EFFECTS OF FOOD SAFETY REGULATORY STANDARDS ON SEAFOOD EXPORTS TO US, EU AND JAPAN

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A Thesis
Submitted to
the Graduate Faculty of
Auburn University
in Partial Fulfillment of the
Requirements for the
Degree of
Master of Science

Auburn, Alabama
August 10, 2009

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Nguyen Thi Van Anh entered Foreign Trade University in Hanoi, Vietnam in 1996 and majored in international trade and Japanese. She received the Japanese government scholarship to study Japanese culture at Tokyo Gakugei University from 1999-2000. After returning to Vietnam and graduating from Foreign Trade University in 2002, Anh taught Japanese at the same university for two years. She then worked as a business development manager at FPT Company from 2003-2006. In August of 2007, Anh entered Graduate School at Auburn University where she received a graduate research assistantship to work toward a Master of Science degree in Agricultural Economics. She married Tran Van Nhuong on January 1, 2004.

THESIS ABSTRACT

EFFECTS OF FOOD SAFETY REGULATORY STANDARDS ON SEAFOOD EXPORTS TO US, EU AND JAPAN

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Master of Science, August 10, 2009
(B.S. Foreign Trade University, Vietnam, 2002)

76 Typed Pages

Directed by Norbert L.W. Wilson

This thesis examines the effects of the enhanced food safety standards imposed in developed countries on seafood exports to these country markets. New impositions of food safety regulations in three major markets are analyzed, including 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). The paper employs a gravity model with bilateral pairs and country-by-time fixed effects to estimate panel data from the UNCOMTRADE database for the period 1992-2005. The results show that the stringency of food safety regulations caused a loss of markets for seafood exporting countries. Among three investigated markets, the Japanese policies were estimated to be the most stringent with an average annual reduction of 79.6% of seafood export value to the country, holding other factors constant. The US HACCP was associated with 58.9% reduction in average annual seafood export to the US, while the reduction caused by the EU MRPL was 57.8%, everything else equal.

Using trade data disaggregated at product level, this study found that different food safety standards had differential effects on seafood products. The enforcement of the Japanese laws, the US HACCP, the EU MRPL caused a respective average loss of 91.1%, 81.2%, and 71.6% to fresh fish trade in these markets. The Japanese policies also caused a reduction of 73.3% of annual export value of crustacean and mollusks to the country. However, dried fish was not significantly hurt by the standards in all three markets, under the studied period. Additionally, the US HACCP was estimated to have cumulative effects on trade, with greater elasticity in the long run (-60.1%) relative to that in the short run (-44.7%). Finally, findings in this paper suggested that addressing omitted variables and endogeneity in the gravity equation are important to avoid underestimating the effects of policy variables.

ACKNOWLEDGEMENTS

I wish to extend my gratitude to my major professor, Dr. Norbert Wilson, for his encouragement, support, intellectual stimulation, patience, and overall guidance throughout my graduate study. I would also like to thank my other committee members, Dr. Henry Kinnucan and Dr. Patricia Duffy, for their time and assistance in the completion of this thesis. My appreciation is also extended to the Department of Agricultural Economics and Rural Sociology for providing me with a graduate research assistantship. Lastly, special thanks go to my husband, Tran Van Nhuong and my daughter, Tran Thi Tuong Anh, for the unconditional love and unlimited support they gave me along my journey.

Style manual or journal used: American Journal of Agricultural Economics

Computer software used: Microsoft Word 2007, Microsoft Excel 2007, and Strata/SE 8.0

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures of the World Trade Organization (WTO) provides member countries guidelines for food safety regulations. These regulations are imposed to protect human health, plants and animal life in importing countries. However, countries are increasingly using SPS measures as non-tariff barriers to trade, especially when tariffs and quantitative restrictions are reduced due to trade liberalization progress (Henson and Loader, 2001).

Seafood is one of the most globally traded products, and its consumption is associated with high incidence of food-borne illness (US GAO, 2001). Consumers and regulatory authorities in importing countries are increasingly concerned with seafood safety and quality. As a result, emerging food safety regulations have been imposed in the industrialized markets, including the mandatory 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).

This paper explores seafood imports into these three major markets. In particular, I try to understand how changes in food safety regulations in these markets affected their imports. I hypothesize that the imposition of the new regulations caused a loss of markets for exporting countries. I also hypothesize that the enhanced regulations have differential effects on differentiated products. I further hypothesize differentiated effects caused by stricter policies in terms of time period of policy enforcement.

To test these hypotheses, I employ the panel gravity model with bilateral pair and country-by-time fixed effects suggested by Anderson and van Wincoop (2003) and Baier and Bergstrand (2007). The results provide empirical evidence on the trade destruction effect of SPS measures in international trade.

II. BACKGROUND

2.1 International Trade in Seafood

International trade in seafood increased during the period 1984-2004 (FAO, 2007). According to FAO (2007), total world exports of seafood achieved a record value of \$71.5 billion in 2004. Adjusting for inflation, seafood trade value increased 17.3% in the period 2000-04, 18.2 % in the period 1994-2004, and 143.9% in 1984-2004. In terms of volume, fishery exports reached a record of 53 million metric tons (live weight equivalent) in 2004, and represented a growth of 13% compared to 1994, and 114% relative to 1984. Moreover, the share of seafood in total world agricultural trade has grew from 5% in 1976 to 16% in 2002, and then declined to 14% in 2004. (This slight decline is because of significant increases in exports of agricultural and forestry products).

The global expansion of trade in fish and fishery products highlights an important role of developing countries as major seafood exporters. FAO (2007) states that in 2004, 48% by value and 57% by volume of seafood traded worldwide came from developing countries. It is also worth noting that Asian countries accounted for 66% of total export value of fisheries from developing countries. Developing countries' net exports rose from \$4.6 billion in 1984 to \$16.0 billion in 1994, and reached \$20.4 billion in 2004. These numbers are higher than those of other typical agricultural products from developing countries, such as coffee, rubber, cocoa, rice, and tea. In terms of its contribution to total agricultural exports, seafood has accounted for 5% of agricultural exports in 1976, growing to 16% in 2002. This represents the role of seafood exports as an important source of income, foreign exchange, and jobs in developing countries.

While most of the major seafood exporters are developing countries in Asia and South America, the top importers are developed countries, among them the European Union (EU), Japan and the United States (US) are the largest import markets. During the period 2002-2004, the developed markets comprising of the EU, Japan and the United States accounted for 77% of the world fishery trade from developing countries (FAO, 2007). In 2005, for example, Japan was the top seafood importing nation, bringing in $14.83 billion of seafood product value in the country, followed by the US whose imported value was estimated at $12.1 billion (Johnson and Associates, 2007). In combination, the EU is the largest importer of fish and fishery products. For individual EU members, Spain is the largest importing country with $5.2 billion, followed by France ($4.2 billion), Italy (3.9 billion), Germany ($2.8 billion), and the United Kingdom ($2.8 billion). The main fishery products imported by developed country include tuna, shrimps and pawns, rock lobsters, small pelagic, and cephalopods (UNCTAD/WTO, 2008).

Conversely, export of seafood from developed to developing countries accounts for only 15% of developed country exports of seafood. Most of exported products in this flow are raw material for further processing, or small and inexpensive pelagic. Moreover, the share of seafood products among developed countries accounts for 85% of seafood exports from developed countries. In contrast, the share of trade in fishery products among developing countries represents only 15 % of developing county exports of fisheries, according to FAO (2007).

2.2 Food Safety Standards on Seafood: Policy Context

Along with the growth in international trade of seafood, there is an increase in the population incidence of food-borne illness due to bacteria contamination in traded seafood (US GAO, 2001). This raises consumer consciousness about safety and quality of seafood, especially consumers in high income markets. Regulatory authorities in these markets are responsive to consumer concerns of food safety by enhancing standards on traded seafood. The significant changes in policies regulating food safety and quality occur in three major markets, the EU, US, and Japan, as described below.

Minimum Required Performance Limits (MRPLs) in the EU

Countries exporting food to the EU must not exceed the Maximum Residue Limit (MRLs) and Acceptable Daily Intake (ADIs). These are maximum levels of tolerance set for substances or their residues in foods with animal origin. According to the EU legislation, all active veterinary drugs used for medical treatment of animals should be assessed so that their corresponding MRLs/ADIs can be established. However, due to the lack of toxicological data or limitation of analytical methods, there are particular substances for which the MRL/ ADI levels are not available. These substances include chloramphenicol and nitrofurans which are prohibited for use in food producing animals in the EU.

