Are Food Safety Standards Weighing Exports Down? A Theoretically-Consistent Gravity Model Approach on Seafood Exports to the EU, Japan and US

by

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Abstract

The findings provide evidence that changing food safety regulations in the EU, the US, and Japan had statistically significant and negative effects on the world trade flow of seafood, over the study period 1992-2005. Estimating a theoretically-consistent gravity model, we find that different food safety regulations have differential effects on aggregated seafood and different effects across seafood products. The Japanese food safety standard had the largest effect of the three standards. US HACCP has a larger effect than previous studies and this effect increases over time. Lower valued products are least affected by the food safety standards.

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A developing literature suggests that food safety standards are weighing down exports. This debate is not simply academic given the questions in the World Trade Organization of the trade effects of food safety standards. A common model for analysis has been the gravity model. However, recent advances in the gravity model suggest that the traditional model is fraught with endogeneity problems, biasing downward policy variable estimates. Additionally, previous modeling has tended to look at a single food safety standard (or aggregated standards) on an aggregated product, implicitly assuming that the same standard (or aggregated standards) affects different food products in the same manner. In this literature, researchers have explicitly, and sometimes implicitly, hypothesized that these standards are trade barriers over catalysts, a question of policy effects over time. Given these methodological and theoretical concerns, a reconsideration of the titular question is appropriate. The contribution of this applied analysis is to show that food safety standards have diverse effects on product categories.

With the use of a theoretically-consistent gravity model, this article explores bilateral trade of seafood products and the effects of food safety regulations on trade from the three largest importers. Considering Hazard Analysis Critical Control Points (HACCP) in the US (1997), minimum required performance limits (MRPLs) in the EU (2002), and the Food Safety Basic Law in Japan (2003), we hypothesize the following: 1) Food safety regulations cause a loss of markets for exporting countries. 2) Food safety regulations have differential effects on differentiated products. 3) Food safety standards are greater for higher valued products. 4) Food safety regulations diminish over time.

International Trade in Seafood and Policy Context

During the period 1984-2004, world exports of seafood increased and achieved a record value of US$ 71.5 billion in 2004 (FAO, 2007). On the one hand, the global expansion of trade in seafood highlights an important role of developing countries as major seafood exporters. FAO (2007) reports that 48% of the value of fish and fishery products traded worldwide in 2004 came from developing countries. On the other hand, the top importers of seafood are developed countries in which the EU, Japan and the US are the largest import markets. During the period 2002-2004, the developed markets comprising of the EU, Japan and the US accounted for 77% of the fishery exports from developing countries (FAO, 2007). In 2005, for example, Japan was the top seafood importing nation with $14.4 billion, followed by the US with an estimated imported value of $12.1 million (Johnson et al., 2007).

New Seafood Regulations

Despite the growth in seafood trade, major importers of seafood imposed food safety regulations over this period. These regulations may have prevented even greater growth of seafood trade. The debate of food regulations in the literature centers on whether these regulations serve as barriers or catalysts (Anders and Caswell, 2009; Jaffee and Henson, 2004; among others). Our results provide evidence that the food regulations from the US, the EU and Japan are trade barriers. More importantly, our results point to differential effects across products over time.

In the US seafood industry, Hazard Analysis Critical Control Point (HACCP) became mandatory application from December 18, 1997 (Anders and Caswell, 2009). HACCP is a preventative system to control hazards in food products, with particular emphasis on the reduction of food-borne pathogens. It was a new approach to food safety, since it focuses on controlling the production process instead of testing final products (Cato, 1998). According to the FDA, the purpose of HACCP adoption is to identify hazardous risks and reduce contaminations at the early stages of the production process. Under HACCP, seafood processing firms need to conduct a hazard analysis. Once firms establish critical control points for each hazard, firms are required to develop and implement a HACCP plan to prevent or eliminate contaminations (GAO, 2001).

In the EU as well as in other markets, chloramphenicol and nitrofuran are banned antibiotics in seafood products. These substances do not have set maximum residue limits (MRL) and/or acceptable daily intake (ADI). The minimum required performance limit (MRPL) is a specified minimum concentration level of a detectable residue. Prior to regulatory change, the capacity to detect the residues in EU member states could vary. In 2002, the EU implemented Commission Decision 2003/181/EC to set out MRPLs for the detection of residues of certain substances in foods of animal origin. The EU set the MRPL for poultry and aquaculture products for chloramphenicol at 0.3μg/kg and for nitrofuran metabolites at 1 μg/kg (EC, 2003). As a result, the EU has been able to detect very low levels of residues in food, with sensitivity increasing ten-fold compared with the early 1990s (FAO/WHO, 2004).

In Japan, a series of incidents relating to food occurred in the period 2000-2002, raising the consciousness of consumers of food safety. In response the Japanese government amended the Food Sanitation Law and passed the new Food Safety Basic Law, taking effect beginning summer 2003 (Japanese Government, the Cabinet Office, 2008). The Food Safety Basic Law is based on a risk analysis, which aims to protect consumer health and safety. Under this law, the Food Safety Commission, an advisory committee constituted of scientific experts, was newly established. This Commission is required to evaluate toxicological residues in food stuff as a part of its risk assessment. In addition, the revised Food Sanitation Law restricts substances without MRLs to zero tolerance and does not allow products with these substances to enter the Japanese market. This regulation is more stringent than what was required in the previous Food Sanitation Law, as the unrevised law did not prohibit residues of substances with no available MRLs (Miyagawa, 2004).

