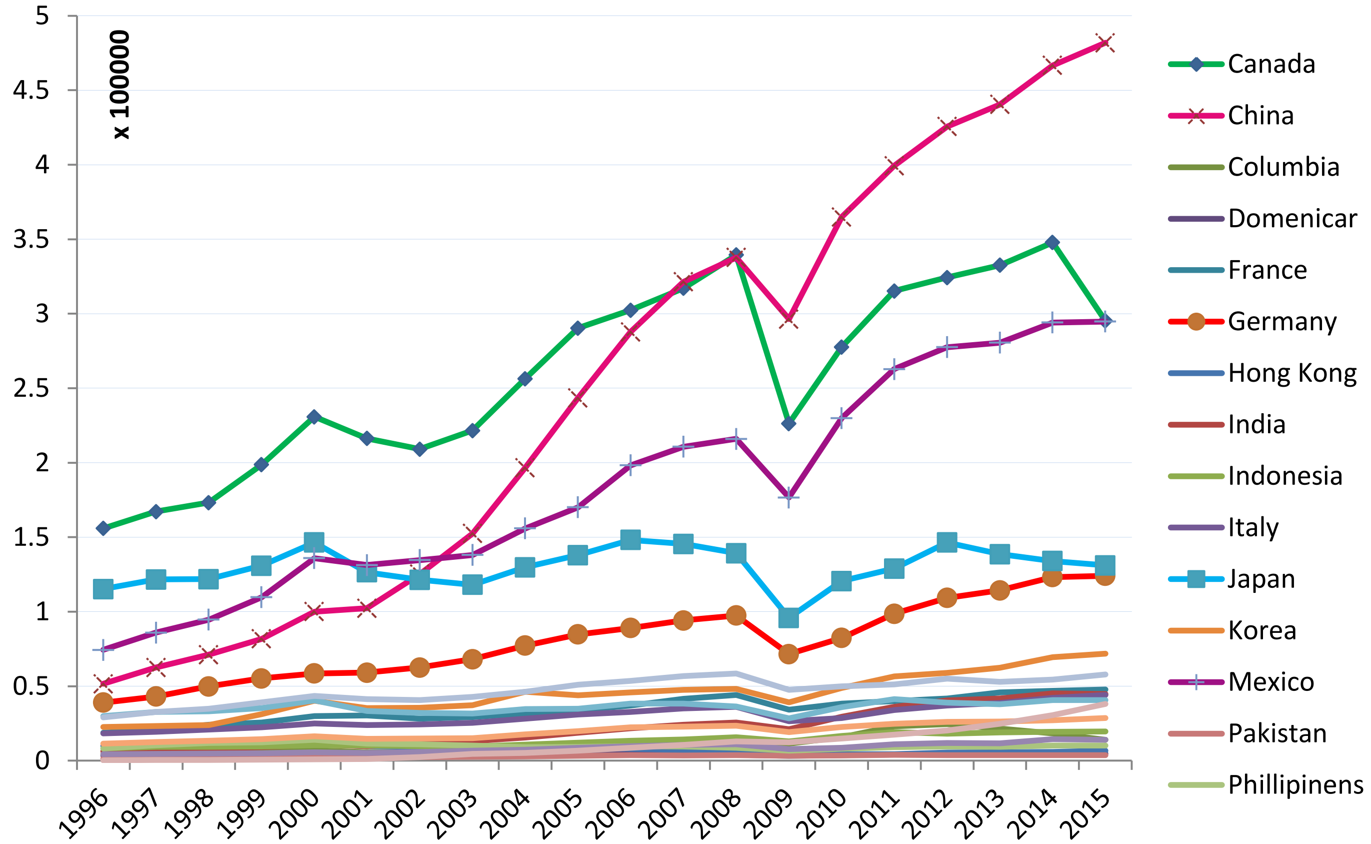


Figure 4. The US total Import from Top-Twenty Countries (100,000 USD)

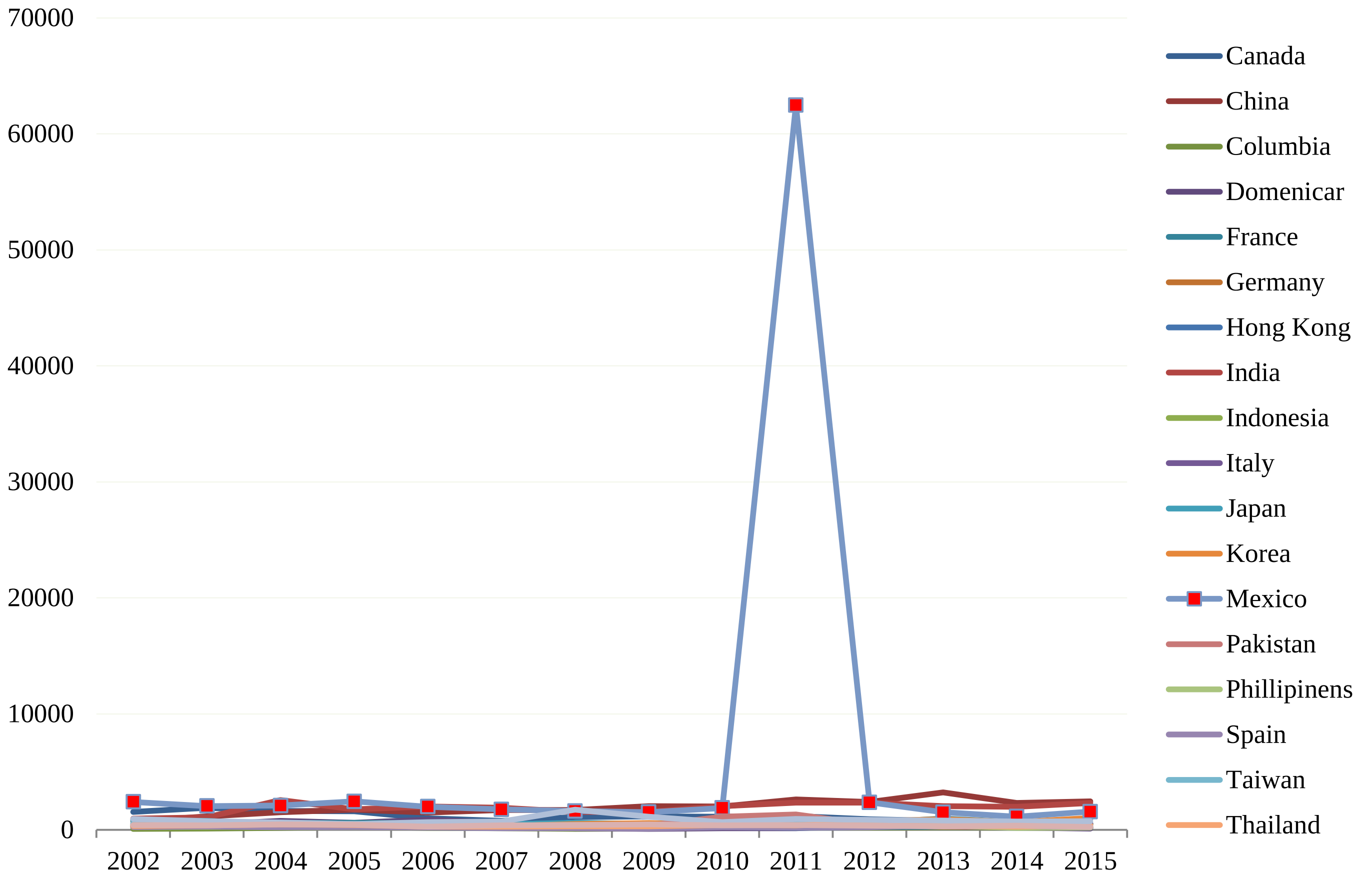


Figure 5. Number of Refusals by Top-Twenty Countries

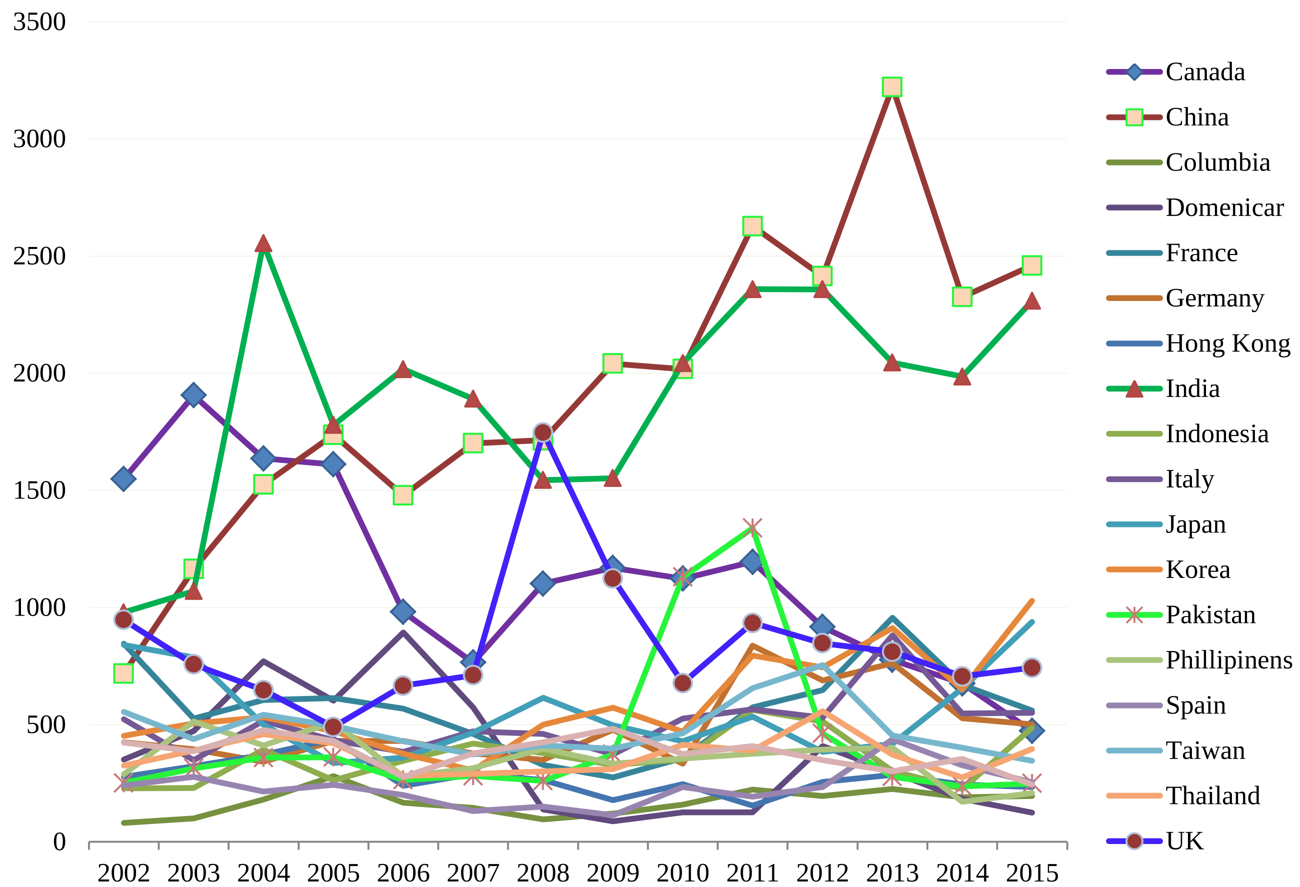


Figure 6. Number of Refusal from Top-Twenty Countries Excluding Mexico

Comparison the Paper and the Former Papers

Baylis, Martens, and Nogueira (2009) (monthly data:1998-2004)	Jouanjean, Maur, and Sheperd (2012) (annual data:1998-2008)	Nakuja (2012) (monthly data: 2001-2011)	Our paper (annual data: 2002-2013)
Alert		X	
Lagged EU R by prod.	Lagged R	Lagged R	Lagged R
Lagged of EU R			
Perishable			Type of product
Processed			
Trade agreement with US			X
English-speaking			X
Years as a member of WTO			X
Corruption			CPI
GDP per capita	X		X
Lagged agricultural export	X	X	Export values
New exporter			
Alerts for new exporters			
Lagged log volume			
Change in employment		Unempmt. rate	Unempmt. rate X
World import quantity			U.S. total imports
Lagged lobby expenditure			X
Lagged lobby x import			
Lagged antidumping case	Tariff	X	X
Lagged change world price			
	Lagged sector R Lagged close country R		
			FDA annual budget
			FDA staff
			Food scandal 2008
			Food scandal 2009
			Food scandal after 2009
			FDA Foreign office
			Spillover effect of R

Chapter 3

U.S Import Demand Elasticities for Shrimp: The Importance of Price Transmission

Abstract

This study addresses two questions of importance to the analysis of policies affecting international trade: (1) to what extent does the omission of transportation costs in tests for the Law of One Price (LOP) result in biased estimates of the elasticity of price transmission (EPT)? and (2)to what extent do biased estimates of EPTs matter when modeling the effects of exchange rate changes on prices and trade flows? The questions are addressed using the U.S. market for imported shrimp as a case study. Tests for LOP are conducted for six major suppliers to the U.S. market, namely Thailand, China, Ecuador, Indonesia, and India. Results based on an Autoregressive Distributed Lag Model and monthly data for the period 1994 to 2014 indicate omission of transportation costs causes estimated EPTs to be underestimated by between x% and y%. The omission also leads to over-rejection of LOP. Specifically, when transportation costs are included in the model, rejection of LOP drops from six to three of the studied trade partners. Simulations of a excess demand-supply model of U.S. shrimp imports indicates understated EPTs cause exchange rate pass-through to be understated, as are the effects of exchange rate movements on imported quantities. An increase in transportation costs has the same effect on U.S. prices and imported quantities as does a depreciating U.S. dollar. Overall, for the considered supply and demand elasticities, most of the incidence of a change in exchange rates and transportation costs is borne by foreign producers.

JEL Code F140

Keywords: import price, export price, trade flows, LOP, exchange rate, and transportation costs

Introduction

For the last 20 years, the US shrimp industry has been dealing with a pressure on imports when the domestic production accounts for less than 25% of total American shrimp consumption. This is important because any change in importing price and supply impacts not only the domestic price but also the domestic shrimp industry that is a vital component of the US coastal economies (Clark, 1992). The proportion of shrimp imports was 1% of the US food imports and 23% of the imports of all fish and shellfish (USDA, 2016). As the top seafood consumed by Americans, the shrimp importing price is six times higher than average food price, 1.4 times higher than average seafood price, and the price was quite volatile over the past 15 years (figure 2). The declined trend of import price from 1999 to 2009 challenged the domestic production and raised a question of whether the exporters are subsidized by their government or use import demand and supply adjustments. In addition, the trend of increase in the price since 2010 has not prevented the import growth over the last period.