Since no approved MRLs/ ADIs are available for these substances, the common approach is to apply a zero tolerance policy. This policy states that no detectable levels of residues in food products traded in or imported to the EU market are accepted (Heberer et al., 2007). As technologies and analytical methods improve, the EU is able to detect very low levels of residues in food products. However, that “very low level” differs among authority laboratories, depending on detection capacity of the equipments they use. To harmonize the required detectable level, the EU established minimum required limits at which the equipments must perform. This requirement led to the implementation of Commission Decision 2002/657/EC, which marks an increase in the stringency of EU standards.

The “Commission Decision 2002/657/EC pursuant to Directive 96/23/EC as regards the setting of Minimum Required Performance Limits (MRPLs) for certain residues in food” was implemented in 2002. It aimed to harmonize control of residues of certain substances whose MRLs/ADIs were not established. For residues of those substances, the Decision set out minimum concentration levels at which the analytical method used at regulatory laboratories should be able to detect and confirm. For instance, the Article 4 set MRPLs of 0.3μg/kg for chloramphenicol and 1 μg/kg for nitrofuran metabolites (Commission Decision 2002/657/EC). The requirement was amended by Commission Decision 2003/181/EC, including MRPLs of 2 μg/kg for malachite green. In addition to establishing MRPLs for malachite green, the Commission also introduced sophisticated analytical technologies, such as mass spectrometry (MS) and liquid chromatography-mass spectrometry (LC-MS), and made them the standard methods. According to FAO/WHO (2004), these changes together have increased sensitivity a ten-fold compared with the early 1990s.

The imposition of Commission Decision 2002/657/EC and improved detection capacity in the EU have profound impacts on international trade of seafood. At the end of 2001, the EU detected chloramphemicol and nitrofuran residues in shrimp imported from Thailand, Vietnam, Myanmar, and in honey imported from China (Alan, Osborne, and Marty, 2003). This resulted in the EU restriction on shrimp imports from Vietnam, China, and 100 percent test on shrimp consignments from Thailand. In combination with restricting or banning imports, the EU authorities also removed from markets and destroyed fish products with antibiotics residues (Alan, Osborne, and Marty., 2003). Malik (2004) presented evidence on the rejection of consignments of pawns and shrimps exported from India to the EU in 2003 and 2004, which caused substantial economic loss to seafood producers in India.

Because of the trade disruption, the use of MRPLs in the EU generated debates on the appropriateness of the policy. MRPLs regulation was criticized because it was not based on a risk assessment of underlying residues to human health, but on the performance of analytical equipments (FAO/WHO, 2004). In addition, operating and maintaining these equipments require not only technical investment but scientific expertise, both are scarce in developing countries.

Amendment of Food Sanitation Law and Inaction of Food Safety Basic Law in Japan

Two primary laws which regulate food safety in Japan are the “Food Sanitation Law” and the “Japanese Agriculture Standard Law”. The former is under the control of the Ministry of Health, Labor and Welfare (MHLW), and the latter is supervised by the

Ministry of Agriculture, Forestry, and Fishery (MAFF) (Kagawa and Bailey, 2006). With the strict enforcement of these regulations, the Japanese government has successfully assured safety of the food sector and bolstered the confidence in Japanese consumers. However, that confidence was adversely affected after a series of incidents and scandals relating to food occurred in the period 2000-2002. Jonker, Ito, and Fujishima (2005) summarized four major incidents which undermined Japanese consumers' trust in the government's regulatory system and raised their consciousness over the safety of food. According to Jonker, Ito, and Fujishima (2005), the food safety crises started with a 2000 food poisoning accident in the dairy sector, affecting 14,700 people. In 2001, an outbreak of Bovine Spongiform Encephalopathy (BSE) occurred, and the inefficient way in which the MAFF investigated and controlled the outbreak made consumers angry. The situation became worse in 2002, when a scandal of mislabeling imported beef involved a reputable food company. This incident occurred the same year as the detection of high pesticide residue in vegetables imported from China. The combination of these problems resulted in consumers' distrust of the food safety system, making safety the most important and sensitive issue in the Japanese food sector.

To respond to consumers' strong reactions, the Japanese government amended the Food Sanitation Law and passed the new Food Safety Basic Law, taking effect summer 2003 (Japanese Government, the Cabinet Office, 2008). The Food Safety Basic Law is based on a risk analysis approach, which aims to protect consumer health and safety. Under this law, the Food Safety Commission, an advisory committee constituted of scientific experts, was established. This Commission is required to evaluate toxicological residues in food stuff as a part of its risk assessment.

Under the revised Food Sanitation Law, the Japanese MHLW also established MRLs to control residue tolerance of veterinary drugs in food with animal origin, including fish and shellfish. Similarly to the situation in the EU, substances without permitted residue levels are treated as zero tolerance and not allowed to enter Japanese market. This requirement is tighter than what required in the previous Food Sanitation Law, as the unrevised law did not prohibit residues of substances with no available MRLs (Miyagawa, 2004). Japan has a national monitoring program on residues, with official laboratories and quarantine stations throughout the country. In 2002, Japan conducted tests for veterinary drugs in 7,912 samples of domestic products and 10,871 samples of products from foreign countries. Violations of excessive drug residue were found in 3 samples of domestic food and in 18 samples of imported food. Analyzed food sample included seafood, such as eel, salmon and shrimp (Miyagawa, 2004).

In addition, the Food Safety Basic Law requires that imported fish and fishery products meet the same regulatory standards as products sold in the domestic market. In principle, importation of fishery products to Japan needs to meet two requirements: food sanitation inspection and customs inspection (Jonker, Ito, and Fujishima, 2005). The new regulations also established stringent measures regarding fish handling, labeling, traceability, storage and transport.

Along with the stringency in public regulations over seafood safety, standards imposed by individual companies or supermarkets in the private sector are also emerging.

Along with careful investigation and selection of seafood suppliers in exporting countries, Japanese buyers seek to control food safety at source. Japanese manufactures and processors of fisheries assign experts to visit or work with producers in exporting countries (Clemens, 2003). Since Japanese consumers and importers are demanding seafood as exactly as what they want in terms of safety standards, the cost of compliance are increasingly incurred by foreign exporters.

Hazard Analytical Critical Control Point in the US

Hazard Analysis Critical Control Point (HACCP) is a preventative system to control hazards in food products, with particular emphasis on the reduction of food-borne pathogens. Since it focuses on controlling the production process instead of testing final products, it was a different approach to food safety issue (Cato, 1998). The concept of HACCP originated in the US in the early 1960s, and since then national governments around the world have adopted HACCP. For instance, HACCP has been applied in Japan, Canada, Australia and adopted by the EU food sector in 1995 (Cato, 1998).

The US Food and Drug Administration (FDA), in December 18, 1997, made HACCP mandatory for the seafood industry. In use, HACCP requires the application of seven principles (Cato, 1998):

1. assess the hazard, list the steps in the process where significant hazards can occur and describe the prevention measures;
2. determine critical control points (CCPs) in the process;
3. establish critical limits for each CCP;
4. establish procedures to monitor each CCP;

5. establish corrective actions to be taken when monitoring indicates a deviation from the CCP limits;

6. establish record keeping for HACCP system; and

7. establish procedures to verify that the HACCP system is working correctly.

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 for hazards which potentially occur. These include pesticides, drug residues, and decomposition in certain species, microbiological contamination, chemical contamination, and natural toxins. Once the firm establishes the critical control points for each hazard, firms are required to develop and implement a HACCP plan to prevent or eliminate contaminations. In practice, operating the HACCP system helps the seafood industry better understand causes and effects of hazards, as well as an approach to food safety issue with a science-based perspective (US GAO, 2001).

To date, several studies have demonstrated the benefits of using HACCP as official public intervention. These studies suggest that HACCP is a cost-efficient tool to control microbiological pathogens in seafood. First, HACCP does not require product sampling and testing as command and control (CAC) does, which is practically important when the proportion of microbiological hazards left in end products is very small. Second, HACCP does not involve the cost of establishing specific levels of standards for each product. Instead it utilizes measurable indicators at critical control points in production process to verify the compliance of firms. Third, HACCP lowers the costs of regulatory enforcement by having authorities periodically check the records of firms. In monitoring HACCP, the regulatory agencies do not have to inspect every step of the actual production processes; instead, the agencies can review and verify the records of firms. In addition to cost efficiency, studies also recognize that HACCP provides seafood industry with a certain degree of flexibility in hazard management. Since this system does not impose a set of specific standards that firms have to follow, it allows the industry to make necessary changes at each stage of production chain (Unnevehr and Jensen, 1999).