Literature Review

A number of empirical studies have attempted to quantify the trade effects of emerging food safety standards. Otsuki, Wilson and Sewadeh (2001), Wilson and Otuki (2003 and 2004) employed the gravity model to provide evidence that EU standards negatively affected agricultural exports. Disdier, Fontagne and Mimouni (2008) provided evidence that sanitary and phytosanitary (SPS) measures, which include food safety regulations, and technical barriers to trade (TBT) have negative effects on the trade of products, especially those from developing countries. Using secondary data analysis and a survey, Cato and dos Santos (1998) estimated that Bangladesh frozen shrimp processors experienced a loss in total revenue of $14.6 million (in 1997 dollars) as consequence of the ban by the EU. Debaere (2005) provided evidence that the declaration of zero tolerance for antibiotics by the EU diverted shrimp exports of Thailand from the EU to the US. Anders and Caswell (2009) investigated the impact of the mandatory application of HACCP in the US on seafood exports from the top 33 countries, and they found that HACCP adoption by the US reduced its import value of seafood from -0.03% to -0.35%.[1] The work of Anders and Caswell (2009), Disdier, Fontagne and Mimouni (2008), Otsuki, Wilson and Sewdah (2001) and Wilson and Outsuki (2003 and 2004) used the traditional gravity model. However theoretical and empirical extensions show that their analysis may have problems of endogeneity because of an omitted variable bias.

This article looks at the impacts of stricter food safety measures placed in the EU, Japan and US markets on export performance of fish exporting countries. We begin with a broad view by assessing the effect of an aggregate measure of food safety regulations on exports, which we hypothesize to have a negative effect. We use a theoretically-consistent gravity model with country-pair and country-by-time fixed effects to control for omitted variables and endogenous policy variables. Next, we narrow our focus by estimating the effect of each country's food safety regulation on aggregate fish trade. We sharpen our focus even more by considering the differential effects of each country's food safety regulation on different types of fish exports. This approach is motivated by the hypothesis that the stringency of food safety regulations may have differential effects on products. Finally, we analyze the differential effects of standards on seafood trade over time to determine if seafood trade serves as a catalyst or a barrier.

Model Development

The traditional gravity model, with pooled data, can be defined as follows:

$$\ln x_{ij} = \alpha_0 + \alpha_1 \ln y_i + \alpha_2 \ln y_j + \alpha_3 \ln d_{ij} + \sum_{n=1}^{N} \alpha_{n+3} \ln \delta_{ijn} + \varepsilon_{ij} \quad (1)$$

where x_{ij} is exports from country *i* to country *j*. The gross domestic products of country *i* and country *j* are y_{it} and y_{jt}. The distance between exporter *i* and importer *j* is d_{ij}. All other factors that could influence bilateral trade between countries *i* and *j*, such as trade agreements, non-tariff barriers, historical ties, etc. are represented by δ_{ijn}.

Despite being a workhorse in empirical research, the gravity model specified in equation 1 is not formally motivated by an economic theory (Anderson, 1979; Bergstrand, 1985; Anderson and van Wincoop, 2003; Baier and Bergstrand, 2007; among others). Anderson (1979) provided a theoretical economic basis to the equation. He showed that trade between two countries depends on their bilateral barriers *relative* to the average trade barriers they face in trading with the rest of the world. However, traditional gravity models did not pay any attention to these relative barriers. Following Anderson (1979), Bergstrand (1985) pointed out that the traditional gravity equation is misspecified since it excluded price terms.

Building on the work on Anderson (1979), Bergstrand (1985) and Deardorff (1998), Anderson and van Wincoop (2003) developed a theoretical gravity model based on a constant elasticity of substitution (CES) demand in a general equilibrium structure. The first order conditions and the imposition of the market clearance condition yields a trade model

(2) $$x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma}$$

where y^W world income, t_{ij} is bilateral trade barriers, σ is the elasticity of substitution, and P_i and P_j are the price indices for exporter *i* and importer *j*. The bilateral trade barriers can be written as

(3) $$t_{ij} = b_{ij} d_{ij}^{\rho}$$

where b_{ij} is an indicator variable representing a border barrier, such as food safety, and d_{ij}^{ρ} is the bilaterial distance. Anderson and van Wincoop (2003) referred to the price indices as the "multilateral resistance" terms. Taking the natural logs of the equation yields a theoretically consistent gravity model, for cross-sectional data:

(4) $$\ln x_{ij} = k + \ln y_i + \ln y_j + (1-\sigma)\rho \ln d_{ij} + (1-\sigma)\rho \ln b_{ij} - (1-\sigma)\ln P_i - (1-\sigma)\ln P_j$$

where *k* is a constant term. The authors argued that including the multilateral resistance variables into the model is crucial to obtain unbiased estimates. Otherwise, the regression estimates would be biased due to the omitted variable problem. Note also that the theoretical gravity model imposes unitary income elasticities.

