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COOL Effects on U.S. Shrimp Trade

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Abstract

We investigate the economic impact of partial implementation of COOL on U.S. shrimp trade by developing a conceptual model that encompasses horizontal and vertical product differentiation. Horizontal differentiation is characterized by explicitly accounting for differences in shrimp processing – fresh or frozen versus peeled, canned, or breaded. Vertical differentiation in the conceptual model is captured by two scenarios – presence and absence of COOL – on trade between major shrimp exporters and United States. COOL implementation results in quality disclosure through origin labeling and additional costs of labeling on fresh and frozen shrimp sold at retail while processed shrimp products are excluded from labeling. The conceptual model indicates a change in product mix with COOL implementation: the relative share of processed shrimp increases when compared to unprocessed shrimp. Empirically testing the hypothesis using an econometric model shows there is no change in the product mix in the two scenarios. The results however change depending on the choice of variable used to proxy quality.

Key Words: Country of Origin Labeling, Shrimp, Trade

Introduction

Globalization of markets and increased economic integration of agricultural and food systems have become possible with developments in transportation, communication, and information technologies, along with policy reforms. With increased international food trade, the food supply chain from producers to consumers increasingly transcends international borders. The consequence of the increase in transnational trade is that countries share the responsibility for food safety, as globalization of the food supply could introduce new food safety risks, revive previously controlled risks, and spread contaminated food more widely (Buzby and Unnevehr, 2003).

One of the means to proxy food safety that is attracting attention in the international trade arena is identity preservation. Under an identity preservation system, information about the origin of food follows from harvest all the way to the consumer. Country of origin labeling (COOL) aims to preserve identity on country of origin and convey this information to consumers. This identity preservation system could be helpful to authorities in the control of foodborne illness but is not a complete solution to the food safety problem. Mandatory COOL (MCOOL) was implemented in United States on seafood in the retail market in April 2005. However, processed seafood (breaded, canned, cooked) does not require labeling.¹ With more than 70 percent of seafood consumed in the United States being imported, the exclusion of processed seafood could redefine the nature of trade between major exporters and the United States.

¹ COOL policy has exemptions and exclusions. "Processed" seafood is excluded leaving more than 50 percent of seafood sold in the United States without labels; 90 percent of fish sellers, such as wholesale markets and restaurants which are classified under "Foodservice", are also exempt (www.foodandwaterwatch.org).

U.S. Imported Shrimp Market

Shrimp products make up the largest single import item among fish products and are expected to continue to be the most popular seafood consumed in the United States (Haby 2003; Kuchler, Krissoff, and Harvey 2010). Most of the shrimp imported to the United States are from developing countries from Southeast Asia. For the foreseeable future, shrimp will continue to be produced primarily by developing nations and dominate seafood trade moving from developing to developed nations (Haby, 2003). However, many less developed countries have a history of raising food safety issues as they have difficulty meeting developed countries' quality and safety standards due to lack of sufficient funds to invest in quality control measures, more adequately trained staff, and purchase expensive equipment (Rahman, 2001). Chinese seafood products have been primarily in the news for testing positive for traces of antibiotic residues or other contaminants (Allshouse et al. 2003; Lumpkin 2007; Acheson 2007; Gale and Buzby 2009). In addition, it is widely reported that U.S. Food and Drug Administration (FDA) may have lower food safety oversight of imported seafood, which lays the emphasis on consumer judgments when consuming shrimp, especially those imported (www.foodandwaterwatch.org). The analysis of FDA refusals of imported seafood shipments from 2003 to 2006 revealed that of the imports refused, more than 65 percent were processed seafood products, which are excluded from country of origin labeling requirements that the U.S. Department of Agriculture oversees.

Shrimp is produced from practically every tropical and subtropical coastal country in the world. Historically, the source of supply has been wild harvests from the worldwide band of nearshore tropical waters. However, with many wild sources being

harvested close to their maximum sustainable levels, new supplies have come from coastal shrimp farms. Most are located in developing countries within Southeast Asia, the Indian subcontinent, and Central America (Haby 2003; Kuchler, Krissoff, and Harvey 2010). In 2011, 91 percent of total shrimp imports were supplied to the United States by just eight countries. Exports to the United States are becoming more geographically concentrated, even among the top eight countries, with exports from Thailand, Vietnam, Indonesia, Malaysia, India, and China accounting for 73 percent of total imports in 2011. The main six providers (Thailand, Vietnam, Indonesia, India, Ecuador and China) in 2011 accounted for 81 percent of the imported volume and value (NMFS Website).

Previous research pointed out the role of imported shrimp in the impressive growth of the U.S. shrimp market. In 2011, the share of imported shrimp in the U.S. market reached 93 percent up from just 62 percent twenty five years earlier (www.globefish.org; NMFS Website). According to Haby et al. (2002) the important factors that could have contributed to the U.S. shrimp import growth include growing worldwide supplies of farm-raised shrimp, stagnant growth in Japanese consumption, higher tariffs in the European Union (E.U.) for some Asian shrimp, a zero-tolerance policy for residues of banned antibiotics in farmed shrimp entering the E.U., the zero tariffs imposed on shrimp products in the United States, the appreciation of the U.S. dollar, and the expansion of the economy in the 1990s. Some of these factors led to a decrease in shrimp prices in the United States and encouraged consumption of shrimp. The strong growth in shrimp consumption has resulted in the United States overtaking Japan as the top shrimp market in the world.

The product forms of shrimp that enter the United States span the continuum of convenience from raw, frozen, shell-on, headless product to hand peeled, cooked, breaded, and canned shrimp. Haby (2003) report that in the eleven years from 1990 to 2001, exporters of farm-raised shrimp went from exporting roughly two-thirds of total production in the shell-on, headless market form to converting a significant fraction of their annual harvests into value-added products like hand-peeled raw and cooked product. In 2011 although frozen shell-on shrimp was still the most imported product, products with more value added, such as peeled frozen shrimp, breaded frozen shrimp, and other frozen preparations (a category that includes cooked shrimp and meals prepared with shrimp, among other products), have remarkably increased their share of imports. Nearly all of the increase in shrimp imports has occurred within two categories: (a) raw, peeled product and (b) cooked, peeled preparations. According to the U.S. country-of-origin labeling law, category (a) is required to be labeled while (b) is not.²

With MCOOL implementation, an exporting country may export more processed than unprocessed shrimp, thus circumventing the compliance costs associated with MCOOL and preventing quality disclosure. Exporters may easily change the product mix for many reasons. First, several of the top ten countries (e.g., Thailand, Vietnam, and Indonesia) have a growing, dependable supply of raw materials (Haby, 2003). Second, convenience can be added to this dependable supply at a relatively low cost because wage rates in most shrimp-exporting countries are much lower than those in the United States. Third, shrimp can be grown to a predetermined count size that meshes with menu requirements and advertising plans. Haby (2003) outlines other institutional

² Kuchler, Krissoff, and Harvey (2010) mention domestic shrimp is largely consumed through foodservice, where there is no legal requirement to inform consumers of the origin of shrimp, and imported shrimp is largely consumed in retail, where COOL or the Tariff Act require identifying country of origin.

considerations that create national demand/supply imbalances that in turn can explain the nature of the shrimp trade including tariffs, currency exchange rates, and enforcement of food safety regulations.

The objective of this work is to address the economic impact of partial MCOOL implementation on the shrimp trade between United States and the major shrimp exporting countries. The spectrum of shrimp products exported to United States is generally consolidated into two primary forms. These include unprocessed shrimp (raw, peeled, frozen, and shell-on) and processed shrimp (cooked, peeled, canned, and breaded). First, with a conceptual model we determine the factors that explain the change in the product export mix with MCOOL implementation, from unprocessed into processed shrimp. Then, we empirically test the diversion hypothesis using an econometric model that accounts for the share of unprocessed shrimp over total shrimp imports as the dependent variable. The independent variables are based on the reduced-form expression of the conceptual model.

Kuchler, Krissoff, and Harvey (2010) use data from a nationally representative panel of households that record retail food purchases, and estimate consumer demand for shrimp with the implementation of COOL. They aggregate shrimp into three distinct products- random-weight shrimp (unprocessed and not pre-packaged), frozen bagged shrimp (unprocessed or partially processed), and frozen bagged and breaded shrimp (processed). They expected demand for random-weight shrimp to be most affected by COOL, however their results suggest consumers did not respond to the new country-of-origin labels on shrimp. Our work is distinct with the focus on exploring effect of partial

COOL in diversion of unprocessed shrimp to processed shrimp form for major shrimp exporters.