III. LITERATURE REVIEW

3.1 Food Safety Standards and International Trade: Empirical Studies.

The Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures of the World Trade Organization (WTO) provides member countries guidelines for food safety regulations. According the SPS Agreement, these regulations are imposed to protect human health, plants and animal life in importing countries. However, countries are increasingly using SPS measures as non-tariff barriers to trade, especially when tariffs and quantitative restrictions are reduced due to trade liberalization progress (Henson and Caswell, 1999; Hooker, 1999; Henson, Brouder, and Mitullah, 2000; Henson and Loader, 2001; Athukorala and Jayasuriya, 2003; Jaffee and Henson, 2004; Henson and Mitullah, 2004; World Bank, 2005; Henson and Jaffee, 2008). These authors demonstrate that food safety standards imposed by developed countries can act as impediments to exports of agricultural and food products. These impediments can prohibit trade because of increased costs, trade diversion from one importer to another, or trade reduction in general trade flows (Henson and Loader, 2001). Many developing countries face financial and technical resources limitations. Thus, stringent standards impose great challenges for these countries in trying to improve or maintain their export capacity (Henson and Loader, 2001; Athukorala and Jayasuriya, 2003; Jaffee and Henson, 2004).

Many empirical studies have attempted to quantify the trade effect of emerging food safety standards. Otsuki, Wilson, and Sewadeh (2001b) employed the gravity model to look at effect of pre-EU harmonized aflatoxin standards on exports from nine African countries. Their findings indicated a negative and significant relationship between higher standards and value of trade flows. Specifically, they showed that 1% reduction in MRL of aflatoxin is associated with a reduction in trade flow by 1.1 % for cereals and 0.43 % for fruits, nuts and vegetables. Wilson and Otsuki (2003) and (2004) extended this analysis by showing the trade effects of food safety regulations on various exporting countries in the world, beyond Africa. Again, their results confirm that harmonizing standards at a stricter level relative to that regulated by international standards can significantly reduce trade value. For example, the authors predicted that if the EU's high standards are applied globally, world trade will reduce by $3.1 billion. In the case of banana imports to OECD countries, the authors estimated that a 1% reduction in the level of allowable pesticide chlorpyrifos would reduce trade value by 1.63%.

In the case of seafood, various studies have assessed the significance of food safety measures in deterring trade and generating compliance costs to exporting countries. Cato and Santos (1998) examined the economic loss to Bangladesh frozen shrimp processors when the European Commission banned seafood export from Bangladesh in 1997 due to its safety and quality problems. Using secondary data analysis and survey method, the authors estimated that Bangladesh shrimp industry experienced a loss in total revenue of $14.6 million (in 1997 dollars) as consequence of the ban.

Debaere (2005) demonstrated how changing trade policy in the EU, including more stringent food safety requirements, affected international trade in shrimp. Two events were examined to illustrate changes in trade policy: the loss of Thailand’s GSP status in the EU and the EU declaration of zero tolerance for antibiotics. The author showed that these two events shifted the Thailand shrimp exports from the EU to the US, causing the shrimp price to fall in the US market and the US implementation of anti-dumping to protect its shrimpers. The study showed that tighter safety regulations on antibiotic in the EU market not only affect trade between the EU and Thailand, but also the trade relationship between Thailand and the US. In showing so, the author highlighted that differences in technical measures on food safety among countries can generate considerable trade diversion effects.

While the common view on the issue of increased technical regulations focus on their negative effects on trade, Anders and Caswell (2008) discussed and econometrically illustrated the tension of “standards as barriers” versus “standards as catalysts”. These authors investigated the impact of the mandatory application of HACCP in the US on seafood exports from the top 33 exporting countries. Estimating a gravity model with random effects, they found a negative and significant relationship between HACCP adoption and seafood imports to the US. For example, the introduction of HACCP in the US can reduce import value of seafood into the US about 3.5 – 45%, holding other factors constant. (These elasticities are calculated from the regression coefficients reported in Anders and Caswell (2008), based on the method suggested by Halvorsen and

Palmquist (1980). These results support the argument that standards impede international trade.

In addition, Anders and Caswell (2008) provided evidence that HACCP has differential effects on countries with different development status. Their findings suggest a negative and statistically significant trade impact for developing countries, while less negative or positive impact for developed countries. However, when analyzing each individual country without categorizing development status, the study indicates that larger exporters generally increase sales, while small exporters experience losses in the presence of the US HACCP. According to the authors, these findings illustrate a more optimistic perspective on the issue of technical measures. That is, through complying with higher standards, seafood exporters can enhance their safety and quality system and improves their export capacity.

3.2 The Gravity Equation

The gravity equation was first used in economics by Tinbergen (1962) to study the effect of free trade agreements on international trade. Since then, it has been widely employed as an empirically effective model to investigate bilateral trade flows between countries. Basically, the gravity equation links variations in bilateral merchandize volume to the GDPs of the involved countries and their bilateral distance**.** In addition, researchers usually include other variables to control for bilateral characteristics which potentially affect trade, such as common language, adjacency, and colonial tie. Since GDP_i and GDP_j variables are used as proxies for the economic sizes of the pair, and distance is a proxy for transportation cost, the gravity equation fits the trade relationship between two regions well. The combination of gravity variables can explain 60-80% variation in bilateral trade volume (Baier and Bergstrand, 2007).

To examine trade effects of stricter food safety standards, the gravity model is considered appropriate for two reasons: First, it does not impose the signs on safety standard coefficients, and therefore, allows researchers to do various hypothesis tests. Second, it can investigate variation in bilateral trade flows with respect to changes in safety regulations, in combination with other basic gravity variable, such as GDPs, distance (Maskus,Wilson, and Otsuki, 2001; Wilson and Otsuki, 2004; and Anders and Caswell, 2008).

Applying the classical cross-section gravity equation to study trade effects of regulatory standards, I can specify the model as follows:

$$\begin{aligned} \ln X_{ij} &= \alpha_0 + \alpha_1 \ln GDP_i + \alpha_2 \ln GDP_j + \alpha_3 \ln DIST_{ij} \\ &\quad + \alpha_4 CONTIG_{ij} + \alpha_5 COLONY_{ij} + \alpha_6 LANG_{ij} + \alpha_7 NAFTA_{ij} \\ &\quad + \alpha_8 EU_{ij} + \alpha_9 FOODSTD_{ij} + \varepsilon_{ij} \end{aligned} \tag{1}$$

where X_{ij} is seafood exports deflated in 2000 dollars from country *i* to country *j*. GDP_i and GDP_j are real GDP (2000 constant price) of exporting country *i* and importing country *j*. $DIST_{ij}$ is the distance between exporter *i* and importer *j*. $CONTIG_{ij}$ is a dummy for shared borders, taking the value of 1 if country *i* and *j* share a common border and 0 otherwise. *COLONY* is a dummy variable, taking the value of 1 if two countries have a common colonial history and 0 otherwise. $LANG_{ij}$ is a dummy for language, taking the value of 1 if country *i* and *j* speak a common language. $NAFTA_{ij}$ and EU_{ij} are dummies denoting membership of country *i* and *j* in the regional trade agreements. $NAFTA_{ij}$ is equal to 1 if both exporter *i* and importer *j* are members of the North American Free

Trade Agreement (NAFTA) and 0 otherwise. EU_{ij} is equal to 1 if both exporter i and importer j are members of the European Union and 0 otherwise. $FOODSTD_{ij}$ represents food safety standards imposed by importing country j on seafood exports from country i.

Despite a workhorse in empirical research, the original formulation of gravity model specified in (1) was not formally motivated by an economic theory (Anderson, 1979; Bergstrand, 1985, 1989; Helpman and Krugman 1985; Deardorff, 1998; Anderson and van Wincoop (2003) and Baier and Bergstrand (2007). It is said to be based only on the resemblance to physical science, or on informal developments in economics (Baier and Bergstrand, 2007). The first estimation of the gravity equation was done by Tinbergern (1962) with intuitive justification rather than a theoretical basis (Deardorff, 1998). Lacking a strong economic foundation undermined the predictive potential of the gravity equation (Bergstrand, 1985). To solve this issue, several studies provide a theoretical economic basis to the equation.

The first theoretical foundation to explain the “behavior” of gravity equation was developed by Anderson (1979). Using constant elasticity of substitution (CES), the author 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 take into account any form of these relative barriers. Following Anderson (1979), subsequent studies adapted the CES system and provided fruitful economic content to the theoretical framework. Bergstrand (1985) pointed out that the traditional gravity equation excluded price terms, therefore it is misspecified. He emphasized that these price terms “importantly influence trade flows and lend behavioral content to the gravity equation” (Bergstrand, 1985, p. 480). In other studies, the theoretical framework was extended to test the monopolistic competition model (Bergstrand, 1989) or the classical Heckscher-Ohlin model (Deardorff, 1998). Generally, the main difference of these studies from the classical gravity equation is the inclusion of the relative trade barriers.