Baier and Bergstrand (2007) pointed out that the theoretically-consistent model suggested by Anderson and van Wincoop (2003) still suffers from an endogeneity problem. They stated, "While the country fixed effects help to account for the endogeneity bias created by prices and the influence of FTAs [free trade agreements] among other countries on the trade from *i* to *j*, they do not correct for the bias introduced if countries select into FTAs." (Baier and Bergstrand, 2007, 76-77) Additionally, Baier and Bergstrand (2007) restricted the income variables to one by scaling the dependent variable by the product of GDPs. Grant and Lambert (2008) adapted Baier and Bergstrand (2007) to estimate treatment effects of membership in regional trade agreements in agricultural and non-agricultural trade. In this article, we adopt the theory-motivated model developed by Anderson and van Wincoop (2003) and Baier and Bergstrand (2007) to account for time-varying price terms and to control for endogeneity of policy variables.

Model Specification

To provide preliminary evidence for the argument that coefficients on food safety standards are biased due to model specifications, we first estimate the classical gravity equation with three different specifications. The alternative models are as follows:

a. the traditional gravity model with no panels and country or time fixed effects,

$$\begin{aligned} \ln x_{ij} = \alpha_0 + \alpha_1 \ln y_i + \alpha_2 \ln y_j + \alpha_3 \ln d_{ij} + \alpha_4 Food\ Safety_{ij} + \alpha_4 Contig_{ij} \\ + \alpha_5 Colony_{ij} + \alpha_6 Lang_{ij} + \alpha_6 NAFTA_{ij} + \alpha_6 EU_{ij} + \varepsilon_{ij} \end{aligned} \quad (5a)$$

where $Food\ Safety_{ij}$ equals one whenever any of the following food safety regulations are in force: the US is the importer between 1998 to 2005 under US HACCP implementation ($USHACCP$); the EU members are the importers from 2002 to 2005 under implementation of MPRLs ($EUMPRL$); and Japan is the importer from 2004 to 2005 under food safety law enforcement in Japan ($JPLAW$). $Contig$ is a dummy variable which is one when the country-pair shares a border. $Colony$ is a dummy variable which is one when the country-pair shares a colonial tie. $Lang$ is a dummy variable which is one when the country-pair shares an official language. $NAFTA$ and EU are dummy variables for membership in the agreements.

b. the traditional gravity model with panels and time fixed effects (eq. 5a with time fixed effects),

$$\ln x_{ijt} = \alpha_0 + \alpha_t + \alpha_1 \ln y_i + \alpha_2 \ln y_j + \alpha_3 \ln d_{ij} + \alpha_4 Food\ Safety_{ij} + \alpha_4 Contig_{ij} + \alpha_5 Colony_{ij} + \alpha_6 Lang_{ij} + \alpha_6 NAFTA_{ij} + \alpha_6 EU_{ij} + \varepsilon_{ij} \tag{5b}$$

where α_t is the time fixed effect. The panels are of country pairs over time. For example one panel is of exports from Peru to Spain from 1992 to 2005, while another is exports from Peru to USA from 1992 to 2005. All of the panels are balanced, that is each country pair has traded over the entire time period.

c. a theoretic gravity model with panels, imposing unitary income elasticities, country and time fixed effects (eq 6a) and a theoretical gravity model with time and country-pair fixed effects (eq. 6b), an extension of Anderson and van Wincoop (2003) for panels

$$\ln\left(\frac{x_{ijt}}{y_{it}y_{jt}}\right) = \alpha_i + \alpha_j + \alpha_t + \alpha_0 + \alpha_1 NAFTA_{ijt} + \alpha_2 EU_{ijt} + \alpha_3 Food\ Safety_{ijt} + \varepsilon_{ijt} \tag{6a}$$

(6b)
$$\ln\left(\frac{x_{ijt}}{y_{it}y_{jt}}\right) = \alpha_{ij} + \alpha_t + \alpha_0 + \alpha_1 NAFTA_{ijt} + \alpha_2 EU_{ijt} + \alpha_3 Food\ Safety_{ijt} + \varepsilon_{ijt}$$

where α_i is the importer fixed effect, α_j is the exporter fixed effect, and α_{ij} is the country-pair fixed effect.

d. a theoretic gravity model with the correction of endogeneity, as suggested by Baier and Bergstrand (2007) with country-by-time and pair fixed effects and an aggregate food safety dummy (eq. 7a), with specific food safety dummies (eq 7b), and our extension of Baier and Bergstrand (2007) which includes product-by-time fixed effects (eq. 7c):

(7a)
$$\ln\left(\frac{x_{ijt}}{y_{it}y_{jt}}\right) = \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_0 + \alpha_1 NAFTA_{ijt} + \alpha_2 EU_{ijt} + \alpha_3 Food\ Safety_{ijt} + \varepsilon_{ijt}$$

(7b)
$$\ln\left(\frac{x_{ijt}}{y_{it}y_{jt}}\right) = \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_0 + \alpha_1 NAFTA_{ijt} + \alpha_2 EU_{ijt} + \alpha_3 USHACCP_{ijt} + \alpha_4 EUMRPL_{ijt} + \alpha_5 JPLAW_{ijt} + \varepsilon_{ijt}$$

(7c)
$$\ln\left(\frac{x_{ijpt}}{y_{it}y_{jt}}\right) = \alpha_{pt} + \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_0 + \alpha_1 NAFTA_{ijt} + \alpha_2 EU_{ijt} + \alpha_3 USHACCP_{ijt} + \alpha_4 EUMRPL_{ijt} + \alpha_5 JPLAW_{ijt} + \varepsilon_{ijt}$$

where α_{it} is the importer-by-time fixed effect and α_{jt} is the exporter-by-time fixed effect. α_{pt} denotes product-by-time fixed effect. With the addition of the product, we create panels of country pairs and products over time. For example we now have a panel of exports of fresh fish from the Peru to Spain and another panel of exports of mollusks and crustaceans from Peru to Spain. Similarly we have the different panels for exports of these products from Peru to the US. Additionally, Peru exports dried fish to the US. As Baier and Bergstrand (2007) provided evidence that the country-time heterogeneity biases the estimates, we include a product-by-time dummy variable to manage the biases generated from a data set of multiple products. x_{ijpt} is the real value of trade of three different fish products.