Conceptual Model

Horizontal (Hotelling, 1929) and vertical differentiation (e.g., Mussa and Rosen, 1978) often focuses on a single characteristic of a product. However, most products embody both horizontal and vertical characteristics. We consider shrimp to be sold in two varieties – unprocessed and processed (horizontal characteristic), and differentiable with respect to origin, where origin is indicative of quality (vertical characteristic). We assume as in Lusk et al. (2006), that country of origin is often associated with product quality. The two varieties of shrimp sold, i.e., unprocessed and processed, are indexed by u and p respectively. Anderson, de Palma, and Thisse (1992) state that consumer utility function can be assumed to be additive in the two characteristics. The simplest way of combining these two types of characteristics is by the following conditional indirect utility for consumer buying shrimp variety i from country j :

$$(1) \quad V_i(\theta, x) = y - p_i + \theta k_j - t(|x - x_i|) \quad \text{where } i = u, p$$

where y is income, p_i is the price of shrimp variety i , k_j is quality associated with shrimp from country j , a consumer type is described by his or her marginal willingness to pay θ for the vertical characteristic and his or her ideal location x with respect to the horizontal characteristic. A variety specification is a pair (k_j, x_i) . The utility is additive in the two characteristics. This assumption means that the two dimensions of the characteristics space are independent and can be properly identified.

Horizontal differentiation set-up is described in more details in what follows. Consumers reside on a linear street with a length of $L > 0$. Consumers are uniformly distributed on this interval, so at each point lies a single consumer. Hence the total number of consumers in the economy is L . Each consumer is indexed by $x \in [0, L]$, where x is the location of the consumer measured as the distance from the origin. Unprocessed shrimp is located u units of distance from point 0 ($x_u = u$). Processed shrimp is located to the right of u , ρ units of distance from point L ($x_p = L - \rho$). Thus, distance from origin can be interpreted as the degree of processing. Based on horizontal differentiation, consumers are assumed to gravitate towards the shrimp product with the lowest “delivered” price, i.e., the price of the product (p_i) plus the transportation cost to the location of the consumer $t(|x - x_i|)$. Transportation cost is the monetary loss equivalent to a consumer who desires x degree of processing but has to purchase shrimp with a different degree of processing.

We consider two scenarios – pre-MCOOL and post-MCOOL implementation to capture the market effects on consumers and shrimp exporting countries. In the pre-MCOOL scenario it is assumed that consumers cannot differentiate with respect to the vertical characteristic as shrimp products are not required to have mandatory labels indicating origin. However, consumers are assumed to differ in their preferences regarding the variety of shrimp consumed, i.e., processed versus unprocessed shrimp. In the post-MCOOL scenario we assume that consumers can differentiate origin of shrimp with labels only for the unprocessed shrimp category. Processed shrimp is excluded from labeling under the country-of-origin labeling law. Firms in a country exporting

unprocessed and processed shrimp in this scenario have to bear compliance costs associated with MCOOL if they are producing unprocessed shrimp.

The U.S. shrimp market comprises of imported shrimp and negligible domestic shrimp. In 2011 imported shrimp accounted for 93 percent of the demand, with local production only able to meet 7 percent of that demand (NMFS Website). Moreover, imported shrimp is available from worldwide producing regions around the year unlike U.S. shrimp production which is seasonal. Due to negligible domestic shrimp production, we assume the U.S. shrimp market is exclusively supplied with imported shrimp. Because developing countries have difficulty meeting developed countries' quality and safety standards, the quality or perceived quality of shrimp from developing countries is assumed to be lower than the quality of shrimp produced in the United States. In the absence of MCOOL, when U.S. consumers are unable to ascertain the origin of shrimp, we assume that consumers form an expectation of shrimp quality. In forming this expectation, we assume that consumer factor in U.S. shrimp quality even though the actual supply of U.S. shrimp is small. Thus, the expected quality of shrimp without MCOOL may be higher than the quality of shrimp from importing countries.

The utility function and the firm's profit-maximization condition of exporting country for the two scenarios – Pre- and Post-MCOOL implementation are set up as follows.

Pre-COOL implementation

Origin is not identified in this scenario. The quality of shrimp is perceived to be average quality \bar{k} .

The conditional indirect utility function is defined as:

$$(2) \quad V_i^{BC} \equiv \begin{cases} y - p_u^{\$} + \theta \bar{k} - t|x - x_u| & \text{if consumer buys } u \\ y - p_p^{\$} + \theta \bar{k} - t|x - x_p| & \text{if consumer buys } p \end{cases}$$

where $p_u^{\$}$ and $p_p^{\$}$ are the price in U.S. dollars consumers in the United States pay to consume shrimp variety u and p respectively. This set-up assumes a covered market, i.e., all consumers buy either unprocessed or processed shrimp and no consumer buys nothing. A market is covered when the transportation cost (or the disutility from consuming a variety that is less than ideal), t , is small enough. Figure 1 is a schematic representation of a covered and uncovered market. The market is covered to the left when $t \leq t''$, i.e., all consumers who prefer a low level of processing purchase the unprocessed shrimp. The market is uncovered to the left when $t > t''$, such as $t = t'$. In other words, some consumers who prefer a low level of processing do not purchase the unprocessed shrimp. In this case, $t'' = \frac{\theta \bar{k} - p_u^{\$}}{x_u}$. Similarly, the market is covered to the right when $t \leq$

t^{**} , and the market is uncovered to the right when $t > t^{**}$, such as $t = t^{**}$. In this case,

$$t^{**} = \frac{\theta \bar{k} - p_p^{\$}}{x_p}. \text{ Thus, in making the assumption that the market is covered we assume}$$

that $t \leq \min[t'', t^{**}]$.

We assume a covered market because the derived expressions of equilibrium price and quantity become unmanageable with an uncovered market. Thereby making further analysis based on these expressions difficult to infer and conclude.

Let \hat{x} denote the consumer who is indifferent between purchasing u or p . Formally, because $x_u < \hat{x} < x_p$, then at \hat{x} , $-p_u^{\$} - t(\hat{x} - u) = -p_p^{\$} - t(L - \rho - \hat{x})$.

Consumer demand can then be written as:

$$(3) \quad \begin{aligned} \hat{x} = D_u &= \frac{p_p^{\$} - p_u^{\$}}{2t} + \frac{u + L - \rho}{2} \\ L - \hat{x} = D_p &= \frac{p_u^{\$} - p_p^{\$}}{2t} + \frac{\rho + L - u}{2} \end{aligned}$$

where D_u and D_p are demand for unprocessed and processed shrimp respectively.

Firms in each exporting country maximize profit of selling unprocessed or processed shrimp to the United States by choosing the price in local currency. However, U.S. demand is based on the landed price in U.S. dollars. Therefore, the demand is affected by exchange rates and ocean freight rates. Moreover, most exporting countries may also need to pay an import duty or tariffs. Thus, the landed price of shrimp in U.S. dollars can be written as:

$$(4) \quad p_i^{\$} = \frac{p_i}{e} T_i + F_i$$

where, e is the exchange rate (local currency per U.S. dollar), p_i is the price of exported shrimp variety in local currency, T_i is the gross tariff rate ($1 +$ the ad valorem tariff rate), and F_i is the ocean freight rate to the United States in U.S. dollars.

Each exporting country is assumed to have one firm producing unprocessed shrimp and one firm producing processed shrimp.³ The firms compete in prices (Bertrand Competition) for the U.S. shrimp market. The profit-maximizing problem of firm i ($i = u, p$) is expressed as:

$$(5) \quad \underset{p_i}{Max} \Pi_i = [p_i - c_i] D_i(p_u^{\$}, p_p^{\$})$$

³ Under a covered market, when one firm produces both processed and unprocessed shrimp, it is not possible to observe the effect of price on market share because the change in demand for one product is exactly offset by the change in demand for the other product. To solve the problem, we assume two firms in a country, one producing processed and the other unprocessed shrimp. The implication is that substitution occurs at the country level with market forces dictating substitution between the products.

where c_i is the marginal cost of producing unprocessed or processed shrimp in the exporter's currency, all other variables are as defined above. After substituting (3) and (4) in (5) we take the first derivative with respect to p_i and solve for equilibrium prices and quantities. The expressions for equilibrium quantity of unprocessed and processed shrimp are given as:

$$(6) \quad \begin{aligned} Q_u^{BC} &= \frac{et(u - \rho + 3L) + e(F_p - F_u) - c_u T_u + c_p T_p}{6et} \\ Q_p^{BC} &= \frac{et(-u + \rho + 3L) - e(F_p - F_u) + c_u T_u - c_p T_p}{6et} \end{aligned}$$

The superscript BC indicates equilibrium quantity in the pre-COOL scenario.