In general, the US has targeted six countries (Thailand, Indonesia, Ecuador, China, Vietnam, and India) for over 75% of their total shrimp imports (figure 3). However, the US shrimp industry has filed a petition agaist all these countries because they believe shrimp imports from these countries damages and challenges domestic production due to unfair support for exports from these governments (Southern Shrimp Alliance, 2016). Therefore, the price changes of shrimp in these exporting countries may have significant impacts on import prices in the US market. The question is whether market power exists in the shrimp market or it is perfectly competitive. A test of the law of one price (LOP) will answer this question.

Law of one price in international agricultural markets, particularly in the seafood industry, has received limited attention (Goodwin, Grennes, and Wohlgenant, 1990). Price transmission has been mainly investigated in some major agricultural products such as cotton, soybean, wheat, and corn and focused on price export demand elasticity facing the U.S. The price transmission elasticity is equal to one in case of zero transportation cost between two countries, otherwise, the price transmission elasticity across countries are less than one (Bredahl, Meyers, and Collins, 1978).

The concept of price transmission was initially mentioned in the international trade perspective by Tweenten and Johnson (1967, 1977). Both authors clarify how it affects the elasticity of foreign demand for U.S. agricultural products. Instead of quantifying the contribution of elasticity of prices in an importing country, in respect to U.S. market prices on export demand elasticity, these two studies set the price transmission elasticity equal to one and ignored it in their simulations. Theoretically, their export demand elasticities for specific major agricultural products, as well as aggregate agricultural exports, are relatively large, totaling -9.5 (Tweenten) and ranging from -2.8 for soybeans to -10.18 for feed grains (Johnson). The price transmission elasticity usually bounds from zero to one, in which, it approaches one (perfect price transmission) in case of free trade with zero transportation costs and no government policy intervention. It approaches zero when government insulates internal production and consumption prices from world market prices, and it ranges between zero and one where there is free-trade with nonzero transportation costs.

Bredahl, Meyers, and Collins (1978) criticized biases in computations by Tweenten and Johnson because they did not consider government policies that insulated domestic producers and consumers from external price fluctuations. Therefore, these authors included the price transmission elasticity derived from the trade policies of several major importing and exporting regions, in estimating the elasticity of foreign demand for U.S. cereals, soybeans, and cotton. In particular, three measures of the elasticity of export demand are calculated under two assumed values of price transmission elasticity to be one and zero. The first simulation assumes that the price transmission elasticity of the rest of world is zero, the second case indicates this elasticity is assigned a value of one, and the last assumes all price transmission elasticities are equal to one. As a result, the computations show that the export-demand elasticities, inclusive of domestic price insulation policies, are much smaller in absolute value than theoretical elasticities computed of Tweeten and Johnson.

On the other hand, Haniotis, Baffes, and Ames (1988) are among the authors who consider the interaction between export price and domestic price in estimating the demand and supply of U.S. wheat, corn, and soybeans. In the model of simultaneous determination of supply and demand for U.S. agricultural products, the authors clarify export-demand elasticity to be the responsiveness of the demand for export to changes in the ratio of domestic export prices to the export prices of major competitors, and export-supply elasticity to be the responsiveness of U.S. export supply to changes in real U.S. export prices. Duffy, Wohlgenant, and Richardson (1989) investigate influence of price interaction on the elasticity of export demand for U.S. cotton via Armington approach. In this research, the price effect is the response of the competing-exporting country prices to the U.S. price instead of the response of internal domestic prices to changes in U.S. price. Their results indicate that accounting for feedback effects of the change of U.S. price on other countries' cotton prices has significant impact on the estimated export demand elasticity, valued from -4 to -1.6.

The last recent research to quantify the magnitude of price transmission elasticity and evaluate its impact on export demand elasticity for corn, soybean, and wheat is conducted by Reimer, Sheng, and Gehlhar (2012). Instead of assuming the bound values of price transmission elasticity, the authors empirically estimate these values using available statistic data. Their results identify that price transmission elasticity of U.S. price to an importing country's price ranges from 0.077 to 1.089. The computations determine that export demand elasticities ranged from -0.45 for no price transmission case to -1.64 for perfect price transmission. These parameters have been used to compare with values from previous studies. However, it is hard to indicate which one is better because of the different definition for export demand elasticity.

In reference to a test of the law of one price between markets, most former studies missed the transportation costs (Asche et al., 2012; Warr, 2008; Katrakilidis, 2008; Funke and Koske, 2007; Dawson and Dey, 2002; Faminow and Benson, 1990; Ardeni, 1989; Protopapadakis and Stoll, 1983), even though, in reality the price paid by an importing country is equal to the price received by an exporting country plus costs of transportation and transition (McChesney et al. 2004). However, transportation costs have been mentioned in testing the market integration in a few papers such as those from Davutyan and Pippenger (1990); Michael and Nobay (1994); Goodwin (1992); Baffes (1991); and Goodwin, Grennes, and Wohlgenant (1990). The results from these all studies indicate that the omission of transportation costs causes serious econometric problems and biases in rejecting LOP. In other words, transportation costs are important in the LOP test model and encourages the LOP holding between markets.

In regards to fish and fish products, price transmission has attracted much of the attention in fish and fish products markets during recent years. However, investigations have been limited to only price transmission in the fish production value chain or among specific products in the domestic market (Jaffry, 2005; Vavra and Goodwin, 2005; Hartmann, Jaffry & Asche, 2000), and most attempts to model the fish products market have concentrated on the export demand (Reimer, Sheng, and Gehlhar, 2012; Bredahl, Meyers, and Collins, 1979; Johnson, 1977; and Tweeten, 1967), while no work has been done on the import demand of fish products. In addition, even though import demand elasticity is a critical indicator to understanding incidental impact of government policy on agriculture, little empirical research has been conducted on how it interacts cooperatively with price transmission elasticity. Therefore, this paper intends to (1) use a LOP test to answer the question of whether there is a problem or not with missing the transportation costs to infer about the LOP since most studies missed the transportation costs, and (2) analyze the effects of exchange rate on prices and quantities in order to discuss whether it matters to use unbiased price transmission elasticities (right specified with transportation costs) in comparison to biased price transmission elasticities (missed specified without transportation costs) to analyze the effect of exchange rate on equilibrium. In other words, how does the missing transportation costs matter, as specified by the LOP test, affect the equilibrium. Additionally, this research will also provide tests of LOP for the shrimp market using updated data and econometrical techniques.

This paper contains multiple research components. The first and the second sections focus on the foundation to set up the LOP equation, and briefly reviews former studies. The third section presents the hypothesis and tests results via an imperial regression model. The next chapter discusses trade prices and quantity with corrected and missed specified models, and then simulates the effects of exchange rate on export supply and import demand elasticities. The final section includes policy analysis and the implication of doing research in this area.

Price transmission, law of one price (LOP), and incidence

Price transmission implies that import demand in each country is a function of that country's price, which, in turn, is a function of the exporting country's price to some degree (Reimer, Zheng, and Gehlhar, 2012). This concept plays an important role with agricultural products under both export supply and import demand perspectives. However, most researchers have focused only on evaluating its impact on export demand elasticity of some major agricultural products of the U.S. such as wheat, cotton, soybean, and corn. Research efforts have likely focused on these commodities because the US holds the larger share of the market in comparison to importing countries, where their domestic prices could be easily affected by changes in the U.S. price. However, most former research efforts have assumed the bound values of price transmission rely on policy analyses, and it has been further assumed to be perfect price transmission, and can be therefore ignored in the estimation. The assumption of perfect price transmission simplifies computations, but this has a profound influence on the estimated elasticity magnitudes and raises serious questions about their applicability to a real world situation because effects may be overestimated or underestimated (Bredahl, Meyers, and Collions, 1978). In reality, there are a number of reasons for implying no perfect price transmission, such as, an imperfect exchange rate pass through, prices not being renegotiated continuously, imperfect market prices, oligopoly market power, exchange rate response, transportation costs, and government policies insulating domestic prices from external price fluctuations (Reimer, Sheng, and Gehlhar, 2012).

The LOP holds that, abstracting from transaction costs, regional markets that are linked by trade and arbitrage will have a common, unique price in common currency (Fackler and Goodwin, 2001). Conventionally, this definition is described for a particular product $P_i = E \times P_j$, where P_i is the importing-currency price, P_j is exporting-currency price, and E is the exchange rate, a ratio of importing-currency to exporting-currency price. The former researchers used this equation popularly to test LOP (Goodwin, Grennes, and Wohlgenant, 1990; Goodwin, 1992; Mohanty et al., 1998; Warr, 2008). However, empirical research has usually measured this linkage by degree instead of a specific relationship to determine the co-movement of prices in different markets. The measurement of price co-movement raises a question of how to distinguish between price transmission and law of one price if transportation costs are included. As a result, the prices may not reflect co-movement completely, but the LOP still holds because of the large transportation costs. Therefore, this paper will test the strong version of LOP, where the spatial arbitrage condition holds for equality or perfectly integrated markets, and the price transmission ratio is unique (Fackler and Goodwin, 2001). In other words, a complete price transmission between two countries indicates that the changes in price in one country are completely and instantaneously transmitted to the price in another country (Rapsomanikis, Hallam, and Conforti, 2003). The basic equation to describe the price linkage between the US market and the other export markets is:

(1) $$P_{US} = P_i + T_i$$

where, *i* represents six major countries (Thailand, Indonesia, Ecuador, China, Vietnam, and India) that export shrimp into the U.S. market, P_{US}, P_i, and T_i are in a common currency of the exporting country (local currency unit, LCU). The equation of price linkage after taking the total differential and converting it into percent change (details attached in the appendix) is:

(2) $$P_{US}^* = (1 - \tau_i)P_i^* + \tau_i T_i^*$$

where, $\tau_i = \frac{T_i}{P_{US}}$, proportional transportation costs.

On the other hand, the import price in the US market measured in US dollar is:

(3) $$\tilde{P}_{US} = P_{US}.e$$

where, $e_i = \frac{US\ dollar}{LCU}$ is the exchange rate.

Total differential provides the following equation:

(4) $$\tilde{P}_{US}^* = P_{US}^* + e^*$$

Inserting (4) into (2) gives the following equation:

(5) $$\underbrace{\tilde{P}_{US}^*}_{US\ dollar} = (1 - \tau_i)\underbrace{P_i^*}_{LCU} + \tau_i \underbrace{T_i^*}_{LCU} + \underbrace{e^*}_{\frac{US\ dollar}{LCU}}$$

where, $\tilde{P}_{US}^*$ is the price in US dollar, P_i^* is foreign price in the local currency unit, T_i^* is transaction costs in the local currency unit.

Equation (5) presented in the form for a regression model is:

(6) $$\ln \tilde{P}_{US,t} = \alpha + \beta lnP_{i,t} + \gamma lne_{i,t} + \delta lnT_{i,t} + \varepsilon_t$$

The real transportation costs of shrimp from these countries into the US are not available and the oil price as the proxy test is invalid (tested). The transportation costs are a difference between c.i.f. price and f.o.b. price. If the f.o.b price and c.i.f. price are used to represent $P_{i,t}$ and $\tilde{P}_{US,t}$, respectively; the tautology issue occurs because the transportation costs between the US and these countries are less than 5% of the prices and not very volatile. Therefore, the commercial landing prices are used to proxy for the US c.i.f. prices.

The LOP is tested with the null hypothesis if the LOP holds, implying the coefficient of exchange rate is equal to 1 ($\gamma = 1$) and the combined coefficient of local price and transportation cost equals 1 ($(\beta + \delta) = 1$). The alternative hypothesis is that this linkage is not unique. If the null hypothesis is accepted, the LOP holds, otherwise prices in these markets are not completely transmissivity.

Although former authors indicate that adding transportation costs into the model provides favorable results to support LOP (Baffes, 1991), none of them figure out a reason for this conclusion. Theoretically, transportation cost ($T_{i,t}$) has a negative correlation with the price received by an exporter i ($P_{i,t}$). Therefore, since the former researchers assessed zero transportation costs, their results are biased due to omission of relevant variables. Note that β and δ are true coefficients of the correct model, and ε is the coefficient of $P_{i,t}$ estimated without transportation cost. The expected value of ε in the model without transportation costs is:

(7) $$\boldsymbol{E}\left[\varepsilon / P_{i,t}, T_{i,t}\right] = \beta + \frac{COV[P_{i,t}; T_{i,t}]}{VAR[P_{i,t}]}\delta$$

Since $\beta > 0$ and δ and $VAR[P_{i,t}]$ are positive, the sign of the bias in ε is the same as the covariance. Given, $COV\left[P_{i,t}; T_{i,t}\right] < 0$, the estimated coefficient ε is smaller than the true value of β. In other words, the omission of transportation costs/tariffs causes the coefficient of price transmission elasticity to be underestimated. This statement will be test in the empirical regression.

Incidence (who bears the tax/tariff?)

The distinctive difference between where LOP holds and does not hold shows up as a gap in export price the foreign country received and the import price the domestic country paid. The inclusion of transportation or transaction costs causes domestic consumers to pay higher and foreign producers to receive lower prices than those assumed from zero transportation costs. In the case of a change in exchange rate between two countries, or tax/tariff applications, who bears greater incidence depends on excess supply and excess demand elasticities. For instance, if the US was a small importing country of shrimp, the excess supply would be perfectly elastic (figure 2), and the exporter should be willing to supply as much of the product as the US wants since its consumption has no effect on the world price (price is exogenous). Under this scenario, the export supply curve is horizontal at the level of the market price ($\varepsilon_i = \infty$). Consequently, domestic consumers would bear all effects of transportation cost/tax/tariff. In contrast, with both excess demand and excess supply elastic, the less elastic a market the more incidence it would bear. Particularly, if the excess supply is less elastic than excess demand (with the US being a large importer), the transportation costs or tariffs would hurt producers in the targeted exporting countries more than protecting US producers. Consequently, incidence of the agricultural protection tariff in developed countries splits more to the producer in the developing country than to the producer in the tariff issued country (Tokarick, 2006). Overall, price wedges equal tariff rate in the case of perfect transmission elasticities, and the less elastic price in the market bears more incidence (Kinnucan and Myrland, 2006).