With equation 7a, we test i) whether aggregate food safety regulations have negative effects on world exports of seafood and test the validity of the Baier and Bergstrand (2007) model relative to the traditional (eq. 5a and 5b) and earlier theoretical gravity models (eq. 6a and 6b). This model is a freeing of the restrictions of the earlier models by allowing the coefficients on the country and time dummy variables to adjust to specific country and time pairing effects.

In refining our focus, we test ii) whether the different standards have differential effects on aggregate fish, with equation (7b), iii) whether the different standards have differential effects on disaggregated fish, with equation (7c), and iv) whether the effects of standards (aggregated and disaggregated) are greater on fish exports (aggregated and disaggregated) over time.

Among the various econometric methods to obtain unbiased coefficients on the disaggregated food safety variables, in this article, we adapt the method suggested by Wooldridge (2002) to estimate the treatment effect of the food safety regulations. With the models considering food safety regulation separately, we run three different models with different bases ($non - USHACCP$, $non - EUMRPL$ and $non - JPLAW$). For example, we include the following food safety dummy variables $USHACCP$, $EUMRPL$, $non - EUMRPL$, $JPLAW$ and $non - JPLAW$. We omit $non - USHACCP$, which serves as the base. We then rerun the model by adding $non - USHACCP$and dropping $non - EUMRPL$, making it the base. We then rerun the model adding in $non - EUMRPL$ and removing $non - JPLAW$, as the base. For ease of interpretation in the tables, we consolidate the three runs into one model, so that each model presents the coefficient for each standard.

Data

Trade data are collected from the United Nations Commodity Trade Statistics Database (UNCOMTRADE). In this database, bilateral trade values and quantities are reconciled for each product category based on reliability indices of exporters and importers. The trade totals are compared with other merchandise trade for all product categories and years (Gehlhar, 2002). The data used for this analysis includes two sets. Set 1 is aggregated seafood trade data (SITC rev.3 code 03). Set 2 is disaggregated seafood data at the product level, including fresh, chilled, frozen fish (SITC rev.3 code 034, below called fresh fish); dried, salted, and smoked fish (SITC rev.3 code 035, below called dried fish); and crustacean and mollusks (SITC rev.3 code 036). Both subsets have 14 years of data, from 1992 to 2005.

Set 1 includes 57 exporting countries and 17 importing countries (Japan, US and EU 15). Set 2 consists of 55 exporting countries and 17 importing countries (Japan, US and EU 15). The 15 European countries covered in the study are those that joined the EU by 2000. GDP data are from the World Bank's World Development Indicators (World Bank, 2006). Information on distance, contiguity and common language are obtained from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII, 2006).

Bilateral real export value (deflated by the 2000 price) of aggregated seafood commodities is averaged at $52.6 million per year. The standard deviation is $166.4 million, more than three times larger than the mean of real seafood trade value. By itemized commodity, means of fresh fish and crustacean and mollusks are close to each other, about $27.7 million, and the mean value of dried fish is about $7.5 million, much lower than that of the other two commodity groups. The average per unit value, in real terms, is $4.53 for fresh fish, $7.34 for dried fish and $4.71 for crustacean and mollusks. Descriptive statistics of the study variables are available upon request. See the appendix for countries included in the data set.

Results

We present the results and tests of the traditional versus the theoretical gravity models for aggregate food safety and aggregate fish in table 1. Model 1 reports estimates of the traditional gravity model (eq. 5a). While Model 2 (eq. 5b) shows the results of the traditional gravity model in panels with time fixed effect. Model 3 presents coefficients estimated from equation (6a) with time and country fixed effects. Model 4 documents the coefficients estimated from equation (6b) with time and country-pair fixed effects. Model 5 has the coefficients from equation (7a) with the country-by-time and country-pair fixed effects.

Tradition versus Theory

Of the two traditional gravity model specifications, Model 2 represents the model typically run. Our model generates typically hypothesized results: statistically significant and correct signs on all the typical gravity model variables (except language is negative). In contrast to Model 1, the policy variable $Food\ Safety_{ijt}$ in Model 2 is statistically significant and negative at the level -0.62 with percentage change of [exp(-0.62)-1=]-46% (Halvorsen and Palmquist, 1980). The explanatory power of the model is relatively low for gravity models at 34%.