We are interested in the share of unprocessed shrimp over the total shrimp exported by a country to United States because MCOOL implementation on unprocessed shrimp may result in a change in the exporting country's product mix. With MCOOL implementation firms producing unprocessed shrimp incur additional costs associated with labeling and quality disclosure, so market forces (change in costs and demand) may lead the exporting country to substitute unprocessed shrimp with processed shrimp. The share of unprocessed shrimp pre-COOL can be considered as a benchmark when evaluating the effects of MCOOL implementation. It is given by:

$$(7) \quad RS^{BC} = \frac{Q_u^{BC}}{Q_u^{BC} + Q_p^{BC}} = \frac{et(u - \rho + 3L) + e(F_p - F_u) - c_u T_u + c_p T_p}{6eLt}$$

The share of unprocessed shrimp decreases with increase in transportation costs, marginal costs of production, and duties levied on unprocessed shrimp. All these costs are levied per unit of volume. Inversely, increase in costs associated with processed shrimp affect positively the share of unprocessed shrimp.

Post-COOL implementation

With MCOOL implementation, exporters must inform consumers of the origin of unprocessed shrimp. Additional costs associated with labeling, i.e., compliance costs are incurred by firms selling unprocessed shrimp and these costs are represented by z and are measured in local currency. When consumers are able to identify the origin of unprocessed shrimp, the quality perception of unprocessed shrimp is based on the country of origin, represented by k_j . However, for processed shrimp, which does not require labeling, perceived quality is the average quality \bar{k} . The utility function and profit maximization function in this scenario are defined as follows:

$$(8) \quad V_i^{AC} \equiv \begin{cases} y - p_u^s + \theta k_j - t|x - x_u| & \text{if consumer buys } u \\ y - p_p^s + \theta \bar{k} - t|x - x_p| & \text{if consumer buys } p \end{cases}$$

$$Max_{p_i} \Pi_i = [p_i - c_i - z] D_i(p_u^s, p_p^s)$$

where $z = 0$ for the firm producing processed shrimp, i.e., when $i = p$. Equilibrium prices and quantities are derived similar to the pre-MCOOL scenario. Equilibrium quantities of unprocessed and processed shrimp are as follows:

$$(9) \quad Q_u^{AC} = \frac{et(u - \rho + 3L) - e\theta(\bar{k} - k_j) + e(F_p - F_u) - (c_u + z)T_u + c_p T_p}{6et}$$

$$Q_p^{AC} = \frac{et(-u + \rho + 3L) + e\theta(\bar{k} - k_j) - e(F_p - F_u) + (c_u + z)T_u - c_p T_p}{6et}$$

The share of unprocessed shrimp over total shrimp exported with MCOOL implementation is given as:

$$(10) \quad RS^{AC} = \frac{et(u - \rho + 3L) - e\theta(\bar{k} - k_j) + e(F_p - F_u) - (c_u + z)T_u + c_p T_p}{6eLt}$$

As in the pre-MCOOL scenario, per unit of volume costs such as transportation costs, marginal costs of production, compliance cost, and duties levied associated with unprocessed shrimp reduces the share of unprocessed shrimp, while costs associated with processed shrimp affect the share positively. With MCOOL implementation, two new terms are introduced that affect the share of unprocessed shrimp negatively. They are consumers' valuation for quality and quality itself, and compliance costs. If $\bar{k} > k_j$ the lower is the quality of unprocessed shrimp, the lower is the share of unprocessed shrimp. However, if the quality of unprocessed shrimp is greater than the perceived quality of non-labeled shrimp, then the greater is the quality of unprocessed shrimp, the greater is the share of unprocessed shrimp. These effects are magnified by the extent to which consumers value quality, i.e., by the size of θ .

Analysis

Given the conceptual model, we are interested in analyzing the change in the product mix of shrimp exported to the United States after MCOOL was implemented.

Following are the results of interest:

$$(11) \quad RS^{AC-BC} = \frac{-zT_u - e\theta(\bar{k} - k_j)}{6eLt} \begin{cases} < 0 & \text{if } \bar{k} - k_j > 0 \\ \neq 0 & \text{if } \bar{k} - k_j < 0 \end{cases}$$

$$(12) \quad \frac{\partial RS^{AC-BC}}{\partial z} = \frac{-T_u}{6eLt} < 0$$

$$(13) \quad \frac{\partial RS^{AC-BC}}{\partial \Delta k} = \begin{cases} \frac{\theta}{6Lt} > 0 & \text{if } \Delta k = \bar{k} - k_j < 0 \\ \frac{-\theta}{6Lt} < 0 & \text{if } \Delta k = \bar{k} - k_j > 0 \end{cases}$$

where RS^{AC-BC} represents the change in the share of unprocessed shrimp with MCOOL implementation.

Equation (11) shows that the share of unprocessed shrimp is smaller after MCOOL implementation, indicating that exporting countries change their product mix toward greater quantities of processed shrimp (non-labeled) with MCOOL if $\bar{k} - k_j > 0$. The size of the change in product mix is influenced by the extent to which a) consumers value quality (θ), b) the perceived quality of the unprocessed shrimp exported by that country (k_j) relative to the perceived quality of non-labeled shrimp sold in the United States (\bar{k}), c) the cost of compliance (z) in U.S. dollars, weighted by the tariff on unprocessed shrimp (T_u), d) the consumers' disutility from not consuming their ideal variety of shrimp (t) multiplied by the size of the market (L).

The parameters of interest are difference in perceived quality of non-labeled shrimp and quality of labeled unprocessed shrimp, weighted by consumers' value for quality, and costs of compliance. These two parameters are the best indicators to measure the effect of MCOOL implementation on the quantity of unprocessed shrimp exported to the United States.

Increase in compliance costs results in decrease in the quantity of unprocessed and thus, labeled shrimp produced as shown in equation (12). The intuition behind this is that as compliance costs are associated with unprocessed shrimp alone, it becomes more expensive to produce unprocessed shrimp when MCOOL is implemented.

Equation (13) shows an increase in the difference in quality between the quality of unprocessed shrimp attributed to the exporting country and the perceived average quality decreases/increases the share of unprocessed shrimp based on the difference in

quality being positive/negative. The intuition is that if quality of unprocessed shrimp of an exporting country is lower/higher than the perceived average quality, the share of unprocessed shrimp decreases/increases as consumers are able to identify unprocessed shrimp through labels and consumer demand for it falls/rises. Exporting country would simply respond to market forces and export more/less processed shrimp to circumvent/allow disclosure of quality via origin labels.

In summary, in this section we demonstrated that MCOOL implementation can result in changing product mix of exported shrimp, i.e., in the transformation of unprocessed shrimp into processed shrimp. To test this hypothesis we develop an empirical model in the next section.

Empirical Implementation

The variables affecting the nature of bilateral shrimp trade between major shrimp exporting countries and United States are largely based on the expressions for the share of unprocessed shrimp in total shrimp exports from a country before and after the implementation of MCOOL (equations 7 and 10). The objective of the econometric model is to test the effect of MCOOL on the share of unprocessed shrimp from major shrimp exporting countries. Based on the conceptual model, consumers' valuation of quality facilitated by MCOOL is an important variable that determines the nature of shrimp product mix. Assuming quality via origin is identifiable with MCOOL, which was implemented in April 2005, we examine the effect of MCOOL on the share of unprocessed shrimp through an interaction variable representing MCOOL implementation and relative quality of shrimp.

The empirical model considers the top shrimp exporting countries to the United States. They are China, Ecuador, Indonesia, India, Mexico, Thailand, and Vietnam. The major shrimp producing regions can be broadly identified as Asia (China, Indonesia, India, Thailand, and Vietnam), Central America (Mexico), and South America (Ecuador). In 2007, Asian countries were specialized in exporting processed shrimp (China – 78 percent), while Central and South America supplied mainly unprocessed shrimp (Mexico – 90 percent, and Ecuador – 99 percent). In 2007, U.S. imports mainly comprised of unprocessed shrimp – nearly 74 percent of total imports (Josupeit, 2008). Thailand is the top shrimp supplier to the United States and its product mix is approximately divided equally between unprocessed and processed shrimp. The monthly time period extends from 1998 to 2008. The empirical model based on the reduced-form expressions of the conceptual model given by equations (7) and (10), is approximated linearly by the following regression equation:

$$(14) \quad RS = \beta_0 + \beta_1 EXC + \beta_2 TRF + \beta_3 FRT_u + \beta_4 FRT_p + \beta_5 COOL * DQLTY + \varepsilon$$

The definitions and descriptions of variables included in equation (14) for country j are as follows:

RS = Monthly share of unprocessed shrimp quantity over total quantity. No units. Value lies between zero and one.