Anderson and van Wincoop (2003) referred to the average trade barriers as “multilateral resistance” terms and explicitly added these terms into the gravity equation, making it theoretically consistent. The authors argued that, including the multilateral resistance variables into the model is crucial to obtain unbiased estimates. Otherwise, the regression estimates will be biased due to the omitted variable problem. The theoretical gravity equation suggested by Anderson and van Wincoop (2003) is presented below:

$$\begin{aligned} \ln\left[\frac{X_{ij}}{GDP_i GDP_j}\right] &= \alpha_0 + \alpha_3 \ln DIST_{ij} \\ &+\alpha_4 CONTIG_{ij} + \alpha_5 COLONY_{ij} + \alpha_6 LANG + \alpha_7 NAFTA_{ij} \\ &+\alpha_8 EU_{ij} + \alpha_9 FOODSTD_{ij} \\ &-\ln p_i^{1-\sigma} - \ln p_j^{1-\sigma} + \varepsilon_{ij} \end{aligned} \tag{2}$$

$$\begin{aligned} p_j^{1-\sigma} &= \sum_{i=1}^{N} p_i^{\sigma-1}\left(\frac{GDP_i}{GDP_w}\right).\exp(\alpha_3 \ln DIST_{ij} \\ &+\alpha_4 CONTIG_{ij} + \alpha_5 COLONY_{ij} + \alpha_6 LANG + \alpha_7 NAFTA_{ij} \\ &+\alpha_8 EU_{ij} + \alpha_9 FOODSTD) \end{aligned} \tag{3}$$

where σ is the elasticity of substitution between countries, $p_i^{\sigma-1}$ and $p_j^{1-\sigma}$ are the price indices for exporter and importer, GDP_w is world GDP. In the above equations, Anderson and van Wincoop (2003) used the price indices, $p_i^{\sigma-1}$ and $p_j^{1-\sigma}$, to indicate the multilateral resistance terms as they are functions of all bilateral trade resistance. These multilateral resistance terms are obtained by simultaneously solving for the equilibrium prices in the market-clearing equations (3). The equation suggested by Anderson and van Wincoop (2003) is consistent with theory and different from empirical gravity equation in two ways: (i) it includes the price indices and (ii) it imposes unitary GDPs coefficient. The authors' main contribution is a symmetric form to simplify the equations derived by Anderson (1979) and Deardorff (1998), making the gravity equation more readily operational. While this model can be estimated by nonlinear least square method, Anderson and van Wincoop (2003) also suggested an alternative method: Replace the multilateral resistance terms with country-specific dummy variables, i.e. using fixed effects by exporter *i* and importer *j*, and estimate by ordinary least square method.

Baier and Bergstrand (2007) recognized that while the gravity model suggested by Anderson and van Wincoop (2003) is theoretically consistent because it includes multiple price terms, it still suffers from an endogeneity problem. This endogeneity comes from unobserved heterogeneity between country pairs. Specifically, they explained that trade-related policy variables are not completely exogenous to the model. Other factors are in the error terms, which are not captured by standard gravity variables, and are simultaneously correlated with both trade flows and policy variables. For example, in their study of free trade agreements (FTA), Baier and Bergstrand (2007) showed that countries endogenously select into a FTA. In other words, countries that have an FTA tend to share economic characteristics which are usually correlated with the level of trade. Since many of these characteristics are unobserved to the econometrician, they are still left in the error terms of the gravity equation, which causes an endogeneity problem.

To solve the issue of endogeneity in cross-section gravity equation, previous studies usually used instrumental variables, such as relative capital-labor ratios, relative factor-endowment differences, an index of democracies, GDP similarities, intra-industry trade indices, etc. However, many of these instruments are correlated with the gravity equation error term, and estimates of the FTA effects using this technique are unstable (Baier and Bergstrand, 2004 and Magee, 2003). From previous studies of cross-sectional data, Baier and Bergstrand (2007) concluded that an “instrumental variable [method] is not a reliable method for addressing the enodegeneity bias of the FTA binary variable in a gravity equation” (Baier and Bergstrand, 2007, p. 83). Thus, Baier and Bergstrand (2007) expanded the previously developed framework to a panel setting to control for endogeneity. They argued that a panel data is a ready alternative to cross-section data when unobserved time-invariant heterogeneity exists. In addition, they introduced country-by-time fixed effects to account for multiple price terms. These authors show that using bilateral country pair fixed effects is useful to control for unobserved time-invariant bilateral terms. However, they argued that since in panel setting, the multilateral price terms, as noted in Bergstrand (1985), are time-varying, they are best adjusted for by using country-by-time fixed effect, instead of bilateral country pair.

Along with two important innovations, expansion of the framework to panel data and introduction of country-by-time fixed effects, Baier and Bergstrand (2007) scaled the left hand side variable by the product of the GDPs as suggested by theory. Using this approach, they confirmed that “one can draw strong and reliable inferences about the average treatment effect of FTAs using the gravity equation applied to panel data” (Baier and Bergstrand, 2007, p. 83).

In empirical studies, Grant and Lambert (2008) adapted Baier and Bergstrand (2007) method to estimate treatment effects on member’s trade in agricultural and non-agricultural products. They found that the magnitude and sign of the FTA agreements variable depends on the particular agreement investigated, the implementation period, and whether products are agricultural or not.

Regarding empirical analysis of food safety and health, Otsuki, Wilson, and Sewadeh (2001a) and Wilson and Otuski (2004) used fixed effects model with importing countries. On the other hand, Anders and Caswell (2008) adopted random effects method. These authors argued that since the fixed effects model drops out all time-invariant variables, including distance between countries, it is inappropriate to examine bilateral trade relationship. However, Baier and Bergstrand (2007) pointed out that, using random effects, one needs to assume no correlation between gravity equation error term and policy which is less plausible.

This paper looks at the impacts of stricter food safety measures placed in the EU, Japan and US markets on export performance of seafood exporting countries. The paper differs from the others in the following ways: First, unlike Anders and Caswell (2008) examining trade effects in the US seafood market, I investigate simultaneously three major markets, the EU, Japan and US. Second, while previous studies focus on the effects of technical barriers on aggregate seafood, this paper also analyzes a disaggregated data set to assess the impacts on different types of seafood. This approach is motivated by the hypothesis that the stringency of food safety regulations may have differential effects on products. Third, we analyze differential effects of standards on seafood trade in terms of different time periods of policy enforcement. Finally, following Anderson and van Wincoop (2003) and Baier and Bergstrand (2007), which are described below, this paper uses the gravity model with bilateral pair and country-by-time fixed effects to control for omitted variables and endogeneity of policy variables. This model has not been estimated in Otsuki, Wilson, and Sewadeh (2001a, b), Wilson and Otsuki (2004) nor Anders and Caswell (2008). The model is specified below:

$$(4)\ \ln\left[\frac{X_{ijt}}{GDP_{it}GDP_{jt}}\right]=\alpha_{ij}+\alpha_{it}+\alpha_{jt}+\alpha_0+\alpha_1 NAFTA_{ijt}+\alpha_2 EU_{ijt}+\alpha_3 FOODSTD_{ijt}+\varepsilon_{ijt}$$

where α_{ij} is bilateral country pair fixed effect, α_{it} and α_{jt} are country-by-time fixed effects, which represent explicitly the multiple price terms. All other variable are defined in equation (1).

IV. MODEL SPECIFICATION AND DATA

4.1 Model Specification

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

Traditional gravity model with no panels and country or time fixed effects:

$$\begin{aligned}\ln X_{ijt} = {} & \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_3 \ln DIST_{ij} \\ & + \alpha_4 CONTIG_{ij} + \alpha_5 COLONY_{ij} + \alpha_6 LANG_{ij} + \alpha_7 NAFTA_{ijt} \\ & + \alpha_8 EU_{ijt} + \alpha_9 USHACCP_{ijt} + \alpha_{10} NON\_USHACCP_{ijt} \\ & + \alpha_{11} EUMRPL_{ijt} + \alpha_{12} NON\_EUMRPL_{ijt} + \alpha_{13} JPLAW_{ijt} \\ & + \varepsilon_{ijt}\end{aligned} \tag{5.1}$$

Gravity model with panels and time fixed effect:

$$\begin{aligned}\ln X_{ijt} = {} & \alpha_t + \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_3 \ln DIST_{ij} \\ & + \alpha_4 CONTIG_{ij} + \alpha_5 COLONY_{ij} + \alpha_6 LANG_{ij} + \alpha_7 NAFTA_{ijt} \\ & + \alpha_8 EU_{ijt} + \alpha_9 USHACCP_{ijt} + \alpha_{10} NON\_USHACCP_{ijt} \\ & + \alpha_{11} EUMRPL_{ijt} + \alpha_{12} NON\_EUMRPL_{ijt} + \alpha_{13} JPLAW_{ijt} \\ & + \varepsilon_{ijt}\end{aligned} \tag{5.2}$$