In Models 3, 4 and 5 we estimate various forms of the theoretical gravity model. Following Anderson and van Wincoop (2003), we attempt to address the omitted variable problem with country fixed effects and time fixed effects. We also impose the unity income elasticity as purported by theory.[2] While the trade agreements are statistically significant and positive, $Food\ Safety_{ijt}$ is not statistically significant in Models 3 and 4. We estimate Model 4 as a variant of the Anderson and van Wincoop (2003) and the Baier and Bergstrand (2007) models. While the model has a higher R^2 at 91%, variables of interest are statistically insignificant. Model 5 is the Baier and Bergstrand (2007) model with country-pair and country-by-time fixed effects. This model has a statistically significant and negative coefficient for $Food\ Safety_{ijt}$ at -0.86 with a percentage change of -58%. The surprising result is the negative value for NAFTA. In all but one of the previous estimates the value was positive and statistically significant, but as noted by Baier and Bergstrand (2007), the value is biased and fluctuates substantially when endogeneity is not appropriately managed. We address this result in a subsequent section. EU is statistically significant and is substantially larger in Model 5 than Models 1 and 2.

The increase in the absolute values of the policy variables in the theoretical gravity models is consistent with the results from Baier and Bergstrand (2007). We also test Model 5 versus Models 3 and 4. With the likelihood ratio test, we reject, at the p-value 0.00, the restrictions of Models 3 and 4 in favor of Model 5. Our results provide evidence in support of the theoretical gravity model of Baier and Bergstrand (2007).

Differential Effects of Differentiated Food Safety Standards on Aggregate Seafood

In this section, we will estimate equation (7b), using aggregated seafood (SITC REV.3 code 03) and disaggregated seafood (SITC REV .3 codes 034, 035 and 036), to determine their differential trade effects. Following Anderson and van Wincoop (2003), we impose a unity restriction on GDP coefficients, and following Baier and Bergstrand (2007), we use country-by-time fixed effects. Estimates of this theoretically-consistent model are reported in table 2. The corresponding elasticities are available in table 3.

Table 2 shows that, for both data sets, $USHACCP_{ijt}$, $EUMRPL_{ijt}$, and $JPLAW_{ijt}$ are all statistically significant and have the expected negative sign. This supports the hypothesis that more stringent food safety regulations in the EU, Japan, and US markets have negative effects on international trade of seafood products. Both data sets yield similar coefficient estimates, supporting the robustness of the estimates. The model with disaggregated data has a product-by-time fixed effect. Our F-test rejects the null hypothesis that the product-by-time fixed effect is zero, supporting our extension of the Baier and Bergstrand (2007) model.

From the regression coefficients of aggregated seafood in table 2, we calculate the elasticities with respect to each standard. Elasticities estimated both in percentage and by level value at the mean are reported in table 3. The largest trade elasticity is for the Japanese laws. Under these laws, average annual export value of seafood to Japan is estimated to change by -79.55%, equivalent to $41.88 million loss, relative to seafood exports to Japan before the law revision. Trade elasticities associated with HACCP imposition in the US was a -58.91% or -$31.01 million change in bilateral seafood trade. Enforcement of the MRPLs in the EU on average, results in a -57.77% or -$30.41 million change in bilateral seafood trade.

From this analysis, strengthened food safety policies have substantial effects on aggregate seafood exports to the US, the EU and Japan. The regulations for Japan clearly have a stronger effect on imports suggesting a greater cost associated with these regulations. For the US and the EU regulations, while they lower imports, the effects are not as strong as those caused by Japanese regulations. Compared to Anders and Caswell (2009) our elasticities are larger as suggested by Baier and Bergstrand (2007).

Table 2 shows that regional trade agreements significantly affect bilateral trade in seafood between country members. However, the directions of the effects are different between the EU and NAFTA. Being a member of the EU is associated with an average 1021.58% increase in annual seafood export value, relative to non-members. Baier and Bergstrand (2007) noted an increase in RTAs of sevenfold under their improved model. Conversely, membership in NAFTA is estimated to have a statistically significant negative effect on trade in seafood of country members. Thus, we can infer that trade of seafood products in the EU 15 is substantial.

Moreover, the negative effect of NAFTA on exports may be explained by the increase of exports from non-NAFTA countries to the US. For example, Adams, Keithly, and Versaggi (2005) stated that in the 1980s, Mexico, Central America, and Northern South America were the leading exporters of shrimp to the US market. Now, exports from Asia and Indonesia dominate the US shrimp market.

Differential Effects of Differential Food Safety Standards on Disaggregated Seafood

Differences in technical standards imposed on various commodities suggest that food safety regulations may have different effects across traded seafood products. Chow tests provide evidence to reject the null hypotheses that the beta coefficients for fresh fish, dried fish, and crustacean and mollusk are equal. This result provides evidence to support the hypothesis of differential effects of food safety regulations on disaggregated products. Therefore, we conduct separate regressions of fresh fish, dried fish, and crustacean and mollusks to test the second hypothesis that food safety regulations affected seafood products differently. To do so, we estimate the country-pair and country-by-time fixed effect model (eq. 7c) separately for each product. The estimated coefficients are reported in table 2, and their corresponding elasticities are calculated in table 3.