EXC = Monthly real exchange rate index. No units. (2005=1)

TRF = Anti-dumping duties imposed by United States on exporting countries – China, Thailand, India, Vietnam, and Ecuador for time period 2005 to 2008. Measured as percentage.⁴

FRT = Monthly transportation charges for shrimp of type *i*. It includes cost, insurance, and freight rate. Measured as value in dollars per kilogram.

COOL = Dummy for Mandatory Country of Origin Labeling law. It is also representative of cost of labeling associated with MCOOL implementation. Value = 0 before April 2005 and thereafter value = 1.

DQLTY = Difference in quality between quality attributed to the exporting country and the perceived average quality. This variable is approximated by the difference of average minimum real wage per month across shrimp exporting countries and the United States, and country *j* minimum real wage per month.⁵ Measured in U.S. dollars. (2005=100)

Costs of producing unprocessed and processed shrimp (c_u, c_p) are not included in this empirical model due to unavailability of separate cost data. We also omit variables of the conceptual model such as the marginal disutility of substituting shrimp with a different degree of processing than desired (t), and proportion of the population who consume unprocessed and processed shrimp (u, ρ). A separate COOL variable to capture other possible effects of MCOOL on the share of unprocessed shrimp is not included in

⁴Anti-dumping duties were imposed on selective countries for certain period of time for unprocessed shrimp. No duties have been imposed on processed shrimp in the time period considered.

⁵ Wage is a demand-side variable that is used to proxy quality in this equation. Cost of production as a supply-side variable to proxy quality would have been ideal. Due to unavailability of cost of production data, we also estimate the equation using producer price index as a proxy for quality. The relevant results are mentioned in the inference section.

the model because of problems of potential multicollinearity between variables COOL and TRF.

Exchange rate can play a decisive role on the share of imported shrimp. For instance in 2007, the U.S. dollar trend affected Thai and Indian shrimp producers. The strengthening of the Thai Baht, relatively stronger than increases in other regional competitors' currencies adversely affected Thai competitiveness. Appreciation of the Real (Brazilian currency) in 2007 has resulted in the Brazilian market becoming an attractive destination for its own producers in contrast to exports to the United States (www.globefish.org). Exchange rate is measured as local currency per U.S. dollar. A depreciation of the local currency (increase in e) will result in an increase in imports of the unprocessed shrimp relative to the total quantity of shrimp imports. Equation 4 shows an increase in e will result in U.S. consumers paying a lower price for shrimp. Based on the U.S. International Trade Commission's Interactive Tariff and Trade Dataweb, the unit value of imported unprocessed shrimp is greater than processed. So even though both unprocessed and processed shrimp face the same change in the exchange rate, an increase in the exchange rate decreases the relative price of unprocessed shrimp, which results in a shift in the product mix. Thus, shift in the product mix occurs because fluctuations in the exchange rate affect the relative demand for unprocessed shrimp.⁶

⁶ Relative demand for unprocessed shrimp with respect to processed shrimp, and the derivative with respect to the exchange rate is given as:

$$\frac{Q_u^{AC}}{Q_p^{AC}} = \frac{6eLt}{et(-u + \rho + 3L) + e(F_u - F_p) + e\theta(\bar{k} - k_j) + T_u(z + c_u) - T_p c_p} - 1$$

$$\frac{\partial Q_u^{AC} / Q_p^{AC}}{\partial e} = \frac{6Lt(T_u(z + c_u) - T_p c_p)}{(et(u - \rho - 3L) - e(F_u - F_p) - e\theta(\bar{k} - k_j) - T_u(z + c_u) + T_p c_p)^2}$$

An increase in exchange rate decreases the relative price of unprocessed shrimp, which results in increase in the share of imported unprocessed shrimp.

Anti-dumping duties were imposed on unprocessed shrimp from China, India, Thailand, Ecuador, and Vietnam from 2005 to 2008. Other things being equal, anti-dumping duties can result in the exporter netting less money on the transaction than if those shrimp were sold in countries with no duties. For example, Brazilian exports of shrimp were affected by the tariff increases on sales to the United States, and since 2003 have almost disappeared from the U.S. market (www.globefish.org). Thus, imposition of anti-dumping duties on unprocessed shrimp could also result in a change in the country-mix of the shrimp exporting countries. Here we look at anti-dumping duties imposed on unprocessed shrimp alone. We expect an increase in anti-dumping duties on unprocessed shrimp for a particular country to result in a decrease in the share of unprocessed shrimp from that country, i.e., $\partial RS / \partial TRF < 0$.

We consider different transportation charges for processed and unprocessed shrimp. Increase in transportation charges for unprocessed shrimp would decrease the share of unprocessed shrimp, while increase in transportation charges for processed shrimp would increase the share of unprocessed shrimp, i.e., $\partial RS / \partial FRT_u < 0$ and $\partial RS / \partial FRT_p > 0$.

To approximate the shrimp quality of major shrimp exporters, minimum real wage per month are used. Because major shrimp exporters are primarily developing countries, and shrimp producing farms hire unskilled labor, we consider minimum real wage rates as a proxy for quality. An increase in minimum wage rates can be indicative of higher quality of shrimp produced because higher wages result in better standard of living. As standard of living increases, consumers demand better facilities and infrastructure. This leads countries to invest more on the infrastructure and employ higher

standards of food safety. Most of the shrimp-exporting countries export farm-raised shrimp, which are harvested from coastal shrimp farms and farms developed in upland areas. A number of reports (Gale and Buzby, 2009; Acheson, 2007; Barboza, 2007; Lumpkin, 2007; Allshouse et. al, 2003, Rahman, 2001) question the quality of shrimp harvested from coastal farms of developing countries based on evidences of unapproved drug residues found in farm-raised shrimp of certain countries. Increase in quality of shrimp may increase the share of unprocessed shrimp demanded with MCOOL implementation as origin can be identified and consumers can buy shrimp based on the reputation they have developed with respect to the origin of shrimp. More discussion on the quality variable and alternative variables that can be used to proxy quality can be found in Appendix I.

The quality variable is characterized as the difference in perceived average and individual quality, i.e., $\bar{k} - k_j$. Assuming perceived average quality is greater than individual quality, increase in individual quality will decrease the difference and vice-versa. The expected sign on the share of unprocessed shrimp with increasing difference in quality in the presence of MCOOL is negative based on $\bar{k} - k_j > 0$, i.e., $\partial RS / \partial DQLTY < 0$. If perceived average quality is less than individual quality then the expected sign on the share of unprocessed shrimp with increasing difference in quality with MCOOL would be positive.

Data Construction and Sources

The monthly shrimp import data was obtained from the *U.S. International Trade Commission's Interactive Tariff and Trade Dataweb* (<http://dataweb.usitc.gov/>). The imports are classified by Harmonized Tariff Schedule (HTS) number and they are

available at the 10-digit level. The data source provides the U.S. import records for the seven major shrimp exporting countries of interest mentioned earlier in kilograms. The data used is aggregated at the 6-digit HTS level. The categories are 030613 (raw, and frozen shrimp), 030623 (raw, and not frozen shrimp), and 160520 (cooked, and processed shrimp). The first two categories represent unprocessed shrimp, while the last category represents processed shrimp. More details on this classification are available in Appendix II. For Mexico and Ecuador there are approximately ten months with zero values of processed shrimp imports. To construct data we regress a set of values for shrimp imports with time, the parametric values are then used to compute fitted values.

Monthly transportation charges are obtained from the above mentioned USITC website under the category ‘import charges’, which represent the aggregate cost of all freight, insurance, and other charges (excluding U.S. import duties). These are reported in dollars. To find the rate (for example, \$1 per kilogram) we divide the charges in dollars by kilograms. We follow the same convention in classifying shrimp as unprocessed and processed based on HTS numbers mentioned previously. Based on the HTS number classification we retrieve transportation charges for unprocessed and processed shrimp.

U.S. anti-dumping duty data was retrieved from a database maintained by Bown (2007) and the *International Trade Commission* website. The anti-dumping duty rates vary from 3.58 to 112.81 percent for the countries that were imposed with duties from 2005 to 2008 (China, India, Ecuador, Thailand, and Vietnam). For more information on anti-dumping duties used, refer to Appendix III.

The monthly real exchange rates (local currency per U.S. dollars) were obtained from the International Monetary Fund’s *International Financial Statistics* for the

countries considered, with 2005 as the base year. An exchange rate index is constructed by setting the value of exchange rate equal to 1 in 2005 across all countries considered.