Gravity model with panels and time and bilateral pair fixed effects:

$$
\begin{aligned}
\ln X_{ijt} &= \alpha_t + \alpha_{ij} + \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_7 NAFTA_{ijt} \\
&+ \alpha_8 EU_{ijt} + \alpha_9 USHACCP_{ijt} + \alpha_{10} NON\_USHACCP_{ijt} \\
&+ \alpha_{11} EUMRPL_{ijt} + \alpha_{12} NON\_EUMRPL_{ijt} + \alpha_{13} JPLAW_{ijt} \\
&+ \varepsilon_{ijt}
\end{aligned}
\tag{5.3}
$$

where $X_{ijt,}$ $GDP_{it,}$ $GDP_{jt,}$ $DIST_{ij,}$ $CONTIG_{ij}$, $COLONY_{ij}$, $LANG_{ij}$, $NAFTA_{ijt}$ and EU_{ijt} are as defined in equation (1); α_t stands for time fixed effect, α_{ij} denotes bilateral pair fixed effects for data from 1992 to 2005. The remaining variables are dummies with six categories: NON_USHACC_{ijt} represents non-imposition of HACCP on seafood in the US, equals 1 if the importer is US and trade occurs from 1992 to 1997, and 0 otherwise. $USHACCP_{ijt}$ represents the US imposition of HACCP, taking the value of 1 if the US is the importer and trade occurs from 1998 to 2005 and 0, otherwise. $NON\_EUMRPL_{ij\mathrm{t}}$ denotes non-implementation of MRPL in the EU, takes the value of 1 if the EU is the importer and trade occurs from 1992 until 2001, and 0 otherwise. $EUMRPL_{ij\mathrm{t}}$ is a dummy representing the EU implementation of MPRPs, and it equals 1 if the EU is the importer and trade occurs from 2002 to 2005 and 0 otherwise. $NON\_JPLAW_{ij\mathrm{t}}$ stands for non-enforcement of food safety laws in Japan, and it takes the value of 1 if Japan is the importer and trade occurs from 1992 until 2003 and 0 otherwise (this dummy does not appear in the above demonstrated equations because it is chosen as the base). $JPLAW_{ij\mathrm{t}}$ stands for food safety law enforcement in Japan, takes value of 1 if Japan is the importer and trade occurs from 2004 to 2005 and 0 otherwise.

Then, I use the theory-motivated gravity equation suggested by Anderson and van Wincoop (2003) and Baier and Bergstrand (2007) to test for three hypotheses: i) more stringent food safety regulations in the EU, Japan and US markets have negative effects on world exports of seafood; ii) emerging standards have differential effects on different categories of seafood; and iii) effects of standards are greater in the longer time period of enforcement.

To test hypotheses i) and ii), I estimate equation (6) below with data of aggregate seafood exports. To test hypothesis iii), I estimate equation (7) below. Equation (7) is an extension of Baier and Bergstrand (2007) in that I add product-by-time fixed effect to equation (6). Since I estimate a pooled data set with differentiated products, the additional product-by-time fixed effect accounts for all potential time-varying heterogeneity between products.

Theoretically consistent model with bilateral pair and country-by-time fixed effects:

$$\begin{aligned} \ln\left[\frac{X_{ijt}}{GDP_{it}GDP_{jt}}\right] &= \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_0 + \alpha_1 USHACCP_{ijt} + \alpha_2 NON\_USHACCP_{ijt} \\ &+ \alpha_3 EUMRPL_{ijt} + \alpha_4 NON\_EUMRPL_{ijt} + \alpha_5 JPLAW_{ijt} \\ &+ \alpha_6 NAFTA_{ijt} + \alpha_7 EU_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{6}$$

Theoretically consistent model with bilateral pair, country-by-time and product-by-time fixed effects:

$$\begin{aligned} \ln\left[\frac{X_{ijt}}{GDP_{it}GDP_{jt}}\right] &= \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_{pt} + \alpha_0 + \alpha_1 USHACCP_{ijt} \\ &+ \alpha_2 NON\_USHACCP_{ijt} \\ &+ \alpha_3 EUMRPL_{ijt} + \alpha_4 NON\_EUMRPL_{ijt} \\ &+ \alpha_5 JPLAW_{ijt} + \alpha_6 NAFTA_{ijt} + \alpha_7 EU_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{7}$$

where α_{ij} is bilateral country pair fixed effect, α_{it} and α_{jt} are country-by-time fixed effects, which represent explicitly the multiple price terms; α_{pt} denotes product-by-time fixed effect. Further, in equation (6) and (7), I scale the left hand side (LHS) variable by product of GDPs, and impose unitary coefficients on GDP_i and GDP_j variable as suggested by theory.

4.2 Estimating Method

As discussed previously, equations (5.1) - (5.3) are estimated for the purpose of comparison, and for supporting claim that coefficients obtained from these equations are biased. The major specification forms of this paper are equation (6) and equation (7). Along with other gravity variables, each equation consists of six dummies representing different groups of standard imposition: USHACCP, NON_USHACCP, EUMRPL, NON_EUMRPL, JPLAW, and NON_JPLAW.

Among various econometric methods to obtain unbiased coefficients on the food safety variables, in this paper, I adapt the method suggested by Wooldridge (2002). I drop one dummy when running the regression to avoid the dummy variable trap. Thus, the dropped variable becomes the base and its estimate is represented by the intercept. The estimated coefficients on the remaining food safety variables measure the proportionate difference in trade flow relative to the base. Therefore, specifying which binary variable as the base is crucial to obtain coefficients on the variables of interest. For example, to estimate equation (6), I first choose NON_USHACCP as the base and drop it out of the model. I run a regression with remaining five dummies on food safety standards, along with other independent variables as in equation (6.1):

$$\begin{aligned}\ln\left[\frac{X_{ijt}}{GDP_{it}GDP_{jt}}\right] = {} & \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_0 + \alpha_1 USHACCP_{ijt} + \alpha_2 EUMRPL_{ijt} \\ & + \alpha_3 NON\_EUMRPL_{ijt} + \alpha_4 JPLAW_{ijt} + \alpha_5 NON\_JPLAW \\ & + \alpha_6 NAFTA_{ijt} + \alpha_7 EU_{ijt} + \varepsilon_{ijt}\end{aligned} \tag{6.1}$$

From this regression, I obtain coefficient on USHACCP and its corresponding t-statistic. The coefficient on USHACCP, after converting to elasticities, shows the proportionate change in trade flow of seafood into the US under HACCP, relative to trade flow when HACCP was not imposed. Similarly, the difference between coefficients on EUMRPL and NON_EUMRPL is associated with the difference in trade flow into the EU before and after MRPL implementation. However, from equation (6.1), I cannot test whether this difference is statistically significant. Wooldridge (2002) suggested that one can select another binary variable as a base and reestimate the equation. The author explained that, by doing so, one can obtain the needed coefficient and its standard error directly without changing other estimates. Following Wooldridge (2002), I chose another dummy variable, NON_EUMRPL, to be the new base, and re-ran the model with specification as in equation (6.2):

$$\begin{aligned}\ln\left[\frac{X_{ijt}}{GDP_{it}GDP_{jt}}\right] = {} & \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_0 + \alpha_1 USHACCP_{ijt} + \alpha_2 NON\_USHACCP_{ijt} \\ & + \alpha_3 EUMRPL_{ijt} + \alpha_4 JPLAW_{ijt} + \alpha_5 NON\_JPLAW \\ & + \alpha_6 NAFTA_{ijt} + \alpha_7 EU_{ijt} + \varepsilon_{ijt}\end{aligned} \tag{6.2}$$

From this equation, I directly obtain the estimate and corresponding t-statistics for the EUMRPL variable. Similarly, I then specify NON_JPLAW as the base, and continue to run equation (6.3):

$$
\begin{aligned}
(6.3)\qquad \ln\left[\frac{X_{ijt}}{GDP_{it}GDP_{jt}}\right] &= \alpha_{ij} + \alpha_{it} + \alpha_{jt} + \alpha_0 + \alpha_1 USHACCP_{ijt} + \alpha_2 NON\_USHACCP_{ijt} \\
&+ \alpha_3 EUMRPL_{ijt} + \alpha_4 NON\_EUMRPL_{ijt} + \alpha_5 JPLAW_{ijt} \\
&+ \alpha_6 NAFTA_{ijt} + \alpha_7 EU_{ijt} + \varepsilon_{ijt}
\end{aligned}
$$

Regression on equation (6.3) produces the coefficient and t-statistics for JPLAW variable.

Generally, to estimate the average effect of changing food safety standards on seafood trade from equation (6), I regress that equation three times. Each time is specified with one of following binary variables as a base: NON_USHACCP, NON_EUMRPL, and NON_JPLAW. By doing so, I obtain the estimated coefficients and standard errors on three key variable: USHACCP, EUMRPL, and JPLAW. The magnitude and significance of the variables other than food safety variables do not change across three regressions.