Theoretical model and hypothesis

Comparative statistics

Since two markets are not isolated completely, import demand in the domestic market is a function of price in the foreign market, which, in turn, is a function of the US price to some degree. A comparative statistic model follows the assumptions that shrimp is a homogeneous commodity and both supply and demand curves feature upward and downward sloping components, respectively, in the cases where the US is a net importer and the six major exporting countries into the US market function net exporters. Once the assumption of perfect price transmission is relaxed, exchange rate and transportation cost compose a gap of prices between markets. Shrimp industry from each country accounts for a relatively small share of global trade flows; hence, exchange rate and transportation costs are treated as exogenous. The global excess demand and excess supply elasticities of shrimp are derived from domestic equilibrium market as follows:

Model for net importing country (the US market)

(8) $D_d^* = \eta_d^{US} P_d^*$ US demand

(9) $S_d^* = \varepsilon_d^{US} P_d^*$ US supply

(10) $M_i^* = \varepsilon_i^{US} P_i^*$ Supply from country i

(11) $M_{ROW}^* = \varepsilon_{ROW}^{US} P_{ROW}^*$ Supply from ROW

(12) $P_d^* = (1 - \tau_i) P_i^* + \varphi_i e_i^* + \tau_i T_i^*$ Price linkage

(13) $P_d^* = (1 - \tau_{ROW}) P_{ROW}^* + \varphi_{ROW} e_{ROW}^* + \tau_{ROW} T_{ROW}^*$ Price linkage

(14) $D_d^* = k_d^{US} S_d^* + k_i^{US} M_i^* + k_{ROW}^{US} M_{ROW}^*$ Market clearance

where, the asterisk (*) indicates proportionate change and the Greek symbols denote elasticities. P_d^* is a change of the US price, P_i^* is a change of price in the exporting country i, $e_i^* = \frac{\text{US dollar}}{\text{Local currency unit}}$ is a change of exchange rate between the US and the exporting country, T_i^* is transportation costs between two countries, and $k_d^{US} + k_i^{US} + k_{ROW}^{US} = 1$ is share of domestic production, import from the major countries, and import from ROW to the US domestic total consumption, respectively.

Net exporting country (Thailand, China, Ecuador, Indonesia, India, Vietnam, and ROW)

(15) $D_i^* = \eta_d^i P_i^*$ Domestic demand in country i

(16) $X_{US}^* = \eta_{US}^i P_d^*$ Export demand to the US

(17) $X_{ROW}^* = \eta_{ROW}^i P_{ROW}^*$ Export demand country i to ROW

(18) $S_i^* = \varepsilon_d^i P_i^*$ Country i supply

(19) $P_d^* = (1 - \tau_i) P_i^* + \varphi_i e_i^* + \tau_i T_i^*$ Price linkage

(20) $P_d^* = (1 - \tau_{ROW}) P_{ROW}^* + \varphi_{ROW} e_{ROW}^* + \tau_{ROW} T_{ROW}^*$ Price linkage

(21) $S_i^* = k_d^i D_i^* + k_{US}^i X_{US}^* + k_{ROW}^i X_{ROW}^*$ Market clearance

where, $k_d^i + k_{US}^i + k_{ROW}^i = 1$ is a share of the domestic production production by domestic consumption, export to the US market, and export to the ROW, respectively.

Simultaneously solving equation (8) to (14), the US import demand elasticity from country i in term of country i price is obtained as follow:

(22) $$\eta_i^{US} = \frac{\theta_i(\eta_d^{US} - k_d^{US}\varepsilon_d^{US} - k_{ROW}^{US}\varepsilon_{ROW}^{US}\theta_{ROW}^{-1})}{k_i^{US}} < 0$$

And the US import demand elasticity from ROW in terms of ROW price (exporting countries)

(23) $$\eta_{ROW}^{US} = \frac{\theta_{ROW}(\eta_d^{US} - k_d^{US}\varepsilon_d^{US} - k_i^{US}\varepsilon_i^{US}\theta_{ROW}^{-1}\theta_i^{-1})}{k_{ROW}^{US}} < 0$$

Where $\theta_i = (1 - \tau_i)$ and $\tau_i = \frac{T_i}{P_d}$ is transportation cost rate.

If the omission of the transportation costs reduces the magnitude of price transmission elasticity (θ_i), then the import demand elasticities are smaller in absolute value. This occurs because the values of the US import demand elasticities from country i are positively related to the price transmission elasticity between two countries. Although the price transmission between the US and ROW offset this effect, the offset value is smaller since it is multiplied with import share and supply elasticities of ROW countries.

Similarly, export supply elasticity to the US market from country i in term of US price is derived simultaneously from equation (8) to (12) as:

(24) $$\varepsilon_{US}^i = \frac{1}{\theta_i}\left(\frac{\varepsilon_d^i - k_d^i\eta_d^i - k_{ROW}^i\eta_{ROW}^i\theta_{ROW}^{-1}\theta_i}{k_{US}^i}\right) > 0$$

And export supply elasticity to the ROW market from country i in term of ROW price (importing countries) is:

(25) $$\varepsilon_{ROW}^i = \frac{\theta_{ROW}}{\theta_i}\left(\frac{\varepsilon_d^i - k_d^i\eta_d^i - k_{US}^i\eta_{US}^i\theta_i}{k_{ROW}^i}\right) > 0$$

The price transmission elasticities in the parentheses may offset each other if there is not much different of price transmission between the US and country i and the US and ROW.

Therefore, the price transmission elasticity in the denominator (equation 24) causes the excess supply elasticity from country i to the US market to be more elastic.

The elasticities of excess supply from exporting countries and excess import demand in the US, as derived from the above equation, are estimated based on parameters collected from reviewing former research. In particular, shrimp in the US market is assumed to be a normal good and the excess demand elasticity is inelastic according to the results of Jones et al. (2008), with the value being -0.59.

For exporting countries, the elasticities are assumed to be the same $\varepsilon_d^i\ \eta_d^i\ \eta_{US}^i\ \eta_{ROW}^i$ for each major exporting country and for ROW. We assume all shrimps are a perfect substitute and there is no difference in the supply elasticities from a country i to the US market. Therefore, elasticities from the Thailand market are used to represent those for the other major exporting countries because most of the elasticities are available for Thailand from former research. The US import supply from Thailand and ROW elasticities are assumed to be equal to the US import demand from these countries. As a result, the US supply elasticities imported from Thailand and ROW are 1.46 and 1.27, and are based on the results from Chidhamon and Tokrisna (2006). These values are reasonable since the US is a large importer and a highly competitive market for the exporters. The supply elasticity from other markets is relatively smaller than that from Thailand since Thailand is a major exporter to the US market. However, the market share is highly sensitive in competing with other exporters such as Mexico or India. On the other hand, the empirical regression analysis of shrimp supply is rare and not published in any recent academic journal papers. This paper uses the US domestic shrimp supply elasticity of 1.1 and relies on published results from Kennedy and Lee (2005), which they determined to be statistically significant at the 0.10 level. The domestic supply and demand elasticities in the Thailand market are 1.70 and 0.90, respectively, based on a study by Dey et al. (2008). Elasticity of Thailand shrimp export supply is assumed to have unity since the US is a dominant importer for Thailand shrimp exports. The ROW is assigned to be half of the Thailand supply elasticity into the US since it accounts for only 8% of the Thailand total production.

The simulation results are presented in tables 2 & 3. Obviously, the excess demand elasticities are less elastic when adding the transportation costs and the excess supply elasticities are more elastic with transportation costs are included.

International shrimp model

The world market for shrimp is based on the assumption of the US being the only net importer and all shrimps being a perfect substitute for others. The net suppliers are Thailand, China, Ecuador, Indonesia, India, Vietnam, and ROW. Import demand and export supply of shrimp are controlled by prices in the net importing and exporting market, respectively. Thus, the exchange rate and transition costs create a gap of prices between markets as follow:

(26) $Q_{US}^{*} = \eta^{US} P_{US}^{*}$ US excess demand ($\eta^{US} < 0$)

(27) $Q_{i}^{*} = \varepsilon^{i} P_{i}^{*}$ Excess supply from country i ($\varepsilon^{i} > 0$)

(28) $P_{US}^{*} = (1 - \tau_i) P_{i}^{*} + \varphi_i e_i^{*} + \tau_i T_i^{*}$ Price linkage b/w country i and the US

(29) $Q_{US}^{*} = \sum_{i=1}^{7} K_i Q_i$ Market clearance

where, $\tau_i = \frac{T_i}{P_{US}}$, rate of transition costs, i=1,…7: Thailand, China, Ecuador, Indonesia, India, Vietnam, and ROW. In which $\sum_{i=1}^{7} K_i = 1$

Endogenous variables: Q_{US}^{*}, Q_i^{*},P_{US}^{*}, P_i^{*} and exogenous variables: e_i^{*} and T_i^{*}

Effects of exchange rate and transition costs on the world trading quantities and prices of shrimp can be determined via the reduced form derived from simultaneously solving equation (26) to (29). To simplify interpretations, a model with two suppliers (Thailand and ROW) and one consumer (the US) are derived to have the following reduced forms of prices and quantities responding to changes of exchange rate and transportation costs.

Exchange rate increases the US import shrimp price and decreases the price received by country i. In particular, when the exchange rate grows, implying the US dollar is weakened, the price of import shrimp in the US market goes higher but the price received by the excess supplier is lower. Similarly, a growth of transportation costs causes US consumers to pay more for imported shrimp because of a higher price, but the price received by the exporting country i is lessened. In addition, both the US dollar depreciation and transportation cost growth in the ROW countries provide positive effects on the prices in both the US market and exporting country i.

Overall, the result from devaluation of the US dollar is a split between the rise in import price paid by the US consumer and a fall in the export price received by the export supplier. The only difference in effect magnitude between the exchange and transportation costs is a gap between coefficient of exchange rate (φ_{TL}) and coefficient of transportation costs (τ_{TL}).

Who bears greater incidence depends on the magnitudes of excess supply and excess demand. To simplify the case of perfect price transmission without transportation costs, the total effect of exchange rate on the US price and the foreign price is one. It is because with the perfect transmission $\frac{P^*_{US}}{e^*_{TL}} = \frac{K_{TL}\varepsilon_{TL}}{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}-\eta_{US}}$ and $\frac{P^*_{TL}}{e^*_{TL}} = \frac{\eta^{US}-K_{ROW}\varepsilon^{ROW}}{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}-\eta_{US}}$, then, the summation of $\frac{P^*_{US}}{e^*_{TL}} + \frac{P^*_{TL}}{e^*_{TL}} = \frac{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}-\eta_{US}}{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}-\eta_{US}} = 1$.

If the supply is perfectly inelastic or the US is a large shrimp importer (ε^{TL}=0), $\frac{P^*_{US}}{e^*_{TL}} = 0$ and $\frac{P^*_{TL}}{e^*_{TL}} = 1$. In other words, the entire effect of exchange rate falls in importing price, and the US price does not bear any impact. In contrast, when the price is perfectly elastic ($\varepsilon^{TL} \rightarrow \infty$, or the US is a small importer of shrimp) then $\frac{P^*_{TL}}{e^*_{TL}} = 0$. It implies that when the US dollar suffers depreciation, the US consumer bears all the price growth in the US market, whereas, the importing supplier does not bear any effect. The detailed results will be presented and discussed in the next section.

US price

$$(30)\ \frac{P_{US}^{*}}{e_{TL}^{*}}=\frac{K_{TL}\varepsilon_{TL}\varphi_{TL}\theta_{TL}^{-1}}{K_{TL}\varepsilon_{TL}\theta_{TL}^{-1}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}-\eta_{US}}>0$$

$$(31)\ \frac{P_{US}^{*}}{T_{TL}^{*}}=\frac{K_{TL}\varepsilon_{TL}\tau_{TL}\theta_{TL}^{-1}}{K_{TL}\varepsilon_{TL}\theta_{TL}^{-1}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}-\eta_{US}}>0$$

$$(32)\ \frac{P_{US}^{*}}{e_{ROW}^{*}}=\frac{K_{ROW}\varepsilon_{ROW}\varphi_{ROW}\theta_{ROW}^{-1}}{K_{TL}\varepsilon_{TL}\theta_{TL}^{-1}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}-\eta_{US}}>0$$

$$(33)\ \frac{P_{US}^{*}}{T_{ROW}^{*}}=\frac{K_{ROW}\varepsilon_{ROW}\tau_{ROW}\theta_{ROW}^{-1}}{K_{TL}\varepsilon_{TL}\theta_{TL}^{-1}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}-\eta_{US}}>0$$

Exporting price

$$(34)\ \frac{P_{TL}^{*}}{e_{TL}^{*}}=\frac{\eta^{US}\varphi_{TL}-K_{ROW}\varepsilon^{ROW}\theta_{ROW}^{-1}\varphi_{TL}}{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}\theta_{TL}-\eta_{US}\theta_{TL}}<0$$

$$(35)\ \frac{P_{TL}^{*}}{T_{TL}^{*}}=\frac{\eta^{US}\tau_{TL}-K_{ROW}\varepsilon^{ROW}\theta_{ROW}^{-1}\tau_{TL}}{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}\theta_{TL}-\eta_{US}\theta_{TL}}<0$$

$$(36)\ \frac{P_{TL}^{*}}{e_{ROW}^{*}}=\frac{K_{ROW}\varepsilon_{ROW}\varphi_{ROW}\theta_{ROW}^{-1}}{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}\theta_{TL}-\eta_{US}\theta_{TL}}>0$$

$$(37)\ \frac{P_{TL}^{*}}{T_{ROW}^{*}}=\frac{K_{ROW}\varepsilon_{ROW}\tau_{ROW}\theta_{ROW}^{-1}}{K_{TL}\varepsilon_{TL}+K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}\theta_{TL}-\eta_{US}\theta_{TL}}>0$$

Similarly, the US import demand curves for shrimp from Thailand and ROW can be determined as follows:

(38)

$$Q_{TL}^{*}=\theta_{TL}\left(\frac{\eta_{US}-K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}}{K_{TL}}\right)P_{TL}^{*}+\frac{\varphi_{TL}(\eta_{US}-K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1})}{K_{TL}}e_{TL}^{*}+\frac{\tau_{TL}(\eta_{US}-K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1})}{K_{TL}}T_{TL}^{*}+\frac{\varphi_{ROW}K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}}{K_{TL}}e_{ROW}^{*}+\frac{\tau_{ROW}K_{ROW}\varepsilon_{ROW}\theta_{ROW}^{-1}}{K_{TL}}T_{ROW}^{*}$$

$$(39)\ Q_{ROW}^{*}=\theta_{ROW}\left(\frac{\eta_{US}-K_{TL}\varepsilon_{TL}\theta_{TL}^{-1}}{K_{ROW}}\right)P_{ROW}^{*}+\frac{\varphi_{ROW}(\eta_{US}-K_{TL}\varepsilon_{TL}\theta_{TL}^{-1})}{K_{ROW}}e_{ROW}^{*}+\frac{\tau_{ROW}(\eta_{US}-K_{TL}\varepsilon_{TL}\theta_{TL}^{-1})}{K_{ROW}}T_{ROW}^{*}+\frac{K_{TL}\varepsilon_{TL}\varphi_{TL}\theta_{TL}^{-1}}{K_{ROW}}e_{TL}^{*}+\frac{K_{TL}\varepsilon_{TL}\tau_{TL}\theta_{TL}^{-1}}{K_{ROW}}T_{TL}^{*}$$

Import demand curves for shrimp from both sources (country i and ROW) are downward sloping and increase in value of US dollar appreciation. In particular, when the exchange rate increases or the US dollar is weakened, a shift in import demand curve causes the US demand for shrimp from a particular country i to go down. This effect works like an import tax. More importantly, the bigger transmission elasticity (θ_{TL}) between two countries causes more shrift in demand and supply, or the effect on world trade flows is larger.