The source for nominal minimum wage rate per month in local currency is the *Global Market Information Database*. Real minimum wage per month in U.S. dollars was constructed using nominal minimum wage rate per month in local currency, CPI for United States (2005=100) and yearly nominal exchange rates. CPI data was obtained from ERS *International Macroeconomic Data Set* and nominal exchange rate was obtained from ERS *Agricultural Exchange Rate Data Set*. The quality variable defined as

$\bar{k} - k_j$ is calculated by the formula $\frac{k_{US} + \sum_{j=1}^7 k_j}{8} - k_j$, where k_{US} is the U.S. real minimum wage per month and k_j is the real minimum wage per month of country j .

Empirical Results

Let us now define the systematic structure of the econometric model for our data. The dependent variable of equation (14) is the share of unprocessed shrimp and takes value between zero and one. However, the linear predictors on the right-hand-side can take any real value. There is no guarantee that the predicted values will be in the correct range unless complex restrictions are imposed on the coefficients. A simple solution to this problem is to transform the proportion to remove range restrictions, and model the transformation as a linear function of the covariates. This transformation is called logit transformation. We do this in two steps: first, we move from the proportion p_i to the odds defined as the ratio of the proportion to its complement, where $odds_i = p_i / (1 - p_i)$. This is a monotonic transformation, meaning odds increase as the proportion increases

and odds can take any positive value and therefore have no ceiling restriction. Second, we take logarithms, calculating the logit or log-odds, which has the effect of removing the floor restriction, where $\text{logit}(p_i) = \log(p_i / (1 - p_i))$. Again this is a monotonic transformation. Thus, logits map proportion p_i from the range (0,1) to the entire real line. Suppose that the logit of the underlying proportion p_i (Relative share of unprocessed shrimp) is a linear function of the predictors, i.e., $\text{logit}(p_i) = x_i b$, where x_i is a vector of covariates (exchange rate, anti-dumping duty, freight rates, and interaction of COOL with difference in quality) and b is a vector of regression coefficients. This defines the systematic structure of the econometric model in equation (14).

Ordinary Least Squares (OLS) regressions were run for the seven countries: China, Thailand, India, Vietnam, Mexico, Ecuador, and Indonesia and checked for problems of multicollinearity. Multicollinearity occurs when there is a linear association between two independent variables. This results in high R^2 showing that the model fits well, high F statistics and deflated t-statistics. Standard errors are inflated and chance of type 2 error is high. With the variance inflation factor < 10 , and significant t-statistics, we conclude that the data does not exhibit multicollinearity. The data is characterized by seven cross-sections and 132 observations for each cross-section. Tables 1 to 7 contain the sample statistics for the variables used for each cross-section.

Due to the time-series nature of the data, autocorrelation is a concern. First-order autocorrelation occurs when the error term in one period is correlated with the error term in the previous period, i.e., $\varepsilon_t = \mu \varepsilon_{t-1} + u_t$, where μ is a parameter less than one in absolute value and u_t is white noise. Autocorrelation results in non-zero off-diagonal

elements of the error variance-covariance matrix. As a result, coefficient estimates are unbiased, but inefficient. In other words, the OLS estimators are no longer the best linear unbiased estimator with the lowest variance compared to all linear unbiased estimators. With positive autocorrelation, a positive (negative) error leads to more positive (negative) errors, and the estimated standard errors will be smaller than they truly are, leading to high computed t-values and high chances of type 1 error.

The Durbin-Watson statistic and the direct estimation of μ suggest problems of first-order positive autocorrelation. Autocorrelation is typically corrected by using an estimated generalized least squares (EGLS) approach, such as the Cochrane-Orcutt procedure. However, Cochrane-Orcutt method drops the first observation. We correct for this problem using the Yule-Walker method of first-order autoregression by transforming each independent variable and the intercept by its lagged value. Unlike Cochrane-Orcutt method, information from the first observation is retained and used. The model corrected for autocorrelation is used for further estimation and analysis.

The seven countries exporting shrimp are likely to share common characteristics. Pooling the information and modeling them as a set of relations to take into account this information explicitly, would be apt. The generalized least square estimator for this model yields the same result as estimating each of the equations individually by OLS. However, there are omitted factors from individual country equations that explain the dependent variable. These become a part of the unobservable error processes. Similarity in the country equations make it natural to assume that the equation errors are correlated. Zellner's Seemingly Unrelated Regressions (SUR) system is ideal to estimate these equations that contain correlated equation errors. When the errors are contemporaneously

correlated across equations, an estimated generalized least squares approach would result in more precise estimates of the coefficients compared to OLS estimates.

Because the generalized least square estimator is the best unbiased estimator for our joint estimating model, it is necessarily better than least squares applied separately to each equation. By including information on the error covariance using SUR system and the estimated generalized least squares estimation rule, we have been able to improve the estimated sampling precision with which we can estimate the unknown coefficient vectors. The improvement is relative to individual relations with their corresponding least squares estimates of the unknown parameters. The estimation results of autocorrelation-corrected OLS and SUR estimation are presented in Table 8.

So far, we have assumed that the coefficient vectors for the seven countries are different. Because these countries have many characteristics in common, e.g., they are all developing countries exporting to the United States, the relations can be aggregated and represented with a common coefficient vector. This would reduce the number of parameters to be estimated and possibly increase the precision with which they are estimated, resulting in a restricted model. However, we allow for country differences by imposing dummies on the intercepts only and letting the intercepts vary only across countries and not over time. The aggregated countries equation would then characterize a time-series and cross-sectional model. To estimate the model we use SAS computer program and the option TSCSREG (Time Series Cross Section Regression) with PARKS method.⁷ This model assumes a first-order autoregressive error structure with

⁷ The mechanics of Parks method is as follows. Parks method considers the first-order autoregressive model in which the random errors are heteroscedastic, contemporaneously correlated, and autocorrelated. The covariance matrix for the vector of random errors is estimated by a two-stage procedure, and parameter coefficients are then estimated by generalized least squares. The first step in estimating covariance matrix

contemporaneous correlation between countries. Table 9 contains estimation results for the restricted model.

Next we check for the compatibility of unconstrained SUR estimates and constrained/restricted estimates, both corrected for autocorrelation and allowing mutual correlation among errors. In other words, we want to check if it makes sense for the countries to be aggregated, i.e., to check that variables affecting bilateral shrimp trade with United States do not exhibit marked differences among countries. Using hypothesis testing procedure at 5 percent critical value, we conclude using the F-test that the use of one coefficient vector for seven countries and a separate intercept for each of the seven countries is valid. The restriction imposed is appropriate and results in unbiased estimators with improved sampling precision.

Inference

The logit transformation makes the dependent variable a linear function of the independent variables, i.e., $\log p_i / (1 - p_i) = x_i b$. Therefore, the independent variable's coefficient vector b are interpreted as follows. A one-unit increase in the independent variable causes expected change in log odds to be b . To translate the change in log odds to the change in odds, we exponentiate change in log odds and b . The percentage

for the vector of random errors involve the use of ordinary least squares to estimate parameter coefficients and the fitted residuals are obtained. However, instead of obtaining residuals separately for each cross-section, this method aggregates data and obtains residuals treating it as one cross-section. To rectify the inaccuracy of not considering cross-sections separately to obtain residuals, we introduce dummies on intercepts to preserve the characteristics of residuals corresponding to a particular cross-section. The residuals obtained by running ordinary least squares on the model with dummies on intercepts, are further used to derive the consistent estimator of the first-order autoregressive parameter. The autoregressive characteristic of the data is removed by using the Yule-Walker method of first-order autoregression by transforming each independent variable and the intercept by its lagged value. The second step in estimating covariance matrix is to apply ordinary least squares to the transformed model and obtain residuals corrected for autocorrelation. Finally, estimated generalized estimators are obtained from the transformed model. This procedure is equivalent to Zellner's two-stage methodology applied to the transformed model (Zellner 1962). Thus, we use a modified Parks method, which accounts for residuals corresponding to each cross-section in the construction of the covariance matrix.

increase/decrease in the odds of exporting unprocessed shrimp to the United States is given as $(\exp(b) - 1) * 100$.

Based on the restricted model having best linear unbiased estimator and the lowest variance compared to other linear unbiased estimators, we interpret the coefficient vectors in Table 9 as follows:

EXC is the real exchange rate index (2005=1). A one-unit increase in exchange rate index results in 46.53 percent increase in the odds of exporting unprocessed shrimp to the United States compared to processed shrimp. Recall that an increase in the exchange rate corresponds to a depreciation of the local currency relative to the U.S. dollar. This results in making unprocessed shrimp imports in United States relatively less expensive, for the same change in the exchange rate. Thus, the demand for unprocessed shrimp is greater relative to processed shrimp, resulting in an increase in the share of unprocessed shrimp imported to the United States. The coefficient on the exchange rate index variable is significant at the 10 percent level of significance.