4.3 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.

The first data set (data on aggregated seafood) includes 57 exporting countries and 17 importing countries (Japan, US and EU 15). The second data set (data on different seafood product) 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, including Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Greece, Portugal, Spain, Sweden, and United Kingdom. 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).

Descriptive statistics of the study variables are presented in Table 1. 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, about 3 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.

V. RESULTS

5.1 Coefficient Estimates by Classical Gravity Equations

Table 2 presents the estimated results for three model specifications with aggregated data on seafood. Model 1 reports estimates of equation (5.1), which is a classical gravity model with no time or bilateral pair fixed effects. Model 2 shows the results of equation (5.2) with time fixed effect. Model 3 presents coefficients estimated from equation (5.3) with time and bilateral pair fixed effects.

In Model 1, column 1, 2, 3 show coefficient estimates when regressing equation (5.1) with NON_USHACCP, NON_EUMRPL, and NON_JPLAW as the base. The results indicate that classical gravity variables such as the GDPs of importing and exporting countries, distance, continuity, and colonial ties are statistically significant. Signs and magnitudes of these variables are as expected in the traditional gravity literature, except for common language. The coefficient on common language is statistically significant, but the sign is unexpected. Two variables presenting regional trade agreements in Model 1, NAFTA and EU, significantly and positively contribute to bilateral trade flow of seafood between members.

Three binary variables representing the average effect of enhanced food safety regulations indicate mixed impacts on seafood exports. The USHACCP variable (column 1) has a negative sign, but is statistically insignificant. Similarly, the EUMRPL variable (column 2) is positive but statistically insignificant. This result implies that the application of HACCP in the US and MRPL in the EU do not significantly affect seafood imports into the countries over the study period, holding everything else constant. The only variable with the expected negative sign and statistical significance at the 10% level is JPLAW (column 3). Over the study period, the enforcement of food safety laws in Japan is associated with an average of 36.9% {(exp(-0.46)-1)*100= -36.9%} reduction in annual seafood imports value into Japan, compared to seafood import before enactment of new laws.

Overall, the classical panel gravity equation in the Model 1 is statistically significant with F-statistics equals 194.60. However, the prediction power of Model 1 is lower than that frequently found in the literature (R^2 is 0.25). As previously discussed in the literature review section, a panel gravity model with no time or country pair fixed effect is not appropriate to estimate the effects of food safety policies. The reason is that this model is misspecified due to its omission of multiple price terms. Additionally, this model still suffers from endogeneity problem caused by unobserved heterogeneity between country pairs. Consequently, the estimates of coefficients are biased and inconsistent, therefore, unreliable.

In the time fixed effects model (Model 2, column 4, 5 and 6), I obtain very similar results to those in Model 1 for the classical gravity variables such as, GDPs, distance, continuity, colonial ties, and language. The model's predicting power is the same as Model 1 with a R^2 of 0.25. However, the coefficient on JPLAW (column 6) is no longer statistically significant, though still negative, as it was in Model 1. Consequently, results in Model 2 show that no food safety variables significantly affect seafood trade in three study markets, EU, US, and Japan.

Consistent with theoretical and empirical findings of other authors (Baier and Bergstrand, 2007 and Grant and Lambert, 2008), these results suggest that the time fixed effects model does not correct the omitted variable and endogeneity problem in the first model. This outcome is understandable, given that the panel data set only covers a short time period (1992-2005), relative to the large involvement of bilateral country pairs (57 exporting and 17 importing countries). Therefore, the heterogeneity between country pairs has not been fixed. Estimates of coefficients in Model 2 are, therefore, unreliable.

For the purpose of comparison, Model 3 (column 7, 8, and 9) with time and country pair fixed effects is estimated. Because the unobserved time-invariant bilateral factors between country pairs have been controlled, I drop other variables representing time-invariant bilateral characteristics such as language, contiguity, and distance. After fixing time and bilateral pair effects, the R^2 has improved from 0.25 in Model 1 and 2 to 0.87 in Model 3, which is typically found in the previous studies.

In Model 3, the effect of importing country GDP on bilateral trade flows of seafood decreased, as indicated by the decrease in coefficient magnitude from 0.85 in Model 1, 2 to 0.39 in Model 3. In contrast, the effect of exporting country GDP does not change much compared to that found in Model 1 and 2. The behavior of the two dummy variables capturing the average effect of regional trade agreement (NAFTA and EU) has also changed sharply. Specifically, the NAFTA variable no longer significantly affects seafood trade between two members. The EU variable is still significant but with an increased magnitude compared to that estimated in Model 1 and 2.

Regarding the key variables of this paper, which indicate the stringency of food safety regulations, these estimates also change compared to those in Model 1 and 2. The USHACCP variable (column 7) is positive and statistically insignificant. The EUMRPL (column 8) turns out to be positive and significant, which is unexpected for trade impact of a food safety measure. In addition, JPLAW has the same pattern regarding sign, magnitude, and significance as Model 1, but the opposite to that in Model 2.

These changes indicate instability of regression coefficients estimated by the first three model specifications. The common weakness of these three models is that they ignore the multiple price terms and do not address the endogeneity of variables representing food safety standards. As Baier and Bergstrand (2007) have pointed out, although Model 3 controls for unobserved time-invariant heterogeneity between bilateral pairs, it does not help obtain unbiased estimates of policy variables if other unobserved time-varying heterogeneity still exists in the panel data.

5.2 The Effect of Stricter Food Safety Standards on International Seafood Trade

In this section, I will estimate equation (6), using data on aggregated seafood (SITC REV.3 code 03), to determine trade effects of emerging technical barriers in developed country markets. As discussed section 4.1, since the classical gravity equation was not grounded on a theoretical foundation, its coefficient estimates are biased and inconsistent. However, the endogeneity and omitted variable problem faced by the traditional gravity equation is accounted for by equation (6). Following Anderson and van Wincoop (2003), I impose a unity restriction on GDP coefficients, and following Baier and Bergstrand (2007), I use country by time fixed effects. Estimates of this theoretically consistent model are reported in Table 3 (Model 4). The corresponding elasticities are calculated and presented in column 1 and 2 of Table 5.

Table 3 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 1,024.6% increase in annual seafood export value, relative to non-members. Conversely, membership in NAFTA is estimated to have a statistically significant negative effect on trade in seafood of country members. Thus, I can infer that trade in seafood products among countries in the EU 15 is substantial.

Moreover, the negative effect of NAFTA on members' seafood trade may be explained by the shift of seafood exports to the US from NAFTA countries to other countries. For example, Adams, Keithly, and Versaggi (2005) state that twenty years ago, Mexico, Central America, and Northern South America were the leading exporters of shrimp to the US market. However, now the US shrimp market is dominated by exports from Asia and Indonesia, with two-thirds of shrimp imported by the US from several countries in the world, not only the NAFTA countries. This diversion in imported shrimp to the US may be reflected partly in the negative effect of the NAFTA variable.

Turning to seafood safety variables, Table 3 shows that HACCP (column 1), EUMRPL (column 2), and JPLAW (column 3) 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. From the regression coefficients in Table 3, I calculate the partial elasticities with respect to each standard, using the method for interpreting dummy variables in semi-logarithmic equations proposed by Halvorsen and Palmquist (1980). Elasticities estimated both in percentage and by level value at the mean are reported in Table 5. The largest trade elasticity is for the amendment of Food Sanitation Law and enactment of Food Safety Basic Law in Japan. Under these laws, average annual export value of seafood to Japan is estimated to reduce by 79.6%, equivalent to $41.9 million, relative to seafood export to Japan before the law revision. Trade elasticities associated with HACCP imposition in the US was 58.9% or $31.0 million reduction in bilateral seafood trade. Enforcement of MRPLs in EU on average, results in 57.7% or $30.4 million reduction in bilateral seafood trade.

It is worth noting that, in Model 1, 2, 3, while USHACCP and EUMRPL variables are insignificant or even positive, JPLAW is the only one that has a significant negative impact on trade in two out of three estimated models. Compared with the JPLAW elasticity of -36.9% obtained in Model 1, 3, the JPLAW elasticity of -79.6% in the theoretically-consistent model (Model 4) is doubled. Compared with findings in Baier and Bergstrand (2007) and Grant and Lambert (2008), the trade effect of policy variables is doubled, or even tripled when using country-by-time fixed effect model, relative to the traditional gravity model. Anders and Caswell (2008) also estimated the HACCP elasticity of -45% using random effects. (As noted previously, this elasticity is calculated from the regression coefficient reported in Anders and Caswell (2008), based on the method suggested by Halvorsen and Palmquist (1980).