Results in table 2 show that fresh fish (fresh, chilled and frozen fish, code 034) is hurt the most by the stringency of food safety standards. On average across all importers, this product has the lowest per unit value of the three products. It should be noted that for the EU countries fresh fish ($4.66) is the second least valuable product after crustaceans and mollusks ($4.34). Although the three standards are statistically significant and negative, *JPLAW* has the largest negative coefficient (-2.42), followed by *USHACCP* (-1.67) and *EUMRPL* (-1.26). In terms of elasticity (table 3), *JPLAW* is estimated to be associated with a -91.11% change in bilateral annual trade value of fresh fish into Japan, relative to that when the policies were not implemented. In terms of value, this is equivalent to a change of -$25.21 million. Annual fresh fish exports to the US follows by a change of -81.17%, or -$22.46 million, in the presence of HACCP. Finally, average annual fresh fish export to a country in the EU is changed by a -71.63%, or -$19.82 million, compared to that before the imposition of the MRPL.

This finding is consistent with the literature. Huss, Ababouch and Gram (2004) listed the risk caused by different types of seafood and pointed out that raw or live seafood are high risk products. Moreover, it is worth noting that, in the data set, code 034 includes fresh, chilled, and frozen fish. Indeed, frozen seafood has the highest percent of rejection/detention cases at the border (56.3%), followed by prepared seafood (23.6%) and processed seafood (10.1%) at the EU border from 1999-2002 (FAO, 2005).

The three food standard variables are statistically insignificant for dried fish. This product is the most valuable product on a per-unit basis across all importers and for each importer. The fact that stricter food safety regulations do not significantly impede dried fish trade can be explained by several reasons. First, since most dried fish are wild-captured, not farm-raised, they have lower or no risk of veterinary drugs. Huss, Ababouch and Gram (2004) indentified the presence of chemical hazard “only applies to fish from aquaculture or coastal areas. For all other fish (the large majority of marine fish), there are no safety hazards and no HACCP plan is required” (p. 162). Second, developed countries catch and process most of the dried fish in the market. For example, the latest data statistics of the nationMaster.com (2009) show that, among the top ten exporters of dried, salted, and smoked fish, eight are developed countries, only two (China and Vietnam, which is not in this data set) are developing countries. It is reasonable to argue that rich countries with greater technical and financial resources can better ensure safety standards for their export products, compared to countries with limited resources. Finally, as Huss, Ababouch and Gram (2004) suggested, dried, salted and smoked fish are products with high salt content and/or very low water activity. Accordingly, growth of pathogens is highly improbable with proper processing techniques, such as drying, salting or smoking.

Turning to the effects of standards on the remaining product category, crustacean and mollusk (code 036), $USHACCP_{ijt}$ and $EUMRPL_{ijt}$ are not statistically significant, while $JPLAW_{ijt}$ is statistically significant and negative. Everything else constant, bilateral annual export value of crustacean and mollusk to Japan experiences an average change of -73.34% relative to that before law enforcement. Again, this finding confirms that Japanese food regulatory measures are the most stringent among the three policies considered. It is surprising that the US and the EU regulations do not inhibit trade in crustacean and mollusk. A large variety of species are included in product code 036, such as shrimp, mussels, crab, and clams, etc., and they may come from both wild and cultured environments. Potentially, the trade effects on this product category are insignificant because of the potentially different trade effects on each product included in this broad category. However, this result provides further evidence against the hypothesis that higher-valued products are protected more through food safety regulations.

The Effects of Food Safety Standards over Time

In this section, we test the fourth hypothesis that trade effects of food safety standards diminish over time based on the findings of Anders and Caswell (2009), who found evidence of a diminished effect. We follow the approach of Anders and Caswell (2009) by looking at US HACCP. Similar to Anders and Caswell (2009), we define the short run (1992-1999) and the long run (1992-2005).[3] We also test a related hypothesis: food safety regulations have a "phase-in" effect, as suggested by Baier and Bergstrand (2007) and Grant and Lambert (2008) of FTAs. The economic motivation of these hypotheses is that after a policy comes into force, it may have a cumulative or lagged effect on trade as time unfolds. This effect would suggest that food safety may serve as a catalyst to trade or at least not a barrier over time.

Results on the differential trade effects of US HACCP overtime is shown in table 4. Although US HACCP is consistently associated with a significant negative effect on seafood trade, the long-run effect is observed to be more negative than the short-run effect. Our result is consistent with our disaggregated data Set 2. Our results suggest that US HACCP has a more substantial effect over time, which is evidence against our hypothesis, which suggests that US HACCP is a stronger barrier over time.

This finding is the opposite of Anders and Caswell (2009) in that they estimated a more negative effect of the US HACCP in the short run versus long run. Their explanation was that, in the longer period of time, countries are able to enhance their safety and quality system to comply fully with HACCP requirement. Though their argument was supported by regression results for all countries in general, it was not supported by evidence on developing countries. For developing countries, Anders and Caswell (2009) found no significant differences between long-run and short-run effects of HACCP.

Conclusion

The findings suggest that changing food safety regulations in the EU, the US, and Japan had statistically significant and negative effects on the world trade flow of seafood, over the study period 1992-2005. Estimating the panel gravity model with country-pair and country-by-time fixed effects separately for each seafood product, we find that food safety regulations have differential effects across seafood products. US HACCP has a larger effect than previous studies using a theoretically-based gravity model.