A growth in transportation cost has a similar effect with strengthening of the US dollar. For instance, the transportation costs between the US and country i increases to make the import shrimp price in the US market more expensive. As a result, the excess demand curves shift to the left, implying the US demand for shrimp from country i has declined. Overall, the effects of exchange rate and transportation costs on the import quantity are identical except for the difference between elasticity of transportation costs (τ_{TL}) an elasticity of exchange rate (φ_{TL}) between two countries. Furthermore, exchange rate and transportation costs from ROW countries provide cross effects. For example, an appreciation of the US dollar in comparison to the ROW currency causes the US demand for shrimp form Thailand to increase. The reason is because import price of shrimp from ROW countries is cheaper, and then the US demand switches from Thailand to ROW countries. A similar impact occurs for transportation costs. A cut in transportation cost between the US and ROW countries will cause the US price of shrimp from these countries to decrease. As a result, the US will import more shrimp from these countries instead of buying shrimp from Thailand. Again, the effects of exchange rate and transportation costs from ROW countries on the US imported demand from Thailand are similar except for the coefficients of exchange rate (φ_{ROW}) and transportation costs ($\boldsymbol{\tau}_{ROW}$) between the US and ROW countries.

Empirical computations analysis

Law of one price tests

Data sources

The FOB prices of shrimp in the US market are proxy for the prices received by the exporting country i, and the difference between the US FOB and CIF price is the transportation cost between the US and the exporting country i. These data are from the USDA Foreign Agricultural Service. These prices and transportation costs are converted into the foreign currency (LCU) prices. The US shrimp unit price of commercial landings is proxy for the US domestic price, and it is assumed to be the same for every exporting country and measured in US dollar. These data are collected from the US National Oceanic and Atmospheric Administration (NOAA). Exchange rate is the exchange rate of the US dollar to the LCU. These data are published in the USDA Economic Research Service, except for the exchange rate of the US dollar and Vietnam dong, which comes from OANDA.

Time series diagnosis

The Augmented Dickey-Fuller (ADF) test is applied to test for unit root to determine whether the dataset is stationary or not. This test has a null hypothesis of non-stationary against an alternative of being stationarity. Overall, all ADF tests (table 4) show that all prices and exchange rates are non-stationary except the price from Vietnam, and all transportation costs are stationary except transportation cost between the US and Thailand. However, all of these variables are stationary once converted to the first differential level. On the other hand, the Phillips and Perron (PP) test is also applied to test for unit root since it is a more comprehensive approach to allow for autocorrelated residuals than the ADF test. The PP tests provide similar results to those of the ADF tests, except for the US price, which is stationary at value of level. The optical lag numbers are chosen relying on the CIA criteria.

Moreover, the prices of a good in two markets are simultaneously determined regardless of the relative size of the countries (Protopapadakis and Stoll, 1983). Therefore, the conventional assumption of exogenous price includes a problem of endogeneity. Consequently, in this paper the Fully Modified Ordinary Least Square (FM-OLS) and Autoregressive Distributed Lag (ARDL) models are applied to overcome the problems with stationarity and endogeneity when testing LOP.

Fully Modified Ordinary Least Square (FMOLS) Estimation

Phillips and Hansen (1990) are the first to propose use of the FMOLS estimator, which employs a semi-parametric correction to eliminate the spurious regression caused by serial correlation effects, and endogeneity that is a result of the existence of a cointegration relationship (Chi and Baek, 2011; and Adom et al. 2015). This method is based on a log-linear form model and two modifications to the OLS estimator: (1) the dependent variable y_t is replaced by a suitably constructed y_t^+ (to modify the variables) and (2) additive correction factors are employed (to estimate directly and eliminate the existing nuisance parameters).

Assuming the basic model has a single equation estimator of the cointegration relationship, then

(40) $$y_t = x_t'\beta + D_{1t}'\gamma + u_{1t}$$

(41) $$x_t = \Gamma_1' D_{1t} + \Gamma_2' D_{2t} + \mathcal{E}_t$$

where, D_{1t} and D_{2t} are deterministic trend regressors, u_{1t} is the cointegration error, and the regressor innovations are expressed as $u_{2t} = \Delta\mathcal{E}_t$.

Assuming the innovations $u_t = (u_{1t}, u_{2t}')'$ are strictly stationary and ergodic with zero means and contemporaneous covariance matrix Σ can be expressed as:

$$\Sigma = \mathrm{E}(u_t u_t') = \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{bmatrix}$$

Because a long-run correlation exists between u_{1t} and u_{2t}, the OLS estimation is biased, causing the conventional testing procedures to be invalid. The FMOLS estimation transforms the dependent variable y_t to y_t^+ to correct the endogeneity

(42) $$y_t^+ = y_t - \widehat{\omega}_{12}\widehat{\Omega}_{22}^{-1}\hat{u}_2$$

and, the serial correlation correction term has the form

(43) $$\hat{\lambda}_{12}^+ = \hat{\lambda}_{12} - \widehat{\omega}_{12}\widehat{\Omega}_{22}^{-1}\widehat{\Lambda}_{22}$$

where Λ is one-sided LRCOV matrix and Ω is a nonsingular LRCOV matrix

(44) $$\Lambda = \sum_{j=0}^{\infty} \mathrm{E}\left(u_t u_{t-j}'\right) = \begin{bmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \Lambda_{22} \end{bmatrix}$$

(45) $$\Omega = \sum_{j=-\infty}^{\infty} \mathrm{E}\left(u_t u_{t-j}'\right) = \begin{bmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \Omega_{22} \end{bmatrix}$$

The resulting FMOLS estimator is then given as

(46) $$\hat{\theta} = \begin{bmatrix} \hat{\beta} \\ \hat{\gamma} \end{bmatrix} = \left(\sum_{t=1}^{T} Z_t Z_t'\right)^{-1} \left(\sum_{t=1}^{T} Z_t y_t^+ - T \begin{bmatrix} \hat{\lambda}_{12}^{+\,\prime} \\ 0 \end{bmatrix}\right)$$

where, $Z_t = (x_t', d_{1t}')'$. $\widehat{\omega}_{1,2}$ is the estimate of LRCOV for u_{1t} which is conditional on u_{2t}.

In this estimation, y_t^+ and $\hat{\lambda}_{12}^+$ are the correction terms for endogeneity and serial correlation, respectively. The resulting estimator, combines endogeneity correction and serial correction, is asymptotically unbiased and has fully efficient mixture-normal asymptotic distribution, which allows for standard Wald tests using the asymptotic chi-square statistical inference

Autoregressive Distributed Lag (ARDL) model

The ARDL model is also applied to compare results with those of the FMOLS model since the dataset has a feature of nonstationary at level but all variables are I(0) at first difference and not I(2). This approach has been popularly applied by Pesaran, Shin, and Smith (1997; 2001); and Pesaran and Smith (1998) to deal with whether the variables are purely I(0), purely I(1), or mutually cointegrated. Another advantage of the ARDL model is its flexibility picking efficient lag numbers for each variable, while other cointegration approaches require all regressors to be integrated of the same order and they determine number of lag for every variable in the model

(Pahlavani, Wilson, and Worthington, 2005). As a result, the ARDL model can avoid the problem of conflict that occurs between ADF and PP tests. Moreover, linear transformation to derive a dynamic error correction model from ARDL can provide short run and long run relationships between variables (Shrestha and Khorshed, 2007; Alam and Ahmed, 2010). According to Pesaran et al. (2001), the ARDL modeling version of equation (6) is as follows:

(47) $\text{dln}\,\tilde{P}_{US,t} = \alpha + \sum_{j=1}^{n} \beta_j dln\tilde{P}_{US,t-j} + \sum_{j=1}^{n} \delta_j dlnP_{i,t-j} + \sum_{j=1}^{n} \gamma_j dlne_{i,t-j} + \sum_{j=1}^{n} \epsilon_j dlnT_{i,t-j} + \varphi_1 ln\tilde{P}_{US,t-1} + \varphi_2 lnP_{i,t-1} + \varphi_3 dlne_{i,t-1} + \varphi_4 dlnT_{i,t-1} + \varepsilon_t$

where, φ_k(k=1…4) are coefficients of long-run relationships and β_j, δ_j, γ_j, and ϵ_j are short-run dynamic coefficients. The null hypothesis is $\varphi_1 = \varphi_2 = \varphi_3 = \varphi_4$=0, which implies no long-run cointegration between the variables.

Results of tests for LOP of the US shrimp market

The choice of number of lags in the ARDL model relies on CIA criteria and is different among variables. For each country, the model is qualified conditions of serial correlation and stability as results from the Breusch-Godfrey Serial Correlation LM test and the Cusum test, respectively. In addition, the Bound test using F-statistics shows that all models have a long-run cointegration between dependent variable and regressors. The Wald test coefficient restrictions for both the FMOLS model and the ARDL model provide similar conclusions on LOP, except for the case of India. Results of LOP tests by the FMLS model and the ARDL model are presented in table 5 and table 6, respectively. The simulation for EDM model relies on the ARDL model since there is not much difference in magnitudes of coefficients between the two models, but the ARDL output is more reliable when the R-squares and statistical indicators are more significant.

The results from LOP tests show inconsistent results of LOP between the two types of model equations in the cases of Thailand, China, and India, and consistent conclusions in the cases of Ecuador, Indonesia, and Vietnam. For the first three countries, the LOP is accepted when the LOP equation includes transportation costs and it is rejected once the LOP equation has a missed specification for transportation costs. As a result, coefficients in missed specification LOP equation are smaller than those in correct form. This indicates that leaving the transportation costs out would cause a dangerous type I error[7] when the LOP should be accepted in the cases of Thailand, China, and India.

Although the econometric results for testing LOP are statistical significant and hold, there are differences in term of economic significance. In particular, the coefficients of exchange rate are supposed to be one or around one if we cannot reject the hypothesis of LOP. The regression results present coefficients that are 0.74, 0.88, and 0.90 for the case of China, Thailand, and India, respectively. This implies that these numbers are statistically significant since they are close to one. However, under an economic perspective, these numbers are relatively underestimated in comparison to hypothesis numbers of 26%, 12%, and 10%, respectively. Therefore, the conventional assumption of perfect transmission elasticity and missed specification will cause the estimation of the effects of changes in exchange rate or transportation costs to be overestimated or underestimated.

The differences of price coefficients between the two models are relatively small (less than 8%) except for the Thailand case (32%). The gaps of exchange rate elasticities between the two models are relatively large, ranging from 0.02 (Ecuador) to 0.45 (Thailand). Therefore, the impact evaluation that relies on the missed-specification equation is inaccurate.

The excess demand elasticity represents only the US excess demand elasticity for all sources. Whereas, excess supply elasticities are combined by seven individual countries, hence, the supply share from each individual country is relatively small compared to total US imports. As a result, the summation of elasticities in the excess supply side is smaller than the individual supply elasticity. Therefore, it is not accurate to conclude that the test for the above theoretical statement failed when the less elastic side bears more incidences. Actually, the US demand elasticity for a specific supplier is hidden in the international trade model. With a simplified model and the assumption of one net importer (the US) and two net exporters (country i and ROW), the US demand curve for shrimp from a particular country i is presented in the appendix for three cases: 1) perfect price transmission, 2) LOP with transportation costs, and 3) LOP without transportation costs. The simulated results for the US demand elasticities are presented in table 7 & 8. Obviously, the US import demand elasticities for shrimp from a particular country

[7] This is an error of rejecting a null hypothesis when it is actually true.

i is much larger than export supply elasticity. Therefore, the incidence of transportation costs and exchange rate splits mostly on the export suppliers instead of the US consumers.

Effects of exchange rate and transportation costs on prices

Bilateral exchange rate between the US and an exporting coutnry causes a possitive effect on the US price and negative effect on the price received by the exporter. In other words, an increase in exchange rate (the weaker US dollar) causes the shrimp price in the US market to be higher and the FOB price lower. Overall, exchange rate very little effect on the US price, and the exporting supplier bears most of the effects. This implies that volatility of shrimp price in the US market is not due to the exchange rate between two countries; but it may be caused by the supply side. Although the import of shrimp accounts for a very high portion of the total US shrimp consumption (the total excess demand is seemly inelastic), the excess demand for a particular country is very elastic because an exporter is dealing with many competitors. As a result, if an adjustment of exchange rate is made between the two countries, the exporting supplier will suffer most and gives benefit to the other suppliers.

For the Thailand supplier scenario, a 10% weakening of the US dollar in comparision to Thai baht, causes the price Americans pay for shrimp from Thailand to increase 0.6%, whereas the exporting price of shrimp in Thailand decreases 12.1%. An increase in price of shrimp imported from Thailand also causes prices from other exporters such as China, Ecuador, Indonesia, India, Vietnam, and ROW to increase by 10%, 0.7%, 0.9%, 12%, 16%, and 10%, respectively. Obviously, the price of shrimp from other exporting countries responds to change in the US dollar-Thai baht exchange rate higher than the US price does. This benefits Vietnam the most and Ecuador the least. In the case of the missed specified LOP equation, the effects of exchange on the US price is smaller (0.5%) and the change of Thailand price switches from being elastic to inelastic (decrease of 8.1%). The exchange rate between the US dollar and Chinese yuan causes a similar effect. For instance, if the Chinese yuan is weakened by 10%, the US price of shrimp imported from China drops by 0.6% and the price received by Chinese exporters increases 12.2%. This adjustment works like an export subsidy for the Chinese shrimp producer. An adjustment of exchange rate between the US and India, and between the US and Vietnam provides higher effects on US prices in comparison to other countries, with, the greater effect resulting from adjusting the US and Vietnam dong ratio. In particular, if the US dollar is strengthened by 10%, the US price of shrimp imported from Vietnam goes down by 17%, and the price received by Vietnamese suppliers goes up by 7.8%. Although the exchange rate between the US dollar and the Vietnam dong causes the largest effect on the US shrimp price, the price of imported shrimp in the US market is inelastic in response to exchange rate from all countries. In addition, Thailand and Chinese shrimp prices are most influenced by exchange rate and Vietnam benefits most from cross effects of exchange rate.