From this analysis, strengthened food safety policies have substantial effects on 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 Japan regulations.

5.3 Differential Effects of Stricter Standards on Seafood Products

Differences in technical standards imposed on various commodities suggest that food safety regulations may have different effects across traded seafood products. To test this hypothesis, I conduct Chow tests for the following three hypotheses for the Model (4): i) beta coefficients of fresh fish equal beta coefficients of dried fish; ii) beta coefficients of fresh fish equal beta coefficients of crustacean and mollusks; and iii) beta coefficients of dried fish equal beta coefficients of crustacean and mollusks. F-statistics of the three Chow tests are reported in Table 4. The Chow test results confirm that equal beta coefficients for fresh fish, dried fish, and crustacean and mollusk are rejected. Therefore I conduct separated regressions of fresh fish, dried fish, and crustacean and mollusks to test for the second hypothesis that seafood products are affected differently by food safety regulations. To do so, I use data set 2 and estimate the country pair and country-by-time fixed effect model (Model 4) separately for each product. Estimated coefficients are reported in Table 4, and their corresponding elasticities are calculated in Table 5.

Results in column 1, 2 and 3 of Table 4 show that fresh fish (fresh, chilled and frozen fish, code 034) is hurt the most by the stringency of food safety standards in all of three major markets. Although three standard variables are statistically significant and negative, JPLAW has the largest negative coefficient (-2.42), followed by USHACCP (-1.67) and EUMRPL (-1.26). In term of elasticity (Table 5), JPLAW is estimated to be associated with a 91.1% reduction in bilateral annual trade value of fresh fish into Japan, relative to that when the policies were not implemented. In term of value, this is equivalent to a decline of $25.2 million. Annual fresh fish export to the US follows by a decline of 81.2%, or $22.5 million, in the presence of HACCP, all else equal. Finally, average annual fresh fish export to a country in the EU is reduced by 71.6%, or $19.8 million, compared to that before the imposition of 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 border (56.3%), followed by prepared seafood (23.6%) and processed seafood (10.1%) at the EU border from 1999-2002 (FAO, 2005). Additionally, these finding are not surprising for Japan, given that in Japan, a considerable amount of fresh fish is eaten raw, therefore is associated with higher hazards.

For dried fish (dried, salted, and smoked fish, code 035), regression coefficients are presented in column 4, 5, 6 of Table 4, and their elasticities are reported in Table 5. All of three food standard variables are positive, but statistically insignificant. This implies that tighter technical barriers imposed in the US, EU and Japan markets do not hurt export of these processed fish to these markets.

The fact that stricter food control 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" (Huss, Ababouch and Gram, 2004, p. 162). Second, most of types and species that are subject to drying, salting, and smoking processes come from developed countries. For example, the latest data statistics of the nationMaster.com show that, among the top ten exporters of dried, salted, and smoked fish, eight are developed countries, only two (China and Vietnam) 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. According to the authors, growth of pathogens is impossible in these products if processing techniques, such as drying, salting or smoking are conducted correctly. These reasons help explain why dried fish trade is not impeded by food regulatory standards.

Turning to the effects of standards on the remaining product category, crustacean and mollusk (code 036), USHACCP and EUMRLP are not statistically significant, while JPLAW is statistically significant and negative. Everything else constant, bilateral annual export value of crustacean and mollusk to Japan experiences an average loss of 73.3% relative to that before law enforcement. Again, this finding confirms that Japanese food regulatory measure is the most stringent among the three policies considered. Although it is surprising that the US and the EU regulations do not inhibit trade in crustacean and mollusk, it cannot be explained further, given the level of aggregation of the data. 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 environment. The trade effects on this product category are insignificant because of the potentially different trade effects on each product included in this category.

In general, given that a large majority of dried fish comes from developed countries, differential effects on fresh and dried fish imply that developing countries are hurt more by standards, relative to developed countries. The losses are even more significant when seafood exports represent a large share in total exports from developing countries. From other aspects, analyzing trade effects at the product level confirms that the Japanese standard is the most stringent and restrictive in three markets, although it has the shortest time of existence.

5.4 The Effects of Standards in the Long-run versus Short-run Period

In this section, I will test the third hypothesis that trade effects of food safety standards differ over time. The economic motivation of this hypothesis is that after a policy comes into force, it may have a cumulative effect on trade as time unfolds (Baier and Bergstrand, 2007). Given the period of study in this thesis (1992-2005), only the US HACCP has an implementation period of eight years, which is long enough to consider cumulative effects. Other standards have shorter periods of enforcement, with four years for the EUMRPLs and only two years for the Japanese laws. Thus, in this section, I only compare trade effects of the US policy, HACCP, in the short-run versus long run. Period 1992-2000 is considered short-run with three years of HACCP imposition, and full period 1992-2005 is considered long-run with eight years of HACCP enforcement. Since I run regressions on the pooled data which includes three different products, I modified Model 6 by adding product and time fixed effect (Model 7). This additional fixed effect helps capture all potential time-varying heterogeneity between products. With this modification, this work is still consistent with previous studies although previous studies only dealt with one product in one regression model. For example, Anderson and van Wincoop (2003) and Baier and Bergstrand (2007) investigated aggregate trade flows, Grant and Lambert (2008) examined aggregate agriculture or non-agricultural product, and Ander and Caswell (2008) examined aggregate seafood trade.

Results on the differential trade effects of the US HACCP overtime is shown in Table 6. Although US HACCP is consistently associated with a significant negative effect on seafood trade, the long-run effect is observed to be greater than the short-run effect. In the long-run (1992-2005), world export of seafood to the US is estimated to reduce by average 60.1%, or $14.0 million, annually, under the presence of the US HACCP. However, in the short-run (1992-2005), HACCP has a less negative effect, with an average reduction of 44.7% of annual seafood export value, equivalent to $10.1 million.

This finding is opposite to what was found in Ander and Caswell (2008) in that they estimated a greater negative effect of the US HACCP in the short-run versus long-run. Their explanation is 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, Ander and Caswell (2008) found no significant difference between long-run and short-run effect of HACCP. The difference between the finding of Ander and Caswell (2008) and finding of this paper may come from difference in econometric model specification. As discussed in literature review section, Ander and Caswell (2008) estimated a random effects model, which assumes zero correlation between HACCP and the gravity equation error terms. According to Baier and Bergstrand (2007), the assumption of zero correlation is not plausible. Also, Ander and Caswell (2008) did not control for the multiple price terms as suggested by theory, which is addressed in this paper.

Additionally, the findings in this paper are consistent with Baier and Bergstrand (2007) and Grant and Lambert (2008) in terms of the magnitude of policy variable over time. These authors found larger positive effects of the FTA variable over time. They showed that because FTAs usually need transitional period for trade liberalization, their full effects can be realized in the longer term. In line with this reasoning, I would argue that since HACCP is a process, not a final product testing procedure, it requires exporters to enhance their entire safety systems to comply. Also, additional costs associated with re-processing, labeling, and testing products which are rejected at the US border under HACCP requirements are significant. Many of rejection/detention cases are destroyed or not allowed for re-exports. Further, some persistent health problems in some products at some areas are hard to fix, given a limited resource of exporters. These reasons effectively reduce market assess to seafood exporters. Thus, in the long-run, when they have flexibility to adjust, exporters may choose to cut back production or withdraw from the market.

VI. CONCLUSION

This paper examines the impacts of increased food safety standards in the EU, US, and Japan on the world's seafood export performance to these markets. Effects of seafood safety policies such as the US implementation of HACCP in 1997, the EU introduction of MRPLs in 2002, and enactment of the Food Sanitation Law, Food Safety Basic Law in Japan in 2003 are captured by dummy variables. The paper uses panel data in a gravity model with bilateral pairs and country-by-time fixed effects. This is a theory-grounded model developed by Anderson and van Wincoop (2003) and Baier and Bergstrand (2007) to control for omitted variables and endogeneity of food safety policies. For the purpose of comparison, the paper also estimates other gravity model specifications for a panel data (the model with no time and country pair fixed effects, the model with time fixed effects, and the model with time and country pair fixed effects).

The findings suggest that changing food safety regulations in the developed markets (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. For instance, the imposition of the US HACCP system resulted in an average 58.9 % of annual loss, or \$31.0 million, of bilateral seafood import value o the US, compared to that before HACCP implementation, *ceteris paribus*. Over the same period, an average annual loss of seafood trade due to the EU implementation of the MRPL was 57.7% (\$30.4 million), while a decline of 79.6% ($41.9 million) was caused by the Japanese laws. Estimating the panel gravity model with bilateral pair and country-by-time fixed effects separately for each seafood product, I found that food safety regulations had differential effects across seafood products. The enforcement of the Japanese laws, the US HACCP, the EU MRPL caused a respective loss of 91.1%, 81.2%, and 71.6% to fresh fish trade to these markets, and a reduction of Japanese imports of crustacean and mollusks by 73.3%.