In all three industrialized markets, the food safety regulations affect the differentiated seafood products differently. This finding suggests food safety regulations have differential effects on exporters based on products exported. An interesting result is that the highest value product, dried fish, was not affected by the various food safety regulations. This product is exported mostly from developed to developed countries. Fresh fish, the least valuable product on a per-unit basis, is consistently exported by more developing countries than the other two products (see Appendix 2). These results suggest that developing countries may find it more difficult to export more processed products and/or higher valued products such as dried fish and crustacean and mollosks. Therefore the differences in financial and technical resources may lead to differences in compliance capacity between countries, which in turn, results in losses to the poorer nations and gain to the richer nations, we see that the most.   From another perspective, differential trade effects across seafood products illustrate different stringency levels between country policies.

Food safety regulations have an increasing greater effect in the long run versus the short run. In total, these findings contribute to more nuanced evidence in support of the standards as barriers debate. So yes, food safety standards are weighing down exports but in differential ways and over time. And the weight falls most heavily on exporters of lower-valued products, which tend to be developing countries.

Footnotes

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[1]It should be noted that the percentage change calculated using the Halvorsen and Palmquist (1980) method would have been between -2.95% and -45.00%.

[2]We drop the traditional gravity variables to provide comparable results among the Models 3, 4 and 5 because of the country-pair fixed effects will force the loss of these traditional gravity model variables.

[3]We estimated a different short run for disaggregated seafood (1992-2000) because of statistical insignificance of the original short-run period.

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Table 1. Estimation Results of Traditional Gravity Models (Aggregate Seafood)

	Traditional Gravity Model		Theoretical Gravity Model		
	Model 1	Model 2	Model 3	Model 4	Model 5
$\ln y_{it}$	0.84*** (46.53)	0.95*** (46.64)	1.00[a]	1.00[a]	1.00[a]
$\ln y_{jt}$	0.20*** (13.23)	0.20*** (13.14)	1.00[a]	1.00[a]	1.00[a]
$\ln d_{ij}$	-0.41*** (-12.69)	-0.42*** (-12.85)			
$FoodSafety_{ijt}$	-0.041 (-0.78)	-0.62*** (-4.54)	0.025 (0.22)	0.039 (0.61)	-0.86*** (-2.85)
$Contig_{ij}$	1.32*** (10.87)	1.30*** (10.74)			
$Colony_{ij}$	0.74*** (6.71)	0.71*** (-0.11)			
$Lang_{ij}$	-0.28*** (-2.82)	-0.25*** (-2.42)			
$NAFTA_{ijt}$	1.23*** (2.83)	1.35*** (3.13)	3.16*** (9.59)	0.072 (0.11)	-2.14*** (-3.42)
EU_{ijt}	0.44*** (5.61)	0.42*** (5.36)	2.61*** (29.14)	2.65*** (33.05)	2.42*** (22.20)
R^2	0.34	0.34	0.78	0.91	0.94
F statistics	387.98	170.16	306.97	128.78	72.41
N	7532	7532	7532	7532	7532
			Likelihood ratio $\chi^2_{810} = 31{,}526$		

Note: The numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.

[a]Indicates values imposed by model construction (Anderson and van Wincoop, 2003)

Table 2. Estimation Results of Theoretical Gravity Models

Variables	Aggregated Seafood	Disaggregated Seafood	Fresh Fish	Dried Fish	Crustaceans and Mollusks
ln y_{it}	1.00[a]	1.00[a]	1.00[a]	1.00[a]	1.00[a]
ln y_{jt}	1.00[a]	1.00[a]	1.00[a]	1.00[a]	1.00[a]
$USHACCP_{ijt}$	-0.89**	-0.93**	-1.67***	0.43	-0.10
	(-2.55)	(-1.99)	(-4.25)	(0.78)	(-0.22)
$EUMRPL_{ijt}$	-0.86***	-0.82**	-1.26***	1.54	0.23
	(-2.85)	(-1.97)	(-3.76)	(1.07)	(0.57)
$JPLAW_{ijt}$	-1.59***	-1.46***	-2.42***	-0.57	-1.32***
	(-4.53)	(-3.12)	(-6.12)	(-0.93)	(-2.84)
$NAFTA_{ijt}$	-2.14***	-1.42**	-1.05	-2.38	-1.92***
	(-3.42)	(-1.77)	(-1.23)	(-1.21)	(-2.75)
EU_{ijt}	2.42***	2.45***	3.11***	0.84***	2.64***
	(22.20)	(15.07)	(20.57)	(3.21)	(14.19)
R^2	0.94	0.80	0.94	0.93	0.93
F statistics	72.40	34.46	57.61	34.06	42.63
N	7532	13468	6020	2884	4564

Note: The numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.
Initially, we ran this model with data set 2, which pools all three categories and includes the product-by-time fixed effect. From Wald testing of the joint significance of the product-by-time fixed effect parameters we show that they are jointly statistically significant at the 0.01% level of significance, F(26, 12103) = 144.78. However Chow tests show that the model should be run separately for each product. The test statistics are as follows: H_0: $\beta_{fresh} = \beta_{dried}$ F[860,7184]=22.52*** H_0: $\beta_{dried} = \beta_{crustacean}$ F[1058,8468]=12.42*** H_0: $\beta_{dried} = \beta_{crustacean}$ F[860,728]=19.48***

[a]Indicates values imposed by model construction (Anderson and van Wincoop, 2003).