The effects of exchange rate on the prices of shrimp when excluding transportation costs, are relatively smaller than when transportation costs are included. For example, the effects of exchange rate on the US price of shrimp imported from China and Vietnam decline approximately 50% with exclusion of transportation costs in comparison to addition of transportation costs. Therefore, a policy analysis based on the missed specification of LOP will cause the impact evaluation to be underestimated by approximately 26%. In addition, the effects of exchange rate on US shrimp price relied on the assumption of perfect price transmission, and this caused an overestimate since the US price of imported shrimp is approximately 50% higher than those of the correct LOP equation. Moreover, with perfect transmission, summation of changes in US shrimp price and an exporting country price (absolute value) should equal one. The other cases of imperfect price transmission, the effect evaluation is underestimated so summation of price effects in the US market and a exporting country is less than one in the case of excluded transportation costs but greater than one in the case where transportation costs are included.

An increase in transportation costs has an effect similar to that of a weakened US dollar or a tax on imports. A growth in transportation cost between the US and an exporting country makes the price of shrimp in the US more expensive. However, the sizes of transportation costs have much smaller effects on shrimp price than those of exchange rate. For instance, transportation costs between the US and Ecuador or Indonesia have no effect on the US prices of shrimp imported from these countries. In the same way, Thailand and Chinese shrimp prices bear the highest effects from transportation costs in comparison to the other exporting countries, and Vietnam gets the largest benefit from cross effects.

Effects of exchange rate and transportation costs on trade flows

Effects of exchange rate and transportation costs split between the US import demand and export supply quantity depending on weight of excess supply and excess demand elasticities. In isolation simulation, both exchange rate and transportation costs do not mean much for the import demand. Similar to the price side, exchange rate and transportation costs provide greater depressing effects on the supply side and very little effect on the demand side.

A depreciation of the US dollar causes both the US demand and export supply from a partner country to decline. The US shrimp import demand is most sensitive to exchange rate between the US and Vietnam, even though the demand elasticities are not elastic for all countries. However, the export supply elasticities from all countries are very elastic to the exchange rate. For example, a 1% weakening of the US dollar value in comparison to Vietnam dong will cause US import demand of shrimp from Vietnam to go down by 0.16%. Whereas, shrimp supply from Vietnam is very elastic to the movement of exchange rate, and it decreases 13.6% in response to a 1% depreciation of the US dollar. The reason for the lower import demand is because a growth in import price of shrimp from Vietnam, associated with an increase in the exchange rate between the two countries, causes the US to switch to more imports from other competitive countries. As a result, the US import of shrimp from China, India, Ecuador, Indonesia, and Thailand rises by 2.44%, 2.26%, 0.82%, 0.75%, and 0.57%, respectively. Once again, this explains why the US demand elasticity for a specific country is very elastic because there are various supplies from other sources. Whereas, the overall demand elasticity is essentially inelastic since US shrimp import accounts for more than 80% of American shrimp consumption. The US demand is least sensitive to changes with the Indonesia exchange rate, and supply from this country also the least elastic to exchange rate movement. For instance, with a 1% appreciation of the Indonesian rupiah, the US import demand for shrimp from Indonesia goes up by 0.03% and the export supply from Indonesia drops by 2.66%. Both import demand and export supply from Indonesia are least elastic to the exchange rate between the two countries, so a shift in exchange rate can benefit other countries with a smaller share of the US market as they increase export to the US market. An increase of US imports from Vietnam, China, India, Ecuador, and Thailand would be 1.54%, 0.45%, 0.42%, 0.15%, and 0.10%, respectively due to 1% appreciation of the Indonesia rupiah in comparison to the US dollar.

The effects of exchange rate on the US shrimp price, with transportation costs included in the LOP test, are smaller with the imperfect verse perfect price transmission assumption. However, these effects are larger than those in the case of imperfect price transmission without transportation costs in the LOP test. For instance, if the LOP test with included transportation costs indicates that the Thailand exchange rate causes the US price of shrimp to decrease by 0.05%, then this number is 0.11% in case of perfect price transmission, but only 0.04% in the case of imperfect price transmission with transportation costs excluded. On average, the assumption of perfect price transmission leads to an impact evaluation of the US import demand quantity being overestimated by twice and underestimated by 30% in that case where the LOP test does not include the transportation costs.

Transportation costs can also cause the trade flows between two countries to decrease because of the resultant increase in delivery price for a commodity. However, this has very little effect on the US import demand of shrimp from an isolated country. Similar to the price effect, transportation costs between the US and Ecuador and between the US and Indonesia do not have any influence on the US import demand for shrimp. In addition, the export supplies from Vietnam and China are the most sensitive to change in transportation costs. For example, if the transportation costs between the US and Vietnam or between the US and China increase by 1%, the export supply of shrimp into the US market drops by 5.14% from Vietnam or 4.99% from China. A reduction in import of shrimp from a partner country will provide opportunities for other countries to import more shrimp into the US. Overall, Vietnam gets the highest benefit from this cross effect.

Changes in exchange rate and transportation costs between the US and Vietnam cause the largest impacts on US shrimp price and import quantity. One reason for this is because the elasticity of excess supply of shrimp from Vietnam[8] is much larger than that of other countries; hence it dominates the effects of other factors. In particular, the US price of shrimp in response to exchange rate with a particular country is determined not only by the export share this country has in the US shrimp import market but is also impacted by export supply elasticity from this country in combination with exchange rate and transportation transmissions. This relationship holds with every country because the denominator in the evaluation is the same for every

[8] Excess supply from Vietnam is highest because the export share of shrimp exporting to the US market from Vietnam is smallest share of total domestic production (23%) whereas it is 67% in case of Thailand.

country. Although the import share, transmissions of exchange rate and transportation cost from Vietnam are smaller than those from other countries, the magnitudes of these factors are much smaller than the magnitudes of excess supply elasticities. Therefore, in the case of Vietnam, any changes in exchange rate or transportation costs will cause the largest effect. The next dominant countries are China and India because their excess supply elasticities are more outstanding than the other shrimp exporting countries.

Both assumptions of perfect price transmission and imperfect price transmission, without inclusion of transportation costs causes a big bias in evaluating the effect of a factor on the US import price and demand for shrimp. If the perfect price transmission elasticity causes the effect on US price of shrimp to be overestimated by 50%, then this number is double the effect on US import demand quantity. However, the test of LOP without transportation costs causes the effect evaluation to be underestimated by approximately 30% in terms of import price and import quantity.

Concluding remarks

This study responds to the two research questions, with the first being whether excluding transportation cost in testing the LOP between two countries causes an error in concluding accurate price transmission elasticities and the second being whether evaluating the effects of exchange rate and transportation costs on shrimp prices and trade flows are biased when using these elasticities. The results indicate that 50% of the LOP tests deal with Type I error when eliminating the transportation cost between two countries, because the elasticities from the model are composed only of prices between two countries and the exchange rates are also underestimated. As a consequence, effects of exchange rate and transportation cost on the US import prices and import demand quantities for shrimp are both underestimated. In addition, the conventional assumption of perfect price transmission between two countries causes this effect evaluation to be overestimate too.

The LOP tests are implemented to determine the price transmission elasticities between the US market and six major partners including Thailand, China, Ecuador, Indonesia, India, and Vietnam. Conclusions on LOP between two markets are inconsistent between models including and excluding transportation costs. Particularly, if the LOP for shrimp is rejected in all major exporting countries with the assumption of zero transportation costs, this law will hold for

Thailand, China, and India when adding transportation costs. This result is consistent with those of the former studies mentioned in the introduction which included transportation and transition costs in their analyses. In reality, transportation cost between the US and these counties ranges from 1% to 5%. Therefore, once the importance of transportation costs in testing LOP is missed, the coefficient of price is smaller than the value of one, which it should be. Consequently, the hypothesis of this coefficient of one is more likely to be rejected, even though it should be accepted. Importantly, results from this study which claim that the conventional standard for LOP should hold when coefficient of price (θ_i) equals one, that is not necessarily true. For example, it is proven in the cases of Thailand (0.68), China (0.56), and India (0.49), that the LOP still holds once these coefficients of price are less than one.

The results in this study are consistent with those of former researchers, indicating that the less elastic side of the market bears the greater incidence of a subsidy (Kinnucan, 2003; Kinnucan and Myrland, 2005; and Ashe, 2001). This study assumes that shrimp imported into the US market from different countries is a homogenous commodity. Overall, exchange rate and transportation costs reduce the import supply price, increase the import demand price, and reduce equilibrium quantity of trading. Incidence splits between a rise in the US shrimp price and a fall in the supply price received by a foreign country, depends on the market structure. Because the US shrimp demand elasticity from a particular source is very elastic, the US price is influenced very little by movements of exchange rate and transportation costs. In contrast, the import suppliers are the most suffered from these changes since their supply elasticities are relatively smaller than import demand elasticities. In addition, this study also distinguishes the difference between US total demand elasticity and demand elasticity for a particular country. For example, if the US total demand elasticity for shrimp is mostly inelastic, the demand for a particular country can be very elastic, since exporting shrimp into the US market is highly competitive.

On the other hand, the US is a major market for shrimp exports from Thailand, Indonesia, and Ecuador. Therefore, the export supply elasticities from these countries are less elastic in comparison to those from Vietnam, China, and India. This means the exchange rate and transportation cost from Vietnam, China, and India causes more effect on US shrimp prices and import demand than the other countries. Because excess supply of shrimp from Vietnam is the most elastic, any changes of exchange rate between the US and Vietnam will create the largest effect in comparisons to changes from the other countries. In addition, a weakening of the US dollar increases the US shrimp price and lowers the price received by a bilateral partner. As a result, the importing supply from this partner to the US market declines, and that gives greater opportunity for the other competitive suppliers. Overall, Vietnam is a country which gains the highest benefit from this cross effect since Vietnam owns the highest excess supply elasticity.

The conventional assumption of perfect price transmission elasticity and missing transportation costs in testing the LOP causes a big bias in estimating the impacts of exchange rate and transportation costs on the price and trade flows of shrimp. The assumption of perfect transmission elasticity of shrimp prices between the US and a partner market causes the effects of exchange rate on the US shrimp price and the US import demand for shrimp to be overestimated by approximately 50% and 100%, respectively. On the contrary, the result of testing LOP without transportation costs overestimates the effect of exchange rate on US shrimp price and import quantity by approximately 30%. These results are consistent with those of former researchers who stated that the assumption of a perfect relationship between two prices causes the elasticity to be overestimated (Reimer, Zheng, and Gehlhar, 2012). The model used in this study can be applied to other research related to analyzing incidents of a trade policy, such tariff or tax.

Appendix

Table 11. Parameters to Simulate for Domestic Models

No.	Notation	Description	Parameters
1	η_d^{US}	US domestic demand elasticity	-0.59
2	ε_d^{US}	US domestic supply elasticity	1.1
3	ε_{TL}^{US}	Elasticity of supply from Thailand	1.46
4	ε_{ROW}^{US}	Elasticity of supply from ROW	1.27
5	k_d^{US}	Share of US's consumption from domestic production	0.20
6	k_i^{US}	Share of US's consumption imported from six major countries	0.67
7	k_{TL}^{US}	Share of US's consumption imported from Thailand	0.20
8	k_{CN}^{US}	Share of US's consumption imported from China	0.06
9	k_{ECD}^{US}	Share of US's consumption imported from Ecuador	0.12
10	k_{INDO}^{US}	Share of US's consumption imported from Indonesia	0.12
11	k_{INDI}^{US}	Share of US's consumption imported from India	0.10
12	k_{VN}^{US}	Share of US's consumption imported from Vietnam	0.08
13	k_{ROW}^{US}	Share of US's consumption imported from ROW	0.13
14	ε_d^{TL}	Thailand domestic supply elasticity	1.20
15	η_d^{TL}	Thailand domestic demand elasticity	-0.61
16	η_{US}^{TL}	Thailand demand elasticity exported to US	-1.00
17	η_{ROW}^{TL}	Thailand demand elasticity exported to ROW	-0.50
18	k_d^{TL}	Share of Thailand's production for domestic consumption	0.05
19	k_{US}^{TL}	Share of Thailand's production for export to US	0.67
20	k_{ROW}^{TL}	Share of Thailand's production for exported to ROW	0.28
21	k_d^{CN}	Share of China's production for domestic consumption	0.41
22	k_{US}^{CN}	Share of China's production for export to US	0.35
23	k_{ROW}^{CN}	Share of China's production for exported to ROW	0.24
24	k_d^{ECD}	Share of Ecuador's production for domestic consumption	0.02
25	k_{US}^{ECD}	Share of Ecuador's production for export to US	0.53
26	k_{ROW}^{ECD}	Share of Ecuador's production for exported to ROW	0.45
27	k_d^{INDO}	Share of Indonesia's production for domestic consumption	0.02
28	k_{US}^{INDO}	Share of Indonesia's production for export to US	0.73
29	k_{ROW}^{INDO}	Share of Indonesia's production for exported to ROW	0.25
30	k_d^{INDI}	Share of India's production for domestic consumption	0.00
31	k_{US}^{INDI}	Share of India's production for export to US	0.45
32	k_{ROW}^{INDI}	Share of India's production for exported to ROW	0.55
33	k_d^{VN}	Share of Vietnam's production for domestic consumption	0.06
34	k_{US}^{VN}	Share of Vietnam's production for export to US	0.23
35	k_{ROW}^{VN}	Share of Vietnam's production for exported to ROW	0.71
36	$\theta_{TL} = (1 - \tau_{TL})$	Price transmission elasticity between US and Thailand	0.98
37	$\theta_{ROW} = (1 - \tau_{ROW})$	Price transmission elasticity between US and ROW	0.62
38	φ_{TL}	Exchange rate elasticity between US and Thailand	0.77
39	φ_{ROW}	Exchange rate elasticity between US and ROW	0.52
40	τ_{TL}	Transportation cost elasticity between US and Thailand	0.33
41	τ_{ROW}	Transportation cost elasticity between US and ROW	0.10

Table 12. Parameters to Simulate for International Models

No.	Item	Definition	Perfect price transmission	Price transmission with TC	Price transmission without TC
1	η^{US}	US excess demand elasticity	-1.46	-0.95	-0.88
2	ε^{TL}	Excess supply elasticity from Thailand	1.44	2.12	3.11
3	ε^{CN}	Excess supply elasticity from China	4.49	7.98	8.32
4	ε^{ECD}	Excess supply elasticity from Ecuador	2.72	3.69	3.93
5	ε^{INDO}	Excess supply elasticity from Indonesia	1.83	2.84	2.88
6	ε^{INDI}	Excess supply elasticity from India	3.28	6.48	6.96
7	ε^{VN}	Excess supply elasticity from Vietnam	6.92	17.55	18.73
8	ε^{ROW}	Excess supply elasticity from ROW	3.45	6.80	7.34
9	K_{TL}	Share of Thailand to the US total imports			0.24
10	K_{CN}	Share of China to the US total imports			0.07
11	K_{ECD}	Share of Ecuador to the US total imports			0.14
12	K_{IND}	Share of Indonesia to the US total imports			0.14
13	K_{ID}	Share of India to the US total imports			0.13
14	K_{TL}	Share of Vietnam to the US total imports			0.10
15	K_{VN}	Share of ROW to the US total imports			0.18