TRF represents the anti-dumping duty imposed on five countries out of the seven considered. These duties were imposed from 2005 to 2008. A unit increase in anti-dumping duty results in decreasing the share of unprocessed shrimp by 1.6 percent. The antidumping duty variable is significant at the 5 percent level of significance and has the expected sign. Anti-dumping duty is levied on unprocessed shrimp; hence an increase in duties will directly affect the share of unprocessed shrimp compared with processed shrimp.

FRT_u measures the transportation charges related to unprocessed shrimp and FRT_p indicates transportation charges for processed shrimp. The conceptual model

predicts that an increase in transportation charges for unprocessed shrimp should decrease the quantity of unprocessed shrimp exported relative to the total quantity of shrimp exported. Alternatively, an increase in transportation charges of processed shrimp should increase the share of unprocessed shrimp. The coefficient for transportation charges of unprocessed shrimp suggests a one-unit increase in costs leads to 14.2 percent increase in the odds of exporting unprocessed shrimp. While the coefficient for transportation costs for processed shrimp says for a one-unit increase in transportation charges of processed shrimp, we can expect to see about 18 percent increase in the share of unprocessed shrimp exported. However, both the variables are not significant at 10 percent level of significance. Based on the conceptual model, the expected sign for transportation charges of unprocessed shrimp is not preserved, and both variables are not significant to explain unprocessed shrimp exports.

The variable of primary interest is DQLTY. It is the difference in perceived average quality to individual quality of shrimp for exporting countries considered. Data shows that developing countries exporting shrimp to the United States have quality lower than the average perceived quality, i.e., $\bar{k} - k_j > 0$. Our hypothesis is that as the difference in this quality increases, the share of unprocessed shrimp should decrease. With MCOOL implementation facilitating the disclosure of the origin of unprocessed shrimp, we expect a change in the product mix exported to the United States. In other words, MCOOL will lead exporting countries to export more processed shrimp. This change will be reflected in the decrease in the share of unprocessed shrimp with respect to processed shrimp exported. We use interaction term of COOL and DQLTY to characterize the effect of change in the difference in quality on the share of unprocessed

shrimp with MCOOL. With MCOOL implementation, a one-unit increase in the difference in quality leads to a 0.05 percent decrease in the share of unprocessed shrimp exported to the United States. The difference in quality variable is not significant at 10 percent significance level. We conclude that implementation of MCOOL does not have a significant effect on the share of unprocessed shrimp.

A variant of equation (14) was estimated, that was specified with no TRF variable. The purpose was to identify the significance of MCOOL implementation in the absence of anti-dumping duties imposed. Recall that both MCOOL and anti-dumping duties were imposed for the same time period. Estimation results show that in the absence of anti-dumping duties, a one-unit increase in the difference in quality with MCOOL leads to a 0.23 percent decrease in the share of unprocessed shrimp exported to the United States. The variable is significant at the 5 percent significance level.

Another result of interest using equation (14) was to use producer price index (PPI) as a proxy for quality instead of real minimum wage per month. Using PPI data, we found that $\bar{k} \neq k_j$, which means that for some countries the perceived quality of shrimp was greater than the average perceived shrimp quality. Estimation results show that a one-unit increase in the difference in quality with MCOOL results in 0.84 percent increase in the share of unprocessed shrimp exported to the United States. The variable is significant at the 5 percent level of significance. It is interesting to note that the share of unprocessed shrimp increases/ decreases for a unit change in the difference in perceived quality depending on $\bar{k} \neq k_j$ or $\bar{k} - k_j > 0$.

The intercepts of the model represented by dummies indicate that country differences are significant and have an impact on the odds of unprocessed shrimp

exported to the United States. Dummy coefficients in this model are significantly different from zero (except for Thailand). The coefficients can be interpreted as the estimated log odds of exporting unprocessed shrimp to the United States by the particular country. For example, D_{India} has a parameter estimate of 1.84. The log of odds in this case can be transformed back to a probability by: $\exp(1.84)/(1+\exp(1.84)) = 0.86$. The interpretation is that the share of unprocessed shrimp from India constitutes to 86 percent of its total U.S. shrimp export.

Some factors not accounted in this model are consumer costs of substituting unprocessed with processed shrimp, proportion of consumers with demand for unprocessed shrimp relative to processed shrimp, and variables specific to countries like cost of producing unprocessed and processed shrimp.

Lastly these results must be interpreted with caution as some variables used to explain change in product mix are proxies for variables that are not measurable. Quality is such a variable which is proxied by the use of real minimum wage per month. Omitting variables in the regression may lead to omitted bias in estimators. The consequence of omitting variables is biased estimators even though sampling variability is smaller than the model with no misspecification.

Conclusion

With partial MCOOL implementation, i.e., exclusion of processed shrimp from labeling, the nature of trade between major shrimp exporters and the United States may be redefined. The major shrimp exporters, which account for 93 percent of shrimp consumed in the United States, are developing countries and are known to have difficulty meeting developed countries' quality and safety standards. Moreover, the analysis of

FDA refusals of imported seafood shipments from 2003 to 2006 revealed that of the imports refused, more than 65 percent were processed seafood products, which are excluded from country of origin labeling requirements that the U.S. Department of Agriculture oversees (www.foodandwaterwatch.org). Partial MCOOL facilitates disclosure of identity or origin and methods of production, which may lead exporters with questionable quality to export more processed shrimp relative to unprocessed shrimp. To test this hypothesis, we first develop a conceptual model that takes into account consumers' preference for quality via origin and the different varieties of shrimp exported, namely unprocessed and processed. The conceptual model shows the share of unprocessed shrimp decreases with MCOOL implementation due to quality disclosure and additional costs of compliance on firms producing unprocessed shrimp.

To test the hypothesis empirically we develop an econometric model based on reduced-form expressions of the conceptual model. The empirical model considers the major shrimp exporters to the United States - China, Thailand, Vietnam, Ecuador, India, Mexico, and Indonesia for the time period 1998 to 2008. MCOOL was implemented for seafood in April 2005, so the variable of primary interest is consumers' valuation of shrimp quality facilitated by partial MCOOL. We assume that with MCOOL consumers would be able to identify the quality of unprocessed shrimp. This partial identification could determine the nature of the shrimp product mix exported to the United States. The effect of MCOOL on the share of unprocessed shrimp through an interaction variable representing MCOOL implementation and relative quality of shrimp has a 0.05 percent effect on the dependent variable but is not significant. Anti-dumping duties levied simultaneously for the same time period as MCOOL has a 1.6 percent effect on the share

of unprocessed shrimp. Exchange rate index affects the share of unprocessed shrimp by 46.5 percent. Anti-dumping duty and exchange rate has a significant impact on the product mix exported. These results must be treated with caution as quality is an unobservable variable that is proxied with minimum wage per month for the country considered. Using PPI as a proxy for quality, changes the results to the interaction variable (COOL and DQLTY) being significant and having a 0.84 percent effect on the share of unprocessed shrimp.

The results of the model suggest partial MCOOL implementation does not affect shrimp trade between developing countries and the United States. However, the choice of variable as a proxy for quality can reverse the results. This suggests that a better and accurate variable representing quality could be useful in inferring the effect of partial MCOOL on U.S. shrimp trade.

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Figure 1: Schematic Representation of an uncovered U.S. shrimp market