Table 3. Elasticities for Aggregated Seafood and Each Disaggregated Product

Variables	Aggregated Seafood		Fresh Fish		Dried Fish		Crustacean and Mollusks	
	%	$mil.	%	$mil.	%	$mil.	%	$mil.
$USHACCP_{ijt}$	-58.91*** (-2.55)	-31.01	-81.17*** (-4.25)	-22.46				
$EUMRPL_{ijt}$	-57.77*** (-2.85)	-30.41	-71.63*** (-3.76)	-19.82				
$JPLAW_{ijt}$	-79.55*** (-4.53)	-41.88	-91.11*** (-6.12)	-25.21			-73.34*** (-2.84)	-20.29
$NAFTA_{ijt}$	-88.26*** (-3.42)	-46.46					-85.29*** (-2.75)	-23.60
EU_{ijt}	1,021.58*** (22.2)	537.80	2,151.66*** (20.57)	595.26	130.54*** (3.21)	9.77	1,306.54*** (14.19)	361.47

Note: Numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively. We omit statistically insignificant values from the calculations.

Table 4. Estimation Results for the Short Run and Long Run

	Short Run[a]		Long Run	
	Aggregated Seafood	Disaggregated Seafood	Aggregated Seafood	Disaggregated Seafood
$USHACCP_{ijt}$	-0.58**	-0.62*	-0.89**	-0.93**
	(-2.18)	(-1.78)	(-2.55)	(-1.99)
$NAFTA_{ijt}$	-1.79**	-1.36	-2.14***	-1.42**
	(-2.45)	(-1.52)	(-3.42)	(-1.77)
EU_{ijt}	1.84**	1.89***	2.42***	2.45***
	(13.60)	(9.86)	(22.0)	(15.07)
R^2	0.94	0.79	0.94	0.80
F statistics	53.17	28.13	72.41	34.46
N	4304	8658	7532	13468

Note: Numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.
[a]The short run for aggregated seafood is 1992-1999 while the short run for disaggregated seafood is 1992-2000.

Appendix1: List of countries exporting seafood to the US, EU15 and Japan (1992-2005)

US		JP		EU15	
Argentina	Peru	Argentina	Portugal	Algeria	Mauritius
Australia	Philippines	Australia	Korea	Argentina	Mexico
Belgium	Poland	Belgium	Singapore	Australia	Netherlands
Belize	Portugal	Brazil	Spain	Austria	N. Zealand
Brazil	Korea	Canada	Sweden	Belgium	Norway
Canada	Singapore	Chile	Switzerland	Brazil	Oman
Chile	Spain	China	Thailand	Canada	Paraguay
China	Sweden	Colombia	Tunisia	Chile	Peru
Colombia	Switzerland	Denmark	Turkey	China	Philippines
Croatia	Thailand	Ecuador	USA	Colombia	Poland
Denmark	Trin. & Tobago	Finland	UK	Croatia	Portugal
Ecuador	Turkey	France		Cyprus	Korea
Finland	UK	Germany		Denmark	Romania
France	Venezuela	Greece		Ecuador	Seychelles
Germany		Iceland		Finland	Singapore
Greece		India		France	Spain
Iceland		Indonesia		Germany	Sweden
India		Ireland		Greece	Switzerland
Indonesia		Italy		Hungary	Thailand
Ireland		Kenya		Iceland	Tunisia
Israel		Madagascar		India	Turkey
Italy		Malaysia		Indonesia	USA
Jamaica		Malta		Ireland	UK
Japan		Mauritius		Israel	Venezuela
Kenya		Mexico		Italy	
Malaysia		Netherlands		Jamaica	
Mexico		N. Zealand		Japan	
Netherlands		Norway		Kenya	
New Zealand		Peru		Madagascar	
Norway		Philippines		Malaysia	
Paraguay		Poland		Malta	

*Korea is Republic of Korea

Appendix 2: List of countries exporting seafood by product (1992-2005)

Fresh Fish		Dried Fish	Mollusks and Crustaceans
Algeria	Peru	Argentina	Argentina
Argentina	Philippines	Australia	Australia
Australia	Poland	Belgium	Belgium
Austria	Portugal	Canada	Canada
Belgium	Rep. of Korea	Chile	Chile
Belize	Singapore	China	China
Brazil	Spain	Denmark	Denmark
Canada	Sweden	Ecuador	Ecuador
Chile	Switzerland	Finland	Finland
China	Thailand	France	France
Colombia	Trin. and Tobago	Germany	Germany
Croatia	Tunisia	Greece	Greece
Cyprus	Turkey	Iceland	Iceland
Denmark	United Kingdom	India	India
Ecuador	USA	Indonesia	Indonesia
Finland		Ireland	Ireland
France		Italy	Italy
Germany		Japan	Japan
Greece		Malaysia	Malaysia
Hungary		Mauritius	Mauritius
Iceland		Mexico	Mexico
India		Netherlands	Netherlands
Indonesia		New Zealand	New Zealand
Ireland		Norway	Norway
Israel		Peru	Peru
Italy		Philippines	Philippines
Jamaica		Poland	Poland
Japan		Portugal	Portugal
Kenya		Rep. of Korea	Rep. of Korea
Madagascar		Singapore	Singapore
Malaysia		Spain	Spain
Malta		Sweden	Sweden
Mauritius		Switzerland	Switzerland
Mexico		Thailand	Thailand
Netherlands		Tunisia	Tunisia
New Zealand		United Kingdom	United Kingdom
Norway		USA	USA
Oman		Venezuela	Venezuela
Paraguay			