Table 13. US Excess Demand Elasticities for Shrimp from a Specific Country

Country	Perfect transmission	LOP with TC	LOP without TC
Thailand	-16.68	-22.02	-23.79
China	-66.99	-91.67	-99.50
Ecuador	-31.33	-42.30	-45.83
Indonesia	-31.03	-41.89	-45.39
India	-35.38	-47.91	-51.93
Vietnam	-46.68	-63.55	-68.94
ROW	-24.07	-32.25	-34.91

Table 14. Diagnosed of Time Series for Testing LOP

	τ (tau) (single mean and trend) (ADF test) (level)	First difference	Optimal lags
Price (-2.87)			
$\ln P_{US}$	-1.75 (unit root)	-6.19(stationary)	
$\ln P_{TL}$	-2.13 (unit root)	-10.62 (stationary)	3
$\ln P_{CN}$	-1.93 (unit root)	-9.28 (stationary)	4
$\ln P_{ECUA}$	-2.47 (unit root)	-13.53 (stationary)	8
$\ln P_{INDO}$	-2.35 (unit root)	-14.06 (stationary)	4
$\ln P_{INDIA}$	-2.02 (unit root)	-13.07 (stationary)	4
$\ln P_{VN}$	-3.95 (stationary)	-14.85 (stationary)	4
Exchange rate (-3.47)			
$\ln E_{TL}$		-11.05 (stationary)	
$\ln E_{CN}$	-1.27 (unit root)	-4.63 (stationary)	
$\ln E_{ECUA}$	-1.45 (unit root)	-4.18 (stationary)	
$\ln E_{INDO}$	-2.18 (unit root)	-12.34 (stationary)	
$\ln E_{INDIA}$	-1.81 (unit root)	-11.67 (stationary)	
lnVN	-1.68 (unit root)	-12.52 (stationary)	
Transport cost (-2.87)			
lntctl	-2.85(unit root)	-14.66 (stationary)	
lncargocn	-6.21 (stationary)	-12.28 (stationary)	
lncargoecua	-4.04 (stationary)	-16.19 (stationary)	
lncargoindo	-3.25 (stationary)	-12.04 (stationary)	
lncargoindia	-3.02 (stationary)	-11.63 (stationary)	
lncargovn	-4.04 (stationary)	-11.87 (stationary)	

**note: If the absolute test statistics is more than critical value (at 5% level) then we can reject the hypothesis that variable has unit root.*

Table 15. Fully Modified OLS Estimates of Price Transmission Elasticities

Variables/ statistics	Thailand		China		Ecuador		Indonesia		India		Vietnam	
	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B
lnPi	0.65	0.50	0.59	0.55	0.72	0.71	0.69	0.66	0.12	0.13	0.55	0.55
	(7.44)	(6.31)	(4.57)	(4.16)	(7.37)	(7.89)	(7.36)	(7.12)	(0.69)	(0.74)	(4.91)	(4.86)
lnT	0.33		0.31		-0.03		0.07		0.00		0.10	
	(3.15)		(2.75)		(-0.74)		(1.69)		(-0.04)		(1.93)	
lnE	0.77	0.42	0.63	0.40	0.63	0.65	0.68	0.61	0.08	0.13	0.59	0.50
	(4.88)	(3.71)	(3.04)	(2.02)	(6.90)	(8.09)	(7.00)	(6.89)	(0.22)	(0.35)	(3.60)	(3.17)
Constant	-0.43	-0.07	0.21	0.10	-0.67	-0.64	-0.64	-0.57	0.94	1.07	-0.43	-0.46
	(-0.89)	(-0.14)	(0.36)	(0.16)	(-1.79)	(-1.83)	(-1.51)	(-1.33)	(1.50)	(1.72)	(-0.39)	(-0.42)
R2	0.32	0.28	0.13	0.13	0.30	0.32	0.28	0.28	0.02	0.01	0.13	012
S.E.	0.20	0.21	0.23	0.23	0.20	0.20	0.21	0.21	0.24	0.24	0.23	0.23
	Accept	**Reject**	**Accept**	**Reject**	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject

**- Numbers in parentheses are T-statistic values*

- For model A: LOP => β1+ β2 = 1 and β3 = 1

- For model B: LOP => b2 = 1

Table 16. Autoregressive Distributed Lag Model (ARDL) Estimates of Price Transmission Elasticities

Variables/ statistics	Thailand		China		Ecuador		Indonesia		India		Vietnam	
	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B
lnP_i	0.68	0.46	0.56	0.54	0.77	0.73	0.65	0.65	0.49	0.45	0.36	0.34
	(6.33)	(4.69)	(3.02)	(2.81)	(6.86)	(7.94)	(6.21)	(5.90)	(1.75)	(1.69)	(2.32)	(1.96)
lnT	0.46		0.38		-0.04		0.05		0.10		0.17	
	(3.18)		(1.91)		(-0.83)		(1.20)		(0.44)		(1.68)	
lnE	0.88	0.43	0.74	0.47	0.69	0.67	0.64	0.59	0.90	0.79	0.45	0.25
	(4.45)	(3.22)	(2.42)	(1.67)	(6.52)	(8.05)	(5.89)	(5.67)	(1.55)	(1.39)	(1.92)	(1.06)
Constant	-0.53	0.20	0.47	0.27	-0.71	-0.69	-0.54	-0.58	1.54	1.61	-0.13	-0.28
	(-0.92)	(0.32)	(0.54)	(0.30)	(-1.67)	(-1.95)	(-1.09)	(-1.12)	(1.63)	(1.74)	(-0.08)	(1.67)
R^2	0.63	0.60	0.58	0.57	0.61	0.64	0.59	0.59	0.61	0.58	0.60	0.58
S.E.	0.15	0.16	0.16	0.16	0.15	0.15	0.16	0.16	0.16	0.16	0.16	0.16
LOP test	**Accept**	**Reject**	**Accept**	**Reject**	Reject	Reject	Reject	**Reject**	**Accept**	Reject	Reject	Reject

**Numbers in parentheses are T-statistic values*

Table 17. Effects of Exchange Rate and Transportation Costs on Equilibrium Price

Reduced form elasticities	Perfect Price Transmission	Imperfect price transmission With TC	Imperfect price transmission Without TC	Reduced form elasticities	Perfect Price Transmission	Imperfect price transmission With TC	Imperfect price transmission Without TC
$\frac{P_{US}^*}{e_{TL}^*}$	0.08	0.06	0.05	$\frac{P_{US}^*}{T_{TL}^*}$	0.00	0.03	0.00
$\frac{P_{TL}^*}{e_{TL}^*}$	-0.92	-1.21	-0.83	$\frac{P_{TL}^*}{T_{TL}^*}$	0.00	-0.63	0.00
$\frac{P_{US}^*}{e_{CN}^*}$	0.07	0.06	0.03	$\frac{P_{US}^*}{T_{CN}^*}$	0.00	0.03	0.00
$\frac{P_{CN}^*}{e_{CN}^*}$	-0.93	-1.22	-0.81	$\frac{P_{CN}^*}{T_{CN}^*}$	0.00	-0.62	0.00
$\frac{P_{US}^*}{e_{ECD}^*}$	0.09	0.04	0.03	$\frac{P_{US}^*}{T_{ECD}^*}$	0.00	0.00	0.00
$\frac{P_{ECD}^*}{e_{ECD}^*}$	-0.91	-0.85	-0.87	$\frac{P_{ECD}^*}{T_{ECD}^*}$	0.00	-0.05	0.00
$\frac{P_{US}^*}{e_{IND}^*}$	0.06	0.03	0.03	$\frac{P_{US}^*}{T_{IND}^*}$	0.00	0.00	0.00
$\frac{P_{IND}^*}{e_{IND}^*}$	-0.94	-0.94	-0.87	$\frac{P_{IND}^*}{T_{IND}^*}$	0.00	-0.07	0.00
$\frac{P_{US}^*}{e_{IN}^*}$	0.09	0.12	0.10	$\frac{P_{US}^*}{T_{IN}^*}$	0.00	0.01	0.00
$\frac{P_{IN}^*}{e_{IN}^*}$	-0.91	-1.59	-1.52	$\frac{P_{IN}^*}{T_{IN}^*}$	0.00	-0.18	0.00
$\frac{P_{US}^*}{e_{VN}^*}$	0.15	0.17	0.09	$\frac{P_{US}^*}{T_{VN}^*}$	0.00	0.06	0.00
$\frac{P_{VN}^*}{e_{VN}^*}$	-0.85	-0.78	-0.47	$\frac{P_{VN}^*}{T_{VN}^*}$	0.00	-0.29	0.00
$\frac{P_{US}^*}{e_{ROW}^*}$	0.14	0.12	0.09	$\frac{P_{US}^*}{T_{ROW}^*}$	0.00	0.03	0.00
$\frac{P_{ROW}^*}{e_{ROW}^*}$	-0.86	-1.02	-0.84	$\frac{P_{ROW}^*}{T_{ROW}^*}$	0.00	-0.27	0.00

Table 18. Effects of Exchange Rate and Transportation Costs on Equilibrium Price

Reduced form elasticities	Perfect Price Transmission	Imperfect price transmission With TC	Without TC	Reduced form elasticities	Perfect Price Transmission	Imperfect price transmission With TC	Without TC
$\frac{Q^*_{US}}{e^*_{TL}}$	-0.11	-0.05	-0.04	$\frac{Q^*_{US}}{T^*_{TL}}$	0.00	-0.03	0.00
$\frac{Q^*_{TL}}{e^*_{TL}}$	-1.33	-2.72	-2.58	$\frac{Q^*_{TL}}{T^*_{TL}}$	0.00	-1.42	0.00
$\frac{Q^*_{US}}{e^*_{CN}}$	-0.10	-0.06	-0.03	$\frac{Q^*_{US}}{T^*_{CN}}$	0.00	-0.03	0.00
$\frac{Q^*_{CN}}{e^*_{CN}}$	-4.18	-9.71	-6.72	$\frac{Q^*_{CN}}{T^*_{CN}}$	0.00	-4.99	0.00
$\frac{Q^*_{US}}{e^*_{ECD}}$	-0.13	-0.04	-0.03	$\frac{Q^*_{US}}{T^*_{ECD}}$	0.00	0.00	0.00
$\frac{Q^*_{ECD}}{e^*_{ECD}}$	-2.49	-3.13	-3.42	$\frac{Q^*_{ECD}}{T^*_{ECD}}$	0.00	-0.18	0.00
$\frac{Q^*_{US}}{e^*_{IND}}$	-0.08	-0.03	-0.02	$\frac{Q^*_{US}}{T^*_{IND}}$	0.00	0.00	0.00
$\frac{Q^*_{IND}}{e^*_{IND}}$	-1.72	-2.66	-2.50	$\frac{Q^*_{IND}}{T^*_{IND}}$	0.00	-0.21	0.00
$\frac{Q^*_{US}}{e^*_{IN}}$	-0.14	-0.11	-0.09	$\frac{Q^*_{US}}{T^*_{IN}}$	0.00	-0.01	0.00
$\frac{Q^*_{IN}}{e^*_{IN}}$	-2.98	-10.32	-10.61	$\frac{Q^*_{ID}}{T^*_{IN}}$	0.00	-1.15	0.00
$\frac{Q^*_{US}}{e^*_{VN}}$	-0.22	-0.16	-0.08	$\frac{Q^*_{US}}{T^*_{VN}}$	0.00	-0.06	0.00
$\frac{Q^*_{VN}}{e^*_{VN}}$	-5.87	-13.60	-8.76	$\frac{Q^*_{VN}}{T^*_{VN}}$	0.00	-5.14	0.00
$\frac{Q^*_{US}}{e^*_{ROW}}$	-0.20	-0.11	-0.08	$\frac{Q^*_{US}}{T^*_{ROW}}$	0.00	-0.03	0.00
$\frac{Q^*_{ROW}}{e^*_{ROW}}$	-2.98	-6.96	-6.16	$\frac{Q^*_{ROW}}{T^*_{ROW}}$	0.00	-1.83	0.00

Table 19. Reduced Elasticities in Case of LOP with Perfect Price Transmission Elasticities

	Etl*	Ttl*	Ecn*	Tcn*	Eecd*	Tecd*	Eindo*	Tindo*	Eindi*	Tindi*	Evn*	Tvn*	Erow*	Trow*
Qus*	-0.11	0.00	-0.10	0.00	-0.13	0.00	-0.08	0.00	-0.14	0.00	-0.22	0.00	-0.20	0.00
Qtl*	-1.33	0.00	0.10	0.00	0.12	0.00	0.08	0.00	0.13	0.00	0.22	0.00	0.20	0.00
Qcn*	0.35	0.00	-4.18	0.00	0.39	0.00	0.26	0.00	0.42	0.00	0.68	0.00	0.62	0.00
Qecd*	0.21	0.00	0.19	0.00	-2.49	0.00	0.16	0.00	0.25	0.00	0.41	0.00	0.37	0.00
Qindo*	0.14	0.00	0.13	0.00	0.16	0.00	-1.72	0.00	0.17	0.00	0.28	0.00	0.25	0.00
Qindi*	0.26	0.00	0.23	0.00	0.28	0.00	0.19	0.00	-2.98	0.00	0.50	0.00	0.45	0.00
Qvn*	0.54	0.00	0.48	0.00	0.59	0.00	0.40	0.00	0.64	0.00	-5.87	0.00	0.95	0.00
Qrow*	0.27	0.00	0.24	0.00	0.30	0.00	0.20	0.00	0.32	0.00	0.52	0.00	-2.98	0.00
Pus*	0.08	0.00	0.07	0.00	0.09	0.00	0.06	0.00	0.09	0.00	0.15	0.00	0.14	0.00
Ptl*	-0.92	0.00	0.07	0.00	0.09	0.00	0.06	0.00	0.09	0.00	0.15	0.00	0.14	0.00
Pcn*	0.08	0.00	-0.93	0.00	0.09	0.00	0.06	0.00	0.09	0.00	0.15	0.00	0.14	0.00
Pecd*	0.08	0.00	0.07	0.00	-0.91	0.00	0.06	0.00	0.09	0.00	0.15	0.00	0.14	0.00
Pindo*	0.08	0.00	0.07	0.00	0.09	0.00	-0.94	0.00	0.09	0.00	0.15	0.00	0.14	0.00
Pindi*	0.08	0.00	0.07	0.00	0.09	0.00	0.06	0.00	-0.91	0.00	0.15	0.00	0.14	0.00
Pvn*	0.08	0.00	0.07	0.00	0.09	0.00	0.06	0.00	0.09	0.00	-0.85	0.00	0.14	0.00
Prow*	0.08	0.00	0.07	0.00	0.09	0.00	0.06	0.00	0.09	0.00	0.15	0.00	-0.86	0.00