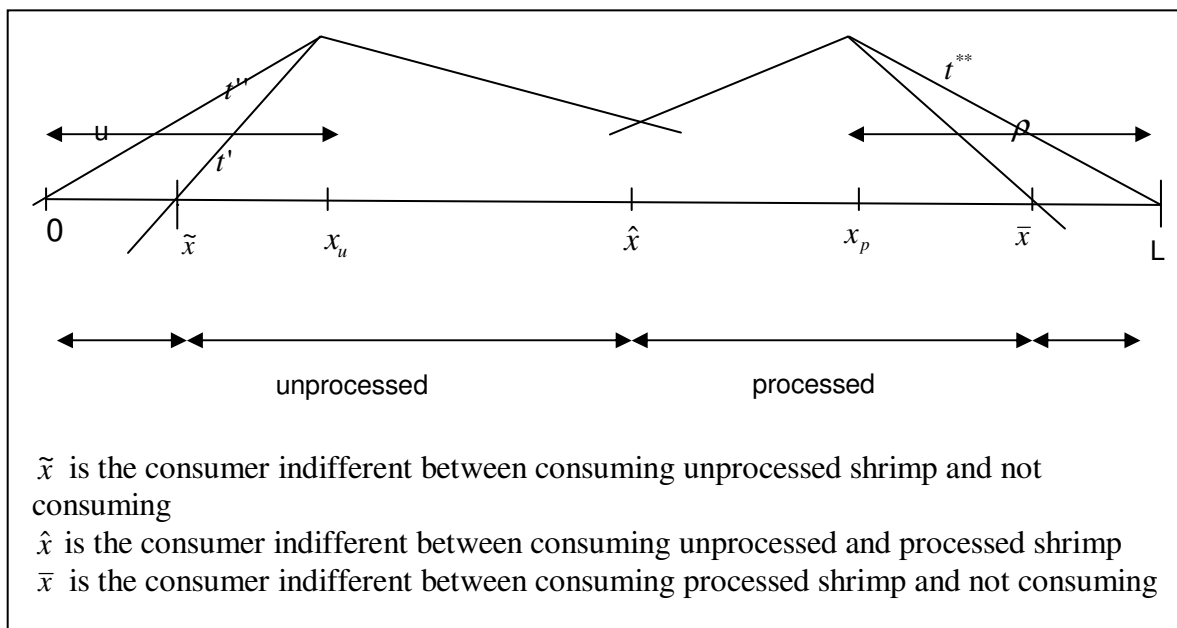


Table 1: Statistics for China – U.S. estimation

Variable	Mean	Standard Deviation	Minimum	Maximum
EXC	0.95297	0.05283	0.82731	1.01346
TRF	46.14545	55.67121	0	112.80
FRT_u	0.25597	0.04273	0.18195	0.46409
FRT_p	0.22939	0.05430	0.0650	0.31635
COOL*DQLTY	36.20227	50.61695	0	114.30

Table 2: Statistics for Thailand – U.S. estimation

Variable	Mean	Standard Deviation	Minimum	Maximum
EXC	0.97201	0.09828	0.76364	1.29728
TRF	2.42121	2.96805	0	6.40
FRT_u	0.30173	0.04618	0.20930	0.38980
FRT_p	0.30206	0.05592	0.18780	0.40040
COOL*DQLTY	20.85455	29.34050	0	69.20

Table 3: Statistics for Vietnam – U.S. estimation

Variable	Mean	Standard Deviation	Minimum	Maximum
EXC	0.97323	0.08460	0.78605	1.07543
TRF	13.10379	20.16890	0	93.10
FRT_u	0.29275	0.03792	0.16820	0.43090
FRT_p	0.27219	0.06701	0.16430	0.74580
COOL*DQLTY	54.05909	75.49127	0	162.40

Table 4: Statistics for Ecuador – U.S. estimation

Variable	Mean	Standard Deviation	Minimum	Maximum
EXC	1.09707	0.21999	0.89966	2.11916
TRF	1.55303	2.00322	0	7.30
FRT_u	0.28211	0.02866	0.23310	0.38460
FRT_p	0.22778	0.10555	0.00020	0.7150
COOL*DQLTY	2.07727	3.49601	0	9.40

Table 5: Statistics for India – U.S. estimation

Variable	Mean	Standard Deviation	Minimum	Maximum
EXC	1.03203	0.08523	0.83064	1.16742
TRF	4.20606	5.19963	0	14.20
FRT_u	0.37896	0.07819	0.26740	0.63660
FRT_p	0.36032	0.09904	0.15800	0.82170
COOL*DQLTY	51.23182	71.5420	0	156.20

Table 6: Statistics for Indonesia – U.S. estimation

Variable	Mean	Standard Deviation	Minimum	Maximum
EXC	1.12199	0.31739	0.78283	2.45426
FRT_u	0.29916	0.02494	0.23555	0.37838
FRT_p	0.26756	0.06034	0.16453	0.73423
COOL*DQLTY	42.58409	59.50563	0	131.90

Table 7: Statistics for Mexico – U.S. estimation

Variable	Mean	Standard Deviation	Minimum	Maximum
EXC	1.00488	0.06852	0.88130	1.24360
FRT_u	0.14653	0.14616	0.03545	0.80518
FRT_p	0.19066	0.1850	0.01050	1.05313
COOL*DQLTY	27.48182	38.48769	0	89.40

Table 8: OLS and SUR estimation results for Equation 14

Variables	China		Thailand		India		Ecuador	
	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR
INTERCEPT	14.16569 (4.68)	11.856 (4.09)	2.53898 (4.05)	2.0002 (3.38)	1.389211 (0.83)	1.3848 (0.85)	0.2989 (0.22)	0.43642 (0.33)
EXC	-12.325 (-4.11)	-10.12 (-3.51)	-0.9106 (-1.82)	-0.52807 (-1.12)	0.804 (0.54)	0.72022 (0.50)	0.72448 (1.08)	0.46748 (0.72)
TRF	-0.01562 (-3.47)	-0.015 (-3.57)	0.03066 (1.20)	0.04059 (1.66)	0.040489 (1.62)	0.04276 (1.75)	-0.04166 (-0.57)	-0.0104 (-0.15)
FRT_u	-0.24086 (-0.11)	0.348 (0.17)	-2.38946 (-2.07)	-2.04187 (-1.89)	-1.23068 (-1.13)	-0.76914 (-0.73)	10.2605 (2.91)	10.7144 (3.13)
FRT_p	-0.32465 (-0.22)	-0.045 (-0.03)	-1.9000 (-2.38)	-1.70983 (-2.29)	1.008999 (1.94)	0.80635 (1.61)	0.23969 (0.41)	0.32418 (0.57)
COOL*DQLTY	-0.01908 (-3.94)	-0.019 (-4.11)	0.00041 (0.16)	-0.0005 (-0.21)	-0.00079 (-0.37)	-0.00115 (-0.56)	0.00561 (0.13)	-0.0197 (-0.48)
Adjusted R²	0.5651	0.7950	0.3867	0.7950	0.8415	0.7950	0.8186	0.7950
Variables	Vietnam		Mexico		Indonesia			
	OLS	SUR	OLS	SUR	OLS	SUR		
INTERCEPT	2.97178 (2.09)	3.5407 (2.60)	1.0868 (0.37)	0.14413 (0.05)	2.92099 (4.81)	2.962607 (5.07)		
EXC	-1.4279 (-1.23)	-1.7447 (-1.55)	4.6738 (1.60)	5.56687 (1.98)	0.26108 (1.26)	0.229851 (1.15)		
TRF	-0.00869 (-2.02)	-0.0071 (-1.71)						
FRT_u	-0.34682 (-0.19)	-0.6372 (-0.37)	0.95429 (0.72)	1.19009 (0.93)	-2.424 (-1.46)	-2.47964 (-1.56)		
FRT_p	-0.07359 (-0.08)	-0.8002 (-0.92)	-0.450 (-1.02)	-0.37489 (-0.88)	0.1434 (0.22)	0.24203 (0.38)		
COOL*DQLTY	0.001236 (0.89)	0.00127 (0.94)	-0.00656 (-0.93)	-0.00696 (-0.99)	-0.00565 (-4.82)	-0.0060 (-5.20)		
Adjusted R²	0.68035	0.7950	0.7656	0.7950	0.9157	0.7950		

Note: Numbers in parenthesis are t-statistics

Table 9: Restricted model estimation results

Variable	Parameter Estimate	Standard Error	t value	Prob
D_{Thailand}	0.033224	0.2888	0.12	0.9084
D_{India}	1.840629	0.3282	5.61	<0.0001
D_{Mexico}	5.259998	0.3813	13.79	<0.0001
D_{Indonesia}	1.795206	0.3130	5.74	<0.0001
D_{Ecuador}	3.5508	0.3608	9.84	<0.0001
D_{Vietnam}	1.198732	0.3039	3.95	<0.0001
D_{China}	1.229279	0.3764	3.27	<0.0001
EXC	0.382035	0.2075	1.84	0.0659
TRF	-0.01612	0.00319	-5.05	<.0001
FRT_u	0.132695	0.5197	0.26	0.7985
FRT_p	0.165554	0.2283	0.73	0.4685
COOL*DQLTY	-0.00057	0.000916	-0.62	0.5367

APPENDIX I

DEFINITION OF PRODUCT QUALITY

Faruq, H. 2006. “New Evidence of Product Quality and Trade” describes at length the various proxies used to measure product quality in the literature (pp. 7-9). Relevant portions are reproduced here:

“Different studies have used different proxies for product quality in trade. Since product quality is not directly observed in trade data, most of these proxies are based on the assumption that price variations contain sufficient information about quality variations. Some of these proxies use cross-country variation in export prices (unit values), while others rely on *both* export and import unit prices. Some of these indices are calculated at the product level, while other indices are constructed at the sectoral level.