Table 20. Reduced Elasticities in Case of Estimated Price Transmission Elasticities Excluding Transportation Costs

	Etl*	Ttl*	Ecn*	Tcn*	Eecd*	Tecd*	Eindo*	Tindo*	Eindi*	Tindi*	Evn*	Tvn*	Erow*	Trow*
Qus*	-0.04	0.00	-0.03	0.00	-0.03	0.00	-0.02	0.00	-0.09	0.00	-0.08	0.00	-0.08	0.00
Qtl*	-2.58	0.00	0.23	0.00	0.23	0.00	0.17	0.00	0.71	0.00	0.62	0.00	0.60	0.00
Qcn*	0.74	0.00	-6.72	0.00	0.53	0.00	0.39	0.00	1.61	0.00	1.40	0.00	1.37	0.00
Qecd*	0.26	0.00	0.18	0.00	-3.42	0.00	0.14	0.00	0.56	0.00	0.49	0.00	0.48	0.00
Qindo*	0.21	0.00	0.15	0.00	0.15	0.00	-2.50	0.00	0.46	0.00	0.40	0.00	0.39	0.00
Qindi*	0.74	0.00	0.53	0.00	0.53	0.00	0.39	0.00	-10.61	0.00	1.41	0.00	1.38	0.00
Qvn*	2.64	0.00	1.88	0.00	1.89	0.00	1.38	0.00	5.74	0.00	-8.76	0.00	4.90	0.00
Qrow*	0.66	0.00	0.47	0.00	0.48	0.00	0.35	0.00	1.44	0.00	1.26	0.00	-6.16	0.00
Pus*	0.05	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.10	0.00	0.09	0.00	0.09	0.00
Ptl*	-0.83	0.00	0.07	0.00	0.07	0.00	0.05	0.00	0.23	0.00	0.20	0.00	0.19	0.00
Pcn*	0.09	0.00	-0.81	0.00	0.06	0.00	0.05	0.00	0.19	0.00	0.17	0.00	0.16	0.00
Pecd*	0.07	0.00	0.05	0.00	-0.87	0.00	0.03	0.00	0.14	0.00	0.12	0.00	0.12	0.00
Pindo*	0.07	0.00	0.05	0.00	0.05	0.00	-0.87	0.00	0.16	0.00	0.14	0.00	0.14	0.00
Pindi*	0.11	0.00	0.08	0.00	0.08	0.00	0.06	0.00	-1.52	0.00	0.20	0.00	0.20	0.00
Pvn*	0.14	0.00	0.10	0.00	0.10	0.00	0.07	0.00	0.31	0.00	-0.47	0.00	0.26	0.00
Prow*	0.09	0.00	0.06	0.00	0.07	0.00	0.05	0.00	0.20	0.00	0.17	0.00	-0.84	0.00

Table 21. Reduced Elasticities in Case of LOP with Estimated Price Transmission Elasticities Including Transportation Costs

	Etl*	Ttl*	Ecn*	Tcn*	Eecd*	Tecd*	Eindo*	Tindo*	Eindi*	Tindi*	Evn*	Tvn*	Erow*	Trow*
Qus*	-0.05	-0.03	-0.06	-0.03	-0.04	0.00	-0.03	0.00	-0.11	-0.01	-0.16	-0.06	-0.11	-0.03
Qtl*	-2.72	-1.42	0.19	0.10	0.12	0.01	0.10	0.01	0.40	0.04	0.57	0.21	0.39	0.10
Qcn*	0.81	0.42	-9.71	-4.99	0.53	0.03	0.45	0.04	1.71	0.19	2.44	0.92	1.68	0.44
Qecd*	0.27	0.14	0.28	0.14	-3.13	-0.18	0.15	0.01	0.57	0.06	0.82	0.31	0.57	0.15
Qindo*	0.25	0.13	0.26	0.13	0.16	0.01	-2.66	-0.21	0.52	0.06	0.75	0.28	0.52	0.13
Qindi*	0.75	0.39	0.77	0.40	0.49	0.03	0.42	0.03	-10.32	-1.15	2.26	0.85	1.56	0.41
Qvn*	2.75	1.44	2.85	1.46	1.81	0.10	1.54	0.12	5.84	0.65	-13.60	-5.14	5.76	1.50
Qrow*	0.66	0.34	0.68	0.35	0.43	0.03	0.37	0.03	1.39	0.15	1.99	0.75	-6.96	-1.81
Pus*	0.06	0.03	0.06	0.03	0.04	0.00	0.03	0.00	0.12	0.01	0.17	0.06	0.12	0.03
Ptl*	-1.21	-0.63	0.09	0.04	0.05	0.00	0.05	0.00	0.18	0.02	0.25	0.09	0.17	0.05
Pcn*	0.10	0.05	-1.22	-0.62	0.07	0.00	0.06	0.00	0.21	0.02	0.31	0.12	0.21	0.05
Pecd*	0.07	0.04	0.08	0.04	-0.85	-0.05	0.04	0.00	0.16	0.02	0.22	0.08	0.15	0.04
Pindo*	0.09	0.05	0.09	0.05	0.06	0.00	-0.94	-0.07	0.18	0.02	0.26	0.10	0.18	0.05
Pindi*	0.12	0.06	0.12	0.06	0.08	0.00	0.06	0.01	-1.59	-0.18	0.35	0.13	0.24	0.06
Pvn*	0.16	0.08	0.16	0.08	0.10	0.01	0.09	0.01	0.33	0.04	-0.78	-0.29	0.33	0.09
Prow*	0.10	0.05	0.10	0.05	0.06	0.00	0.05	0.00	0.20	0.02	0.29	0.11	-1.02	-0.27

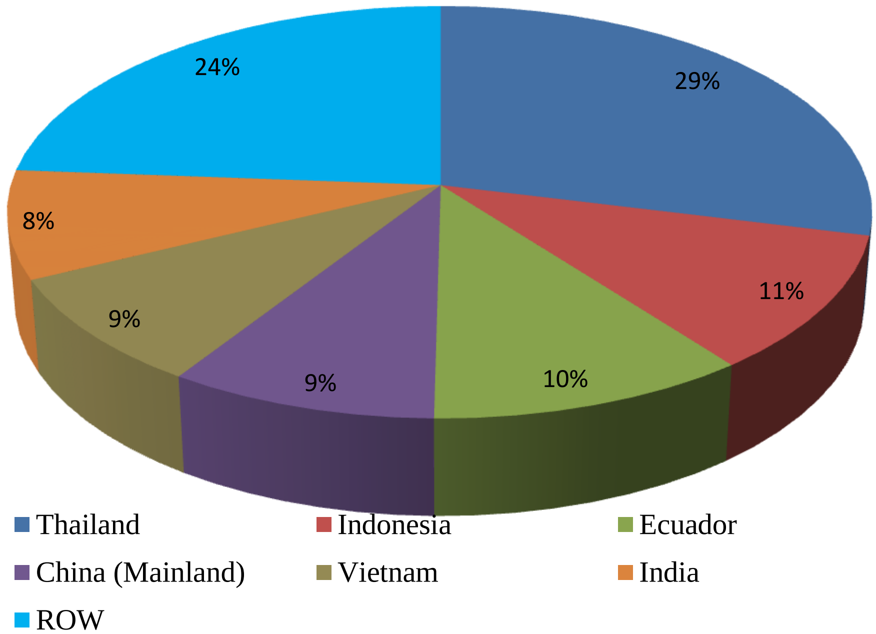


Figure 7. Distributions of Export Countries for the Last 15 years (2000 – 2014)

Data source: USDA, 2015

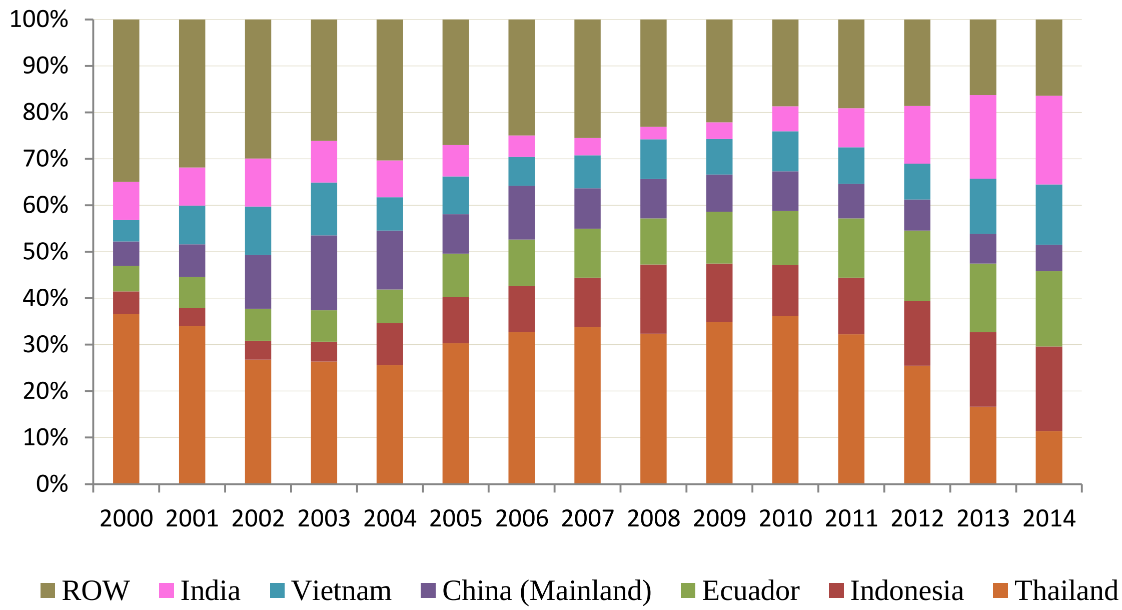


Figure 8. Historical Distributions of Export Countries for the Last 15 years (2000 – 2014)

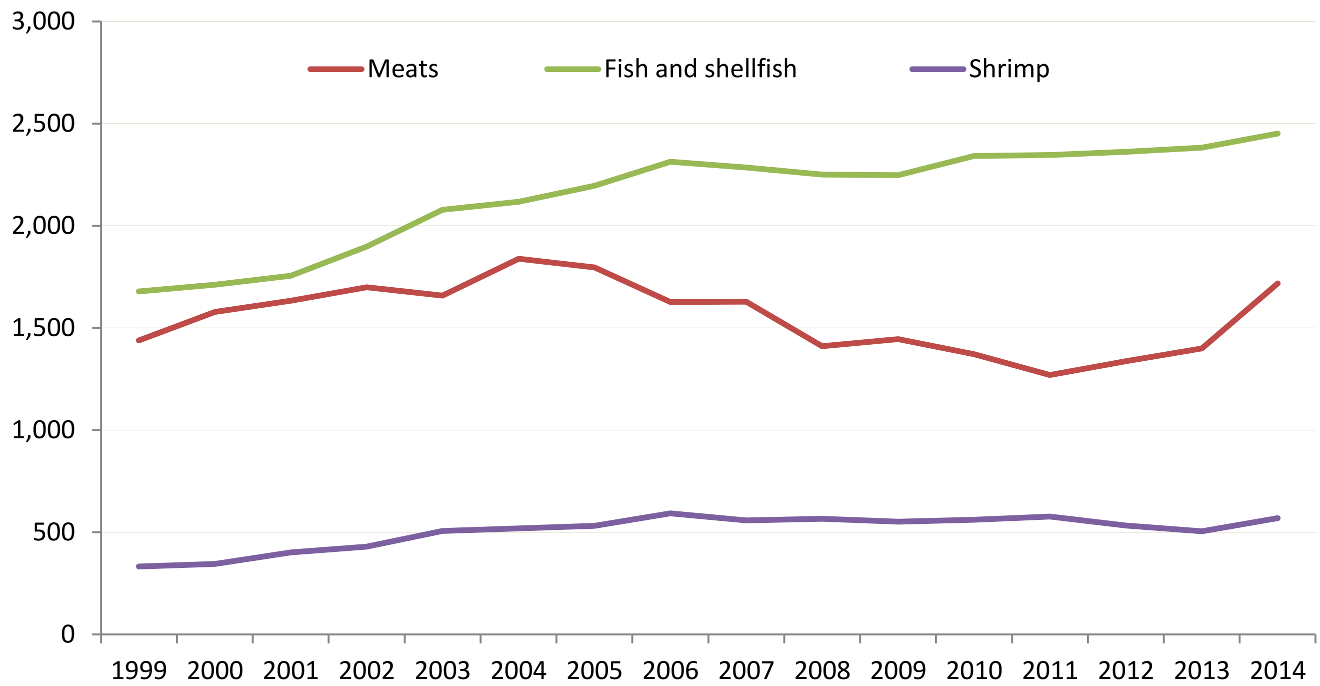


Figure 9. Volume of the US Food Import Share (1000 metric tons)

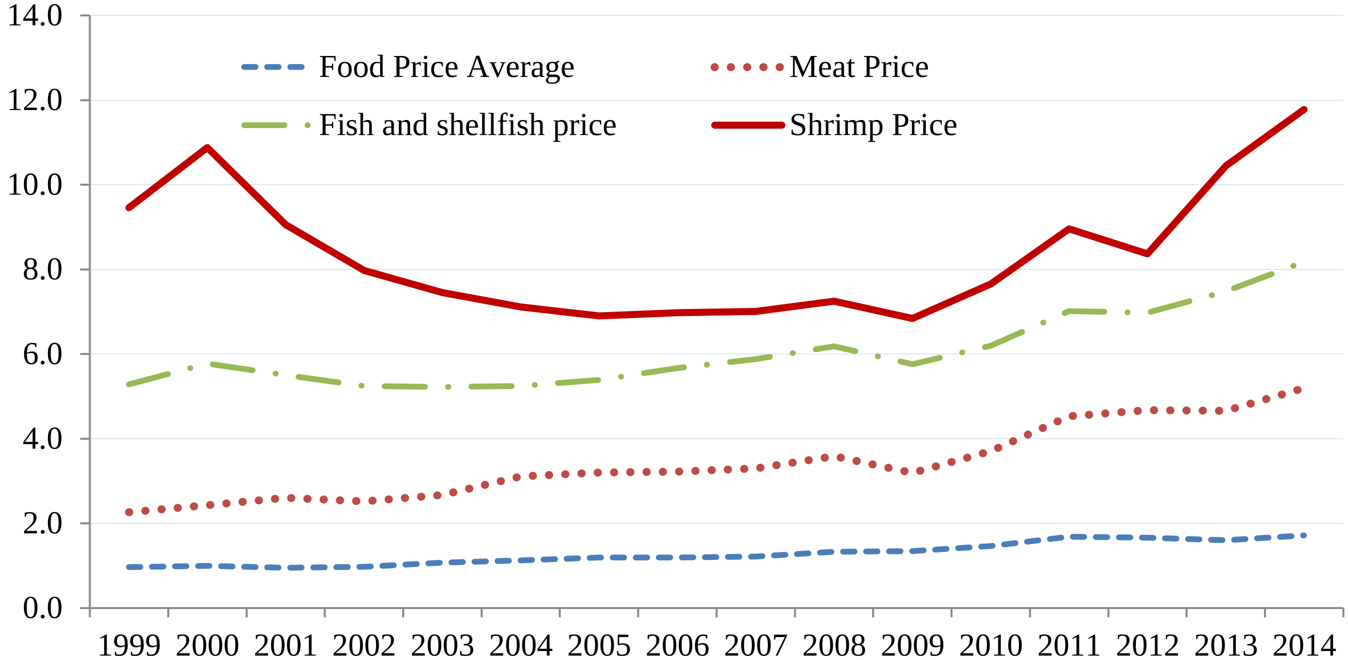
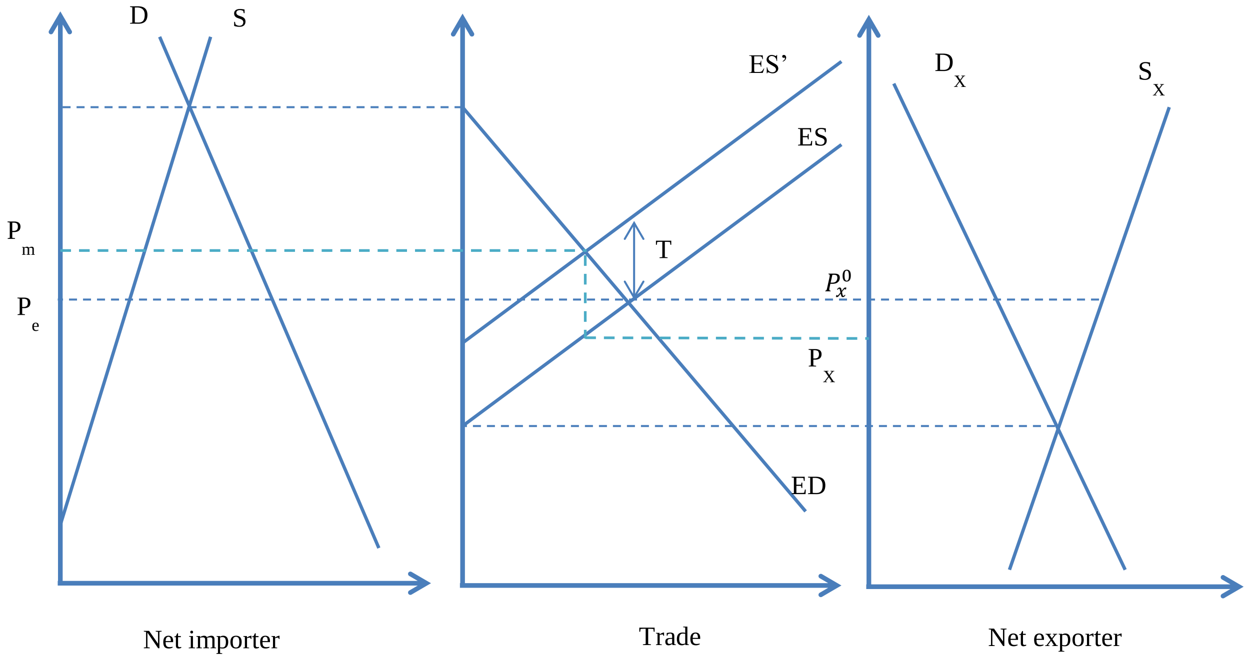
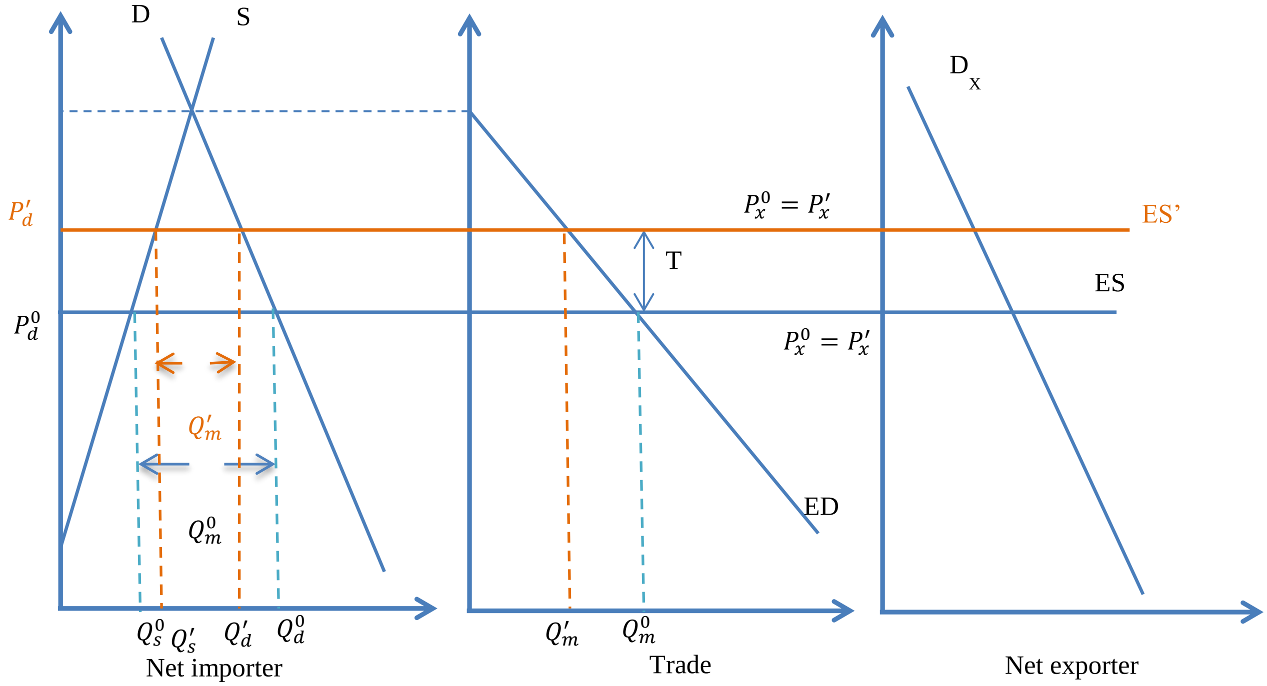


Figure 10. Unit Prices of Importing Foods (Thousand per Metric Ton)



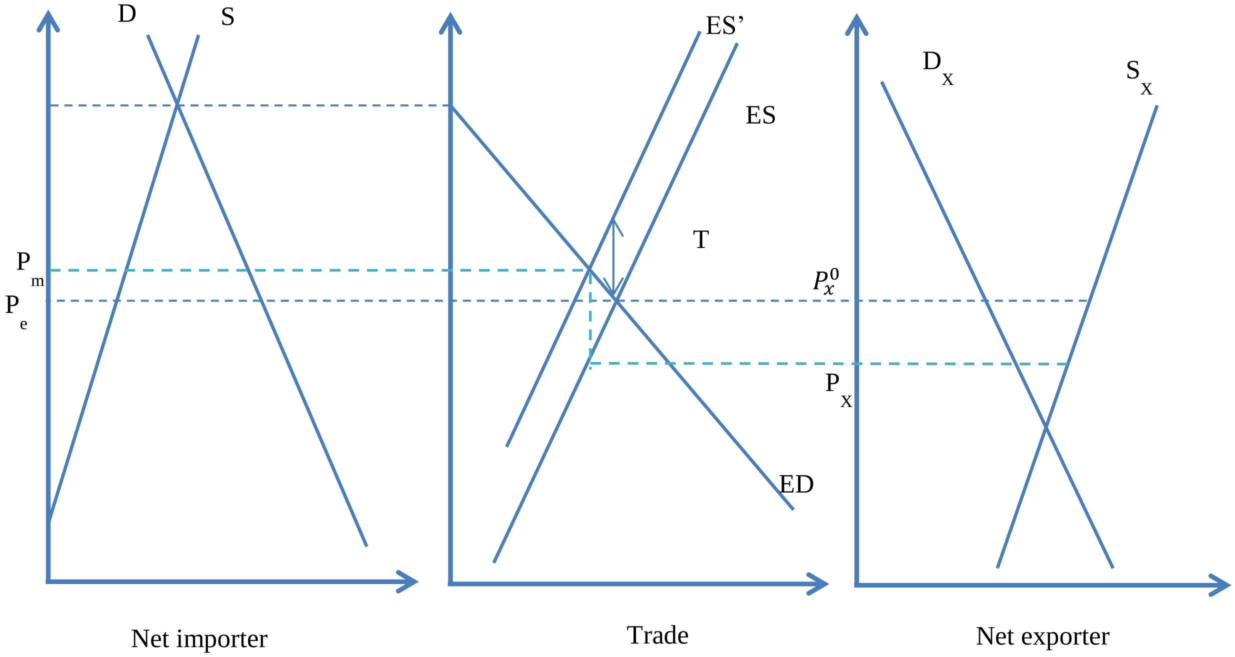
Price transmission elasticity $\theta_{xm} = \frac{dP_m}{dP_x}\frac{P_x}{P_m} < 1$ (bec$ause\ P_x < P_m$)

Figure 11. Both Excess Supply and Excess Demand are Elastic



Price transmission elasticity $\theta_{xm} = \frac{dP_m}{dP_x}\frac{P_x}{P_m} < 1$ (bec*ause* $P_x < P_m$)

Figure 12. Supply Elasticity is Perfectly Elastic



Price transmission elasticity $\theta_{xm} = \frac{dP_m}{dP_x}\frac{P_x}{P_m} < 1$ (because $P_x < P_m$)

Figure 13. Excess Supply is Less Elastic than Excess Demand

The international shrimp model with two exporters (country i and ROW) and one importer (USA) with an assumption of zero transportation costs is:

(1) $Q_{US}^* = \eta^{US} P_{US}^*$

(2) $Q_i^* = \varepsilon^i P_i^*$

(3) $Q_{ROW}^* = \varepsilon^{ROW} P_{ROW}^*$

(4) $P_{US}^* = e_i^* + P_i^*$

(5) $P_{US}^* = e_{ROW}^* + P_{ROW}^*$

(6) $Q_{US}^* = K_i Q_i^* + K_{ROW} Q_{ROW}^*$

Endogenous variables: $Q_{US}^*, Q_i^*, Q_{ROW}^*, P_{US}^*, P_i^*, P_{ROW}^*$

Exogenous variables: e_i^* and e_{ROW}^*

The import demand curve for shrimp from a country i is derived by dropping equation (2) as:

$$Q_i^* = \frac{\eta^{US} - K_{ROW}\varepsilon^{ROW}}{K_i} P_{US}^* + \frac{K_{ROW}\varepsilon^{ROW}}{K_i} e_{ROW}^*$$

Or $Q_i^* = \eta_i^{US} P_{US}^* + \frac{K_{ROW}\varepsilon^{ROW}}{K_i} e_{ROW}^*$

Where $\eta_i^{US} = \frac{\eta^{US} - K_{ROW}\varepsilon^{ROW}}{K_i}$

In this case, if share of country i to the US shrimp imports is 100% then $K_{ROW} = 0$. As a result, $\eta_i^{US} = \eta^{US}$. However, K_i is small, then the US import demand elasticity for shrimp from a particular country i is more elastics than the US overall demand elasticity. The US excess demand elasticities from a particular country i is presented in table 3.

The international shrimp model with two exporters (country i and ROW) and one importer (USA) with transportation costs T is:

Endogenous variables: $Q_{US}^*, Q_i^*, Q_{ROW}^*, P_{US}^*, P_i^*, P_{ROW}^*$

Exogenous variables: e_i^* and e_{ROW}^*

(1’) $Q_{US}^* = \eta^{US} P_{US}^*$

(2’) $Q_i^* = \varepsilon^i P_i^*$

(3’) $Q_{ROW}^* = \varepsilon^{ROW} P_{ROW}^*$

(4’) $P_{US}^* = (1 - \tau_i)P_i^* + \varphi_i e_i^* + \tau_i T_i^*$

(5’) $P_{US}^* = (1 - \tau_{ROW})P_{ROW}^* + \varphi_{ROW} e_{ROW}^* + \tau_{ROW} T_{ROW}^*$

(6’) $Q_{US}^* = K_i Q_i^* + K_{ROW} Q_{ROW}^*$

Endogenous variables: Q_{US}^*, Q_i^*, Q_{ROW}^*, P_{US}^*, P_i^*, P_{ROW}^*

Exogenous variables: e_i^*, e_{ROW}^*, T_i^*, and T_{ROW}^*

The import demand curve for shrimp from country i is:

$$Q_i^* = \underbrace{\frac{\eta^{US} - \frac{K_{ROW}\varepsilon^{ROW}}{1-\tau_{ROW}}}{K_i}}_{\eta_i^{US}} P_{US}^* + \frac{K_{ROW}\varepsilon^{ROW}\varphi_{ROW}}{K_i(1-\tau_{ROW})} e_{ROW}^* + \frac{K_{ROW}\varepsilon^{ROW}\tau_{ROW}}{K_i(1-\tau_{ROW})} T_{ROW}^*$$

Because the price transmission elasticity is less than one the numerator of η_i^{US} is smaller. Therefore, the US import demand elasticity for a country i in case of non-perfect transmission is smaller than that of perfect transmission (table 8).

Data sources links

1) Exchange rate
http://www.ers.usda.gov/data-products/agricultural-exchange-rate-data-set.aspx
Vietnam dong exchange rate at
http://data.worldbank.org/indicator/PA.NUS.FCRF
Vietnam dong – USD exchange rate monthly at
http://www.oanda.com/currency/historical-rates/
https://www.quandl.com/data/CURRFX/USDVND-Currency-Exchange-Rates-USD-vs-VND
2) Shrimp imports (value and quantity) from USDA
http://www.ers.usda.gov/data-products/aquaculture-data.aspx#28188
3) Shrimp import for consumption (CIF and FOB value and quantity) from GATS USDA
http://apps.fas.usda.gov/GATS/default.aspx
4) Information on method of transport for shrimp
http://worldtradedaily.com/2012/09/07/hs-code-030613-frozen-shrimp/
5) The Global Oil Price Data http://www.investing.com/commodities/crude-oil-historical-data
6) The US oil, diesel, and gasoline prices at
http://www.eia.gov/dnav/pet/PET_PRI_GND_DCUS_NUS_M.htm
and at http://www.eia.gov/dnav/pet/PET_PRI_SPT_S1_M.htm
7) Global shrimp price
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Southern Shrimp Alliance Website, 2016:
http://www.shrimpalliance.com/

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