To check for systematic differences in product quality, Rodrik (1994) examines the unit values for Taiwan and Korea manufactured exports to the United States. Schott (2004) also uses product level unit values to measure quality. In essence, he estimates quality by calculating unit values of all U.S. imports (equivalently, exports of all other countries) at the product level. The unit values provide substantial variation at a very disaggregate level, and may not be perfect indicators of quality due to underlying product heterogeneity and classification error involving inaccurate recording of units and misclassification of goods. Hallak (2005) uses a more aggregate price index to estimate quality. More specifically, he uses the Fisher price index, which is the geometric mean of the Laspeyres index and the Paasche price index. The Laspeyres index itself weights the price in each period by the quantities in the base period, while the Paasche price index uses the current period quantities to weight the prices. Hummels and Klenow (2005) also use a variant of the Fisher Price Index to infer the quality margin. They decompose each country’s exports to a given market category into its price and quantity components and compare them across exporters.

A number of studies do not construct any specific quality (or price) indices, but use other ways to estimate quality differences across countries. For example, Hummels and Skiba (2004) estimate quality differences by calculating price variation across all country pairs for products in a given category. This removes certain commodity-specific variation in prices (e.g. a low quality car might be much more expensive than a high quality stereo system). They also hold the supply side of the model constant so that price variations across importers arise purely due to changes in the quality mix.

Several studies also explore the horizontal dimensions of product differentiation. Instead of equating quality with a price index (under the assumption that all price dispersions occur due to vertical quality differentiation), they allow cross-country variation in prices to be caused by factors other than quality, such as comparative advantage. For example, Hallak and Schott (2005) develop a decomposition methodology

that separates observed export prices into quality versus quality-adjusted prices. However, despite allowing for horizontal differentiation, they find that for many countries, there is not much difference between a country's quality index and its price index (notable exceptions include China and Ireland). Khandelwal (2005) also allows for horizontal differentiation by applying the discrete choice methodology in Berry, Levinsohn, and Pakes (1995). He infers countries' unobserved product quality by allowing market shares to influence quality estimates, so that products with larger market shares have higher quality (conditional on price) and vice-versa. This methodology, while useful at a disaggregate level, is computationally intensive and difficult to implement at the country level.

In conclusion, since product quality is not directly observable from trade data, there is a lack of consensus on an appropriate measure of quality. Researchers have traditionally used various price indices to proxy for quality, but this approach ignores the horizontal aspects of product differentiation. On the other hand, efforts to incorporate horizontal differentiation have been relatively scarce and are somewhat difficult to implement at a more aggregate level.”

We use wages to proxy for quality assuming minimum wages as a cost measure is indicative of product quality across countries. As an alternative quality proxy, we also use producer price index. It measures the average change over time in the selling prices received by producers for their output. But this index is aggregated at the country level, so it is too generalized, i.e., it makes no distinction with respect to the product category of interest (shrimp). Too much aggregation leads to dangers of comparing different products (for example, apples to oranges). Data at a disaggregated level is not available for the countries under consideration, so we report results based on minimum real wages as proxy for quality.

APPENDIX II

DEFINITION OF UNPROCESSED AND PROCESSED SHRIMP

Crucial to the accuracy of this work was to have proper and defined categories representing processed and unprocessed shrimp. We define shrimp to be processed/unprocessed based on the language reported for Country of Origin Labeling law in USDA-AMS (2004). The regulation defines a “processed food item” as a retail item derived from a covered commodity that has undergone specific processing resulting in a change in the character of the covered commodity, or that has been combined with at least one other covered commodity or other substantive food component (e.g., breading, tomato sauce). The addition of a component (such as water, salt, or sugar) that enhances or represents a further step in the preparation of the product for consumption, would not in itself result in a processed food item. Specific processing that results in a change in the character of the covered commodity includes cooking (e.g., frying, broiling, grilling, boiling, steaming, baking, roasting), curing (e.g., salt curing, sugar curing, drying), smoking (cold or hot), and restructuring (e.g., emulsifying and extruding). In an effort to make the definition of a processed food item clearer in the interim final rule, AMS (USDA) modified the language in the proposed rule for fish and shellfish to provide specific examples of the types of processing that would result in a product being considered a processed food item. Under the interim final rule, all cooked items (e.g., canned fish, cooked shrimp) and breaded products are considered processed food items and are excluded from coverage.

The most disaggregated level of data is obtained from the USITC website at the 10-digit level. We consider three HTS categories: 030613 is broadly defined as raw,

unpeeled/peeled, and frozen shrimp; 030623 is raw, unpeeled/peeled, and not frozen; and 160520 is cooked, peeled, breaded, and canned. However, at the 10-digit level, description of data in the USITC website also includes ‘cooked by steaming or boiling for the 030613 and 030623 categories’. Correspondence with personnel in the Census Bureau, and FAS (USDA) indicate that the descriptions at the 10-digit level are at best considered ambiguous. The suggestions have been to follow the publication of USITC which outlines HTS categories by chapters. Chapter 3 relates to unprocessed shrimp and chapter 16 refers to processed shrimp. Also, tariff classification and country of origin labeling rulings published online (www.faq.s.org) clarify classification of shrimp as processed/ unprocessed by the following statements in 2007 NY Rulings - NY N010853:

“The applicable subheading for the frozen, processed shrimp, when imported in **raw, unpeeled condition** (for example, “headless, shell-on”) will be [0306.13.00](#), Harmonized Tariff Schedule of the United States (HTSUS), which provides for crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine, fit for human consumption: frozen: shrimps and prawns: shell-on, imported in accordance with Statistical Note 1 to chapter 3. The statistical suffix, in the range of “03” to “27”, will depend on the count size, as specified in the HTSUS. The rate of duty will be Free.

The applicable subheading for the frozen, processed shrimp, when imported in **raw, peeled condition** (for example, “raw, peeled, tail-on”) will be [0306.13.0040](#), HTSUS, which provides for crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine, fit for human consumption: frozen: shrimps and prawns: peeled, imported in accordance with Statistical Note 1 to chapter 3. The rate of duty will be Free.

The applicable subheading for the frozen, processed shrimp, when imported in **cooked, peeled condition** (for example, “cooked, peeled, deveined”) will be [1605.20.1030](#), HTSUS, which provides for crustaceans, molluscs and other aquatic invertebrates, prepared or preserved: shrimps and prawns: other: frozen, imported in accordance with Statistical Note 1 to chapter 16: other: other. (Note: If the product is imported in airtight containers, the applicable statistical suffix will be “10”, instead of “30”.) The rate of duty will be Free.”

APPENDIX III

ANTIDUMPING DUTY IMPOSITION

Under the antidumping statute, U.S. Department of Commerce (“Commerce”) is charged with investigating allegations of dumping by foreign producers or importers, and, if dumping is found, to counter the effects of such dumping by ordering a duty on dumped imports, i.e., an anti-dumping duty. In the course of an investigation, Commerce may, at different times, estimate the rate of anti-dumping duty that will ultimately be assessed. The initial estimate follows an affirmative preliminary determination that dumping has occurred. Pursuant to this initial estimate, Commerce instructs the Bureau of Customs and Border Protection (“Customs”) to collect estimated duties, sometimes referred to as “cash deposits,” on entries of the merchandise that is subject to investigation.⁸ After Commerce completes its investigation, it issues a final determination which may (and usually does) adjust Commerce’s initial estimate. This final determination is implemented in the antidumping duty order. Pursuant to U.S. law, every year after an antidumping duty order goes into effect, interested parties have an opportunity to request an administrative review during the anniversary month of the order. During the administrative review, Commerce determines the amount of antidumping duties to assess on entries that were made during the period of review and establishes a new cash-deposit rate on future entries for each of the companies reviewed. So generally the cash deposit rate established pursuant to the amended final determinations would remain in effect until the issuance of the final results of the first administrative review. The administrative review effectively updates the anti-dumping

⁸ Cash deposit rate is merely an estimate of the eventual liability importers subject to an antidumping duty order will bear. It is an interim or provisional rate.

duty order. Once the actual rate of dumping for particular goods is established through an administrative review, Commerce instructs Customs to collect the required duties, or refund any monies owed, for the goods imported during that period. “Liquidation,” which is the final assessment and collection of duties, occurs only once for each entry of goods, and, for the most part, may not be subsequently undone.⁹ Thus anti-dumping duty investigations on countries can be classified as preliminary determination, final determination, subsequent reviews, and amended final determination of less-than-fair-value anti-dumping investigations.

Further details on the duties imposed and subsequent reviews are archived at <http://ia.ita.doc.gov/frn/index.html>. In our model we use cash-deposit rates and liquidation rate to capture the structural change on relative share of unprocessed shrimp imports for the time period considered.

⁹ Because liquidation may not, in most cases, be subsequently undone, it is “suspended” until such time as a party may request an administrative review, and during the pendency of any such review.