In all three industrialized markets, fresh fish is the most sensitive, while dried fish is not sensitive to the change of food safety policies. With a large majority of dried fish coming from developed countries, this finding suggests that richer countries are not hurt by tighter technical barriers as poorer countries are. Differences in financial and technical resources lead to differences in compliance capacity between countries, which, in turns, results in losses to the poorer nations and gain to the richer nations. The loss of market share becomes more significant to developing world because fish and fishery exports account for a large proportion in total agricultural exports of those countries. From another perspective, differential trade effects across seafood products illustrate different stringency levels between country policies. The Japanese standards are obviously the strictest in all three study markets, suggesting a high cost incurred by Japanese trading partners.

Considering the effects of emerging technical standards on seafood trade in terms of time period, I found that standards had increasing cumulative effects over time. For instance, in the long-run, the trade elasticity with respect to HACCP implementation is -60.1%, while the elasticity in the short run is -44.7%. Since compliance with food safety regulations is costly, affected countries faced increasing costs overtime. Given that those hurt the most by standards are developing countries, over time, they may choose to cut back production or ultimately, withdraw from the market.

In addition, the findings are consistent with those of previous studies in that, addressing omitted variable problem and endogeneity of trade policy variables is important to obtain unbiased coefficient estimates. As the results suggest, failing to address the endogeneity of policy variables will lead to underestimating the impacts of policy variables on trade.

Finally, an alternative for this paper may be a model with only one food safety variable, which is the combination of three policies, the US HACCP, the EU MRPLs, and Japanese laws. Using this variable, I will be able to look at the phase-in effects of food safety standards by conducting the lags, which may be econometrically more reasonable than the separation of long-run and short-run. Moreover, from a cursory review of the data, more products come from the least developed countries for fresh fish relative to dried fish. It will be interesting to analyze the differential effects of these policies on less developed countries. These improvements will be considered in the future research.

Table 1. Descriptive Statistics of Study Variables

Variable	N	Mean	Standard Deviation	Minimum	Maximum
Annual real export value, aggregated seafood ($)	7,532	52,643,811	166,373,793	157	2,580,000,000
Distance (km)	7,532	6,107.80	4,716.73	173.03	19,586.18
Real GDP IM ($1000)	7,532	1,699,338,100	2,553,765,300	50,900,000	11,000,000,000
Real GDP EX ($1000)	7,532	636,369,197	1,550,952,700	435,000	11,000,000,000
Annual real export value-items 034 ($)	6020	27,665,005	86,767,242	101	1,807,998,448
Annual real export value-items 035 ($)	2884	7,481,227	20,714,059	414	258,784,021
Annual real export value-items 036 ($)	4564	27,666,366	83,915,503	212	973,611,053
Annual real export value-combined 034-036 ($)	13468	23,343,368	76,884,523	101	1,807,998,448

Table 2. Estimation Results of Classical Gravity Models

	Model 1			Model 2			Model 3		
	1	2	3	4	5	6	7	8	9
ln$DIST_{ij}$	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***	-0.20***			
	(-5.84)	(-5.84)	(-5.84)	(-5.84)	(-5.84)	(-5.84)			
lnGDP_{jt}	0.85***	0.85***	0.85***	0.85***	0.85***	0.85***	0.39***	0.39***	0.39***
	(31.68)	(31.68)	(31.68)	(31.51)	(31.51)	(31.51)	(4.46)	(4.46)	(4.46)
lnGDP_{it}	0.21***	0.21***	0.21***	0.21***	0.21***	0.21***	0.22***	0.22***	0.22***
	(13.23)	(13.23)	(13.23)	(13.18)	(13.18)	(13.18)	(7.16)	(7.16)	(7.16)
$USHACCP_{ijt}$	-0.07	-0.79***	-1.25***	-0.06	-0.76***	-1.24***	0.04	3.35***	1.43***
	(-0.39)	(-5.22)	(-7.95)	(-0.31)	(-4.33)	(-7.29)	(0.46)	(7.95)	(4.01)
$NON\text{-}USHACCP_{ijt}$	-	-0.72***	-1.18***	-	-0.70***	-1.18***	-	3.31***	1.39***
	-	(-4.46)	(-6.96)	-	(-4.25)	(-6.73)	-	(7.94)	(3.90)
$EUMRPL_{ijt}$	0.79***	0.07	-0.39***	0.85***	0.15	-0.33	-3.16***	0.16**	-1.77***
	(4.83)	(1.18)	(-2.99)	(3.44)	(0.79)	(-1.66)	(-7.49)	(2.00)	(-4.76)
$NON\text{-}EUMRPL_{ijt}$	0.72***	-	-0.46***	0.70***	-	-0.48***	-3.31***	-	-1.92***
	(4.46)	-	(-3.67)	(4.25)	-	(-3.72)	(-7.94)	-	(-5.22)
$JPLAW_{ijt}$	0.72***	0.00***	-0.46*	0.76**	0.06	-0.42	2.63***	5.95***	-0.43***
	(2.61)	(0.01)	(-1.76)	(2.24)	(0.19)	(-1.35)	(5.61)	(14.11)	(-3.37)
$NON\text{-}JPLAW_{ijt}$	1.18***	0.46***	-	1.18***	0.48***	-	3.07***	6.38***	-
	(6.96)	(3.67)	-	(6.73)	(3.72)	-	(6.76)	(15.65)	-

Notes: Each model is estimated with NON_USHACCP, NON_EUMRPL_{ijt}, and NON_JPLAW_{ijt} as the base, respectively; numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.

Table 2. Estimation Results of Classical Gravity Models (Continued)

Variable	Model 1			Model 2			Model 3		
	1	2	3	4	5	6	7	8	9
$CONTIG_{ij}$	0.48***	0.48***	0.48***	0.48***	0.48***	0.48***			
	3.80	(3.80)	(3.80)	(3.80)	(3.80)	(3.80)			
$COLONY_{ij}$	1.24***	1.24***	1.24***	1.24***	1.24***	1.24***			
	10.60	(10.60)	(10.60)	(10.60)	(10.60)	(10.60)			
$LANG_{ij}$	-0.50***	-0.50***	-0.50***	-0.50***	-0.50***	-0.50***			
	-4.50	(-4.50)	(-4.50)	(-4.50)	(-4.50)	(-4.50)			
$NAFTA_{ijt}$	3.38***	3.38***	3.38***	3.38***	3.38***	3.38***	0.15	0.15	0.15
	7.27	(7.27)	(7.27)	(7.27)	(7.27)	(7.27)	(0.25)	0.25	(0.25)
EU_{ijt}	1.00***	1.00***	1.00***	1.00***	1.00***	1.00***	1.85***	1.85***	1.85***
	12.32	(12.32)	(12.32)	(12.22)	(12.22)	(12.22)	(24.85)	24.85	(24.85)
CONSTANT	-17.29***	-16.57***	-16.11***	-17.18***	-16.52***	-16.00***	-4.60	-7.98***	-5.99**
	-17.64	(-18.37)	(-16.68)	(-17.23)	(-18.20)	(-16.33)	(-1.63)	-3.12	(-2.14)
R^2	0.25	0.25	0.25	0.25	0.25	0.25	0.88		
F statistics	194.60	194.60	194.60	97.35	97.35	97.35	96.82		
N	7532	7532	7532	7532	7532	7532	7532		

Notes: Each model is estimated with NON_USHACP_{ijt}, NON_EUMRPL_{ijt}, and NON_JPLAW_{ijt} as the base, respectively; Numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.

Table 3. Estimation Results of the Model 4 for Aggregated Seafood

	Model 4		
Variable	(1)NON-USHACP as the base	(2)NON-EUMRPL as the base	(3)NON-JPLAW as the base
$\ln GDP_i$	1.00^{+}	1.00^{+}	1.00^{+}
$\ln GDP_j$	1.00^{+}	1.00^{+}	1.00^{+}
$USHACCP_{ijt}$	-0.89**	-2.56***	-6.28***
	(-2.55)	(-5.77)	(-11.94)
$NON\text{-}USHACCP_{ijt}$	-	-1.67***	-5.39***
	-	(-5.29)	(-12.45)
$EUMRPL_{ijt}$	0.81**	-0.86***	-4.59***
	(1.96)	(-2.85)	(-11.20)
$NON\text{-}EUMRPL_{ijt}$	1.67***	-	-3.72***
	(5.29)	-	(-11.86)
$JPLAW_{ijt}$	3.81***	0.44	-1.59***
	(7.28)	0.99	(-4.53)
$NON\text{-}JPLAW_{ijt}$	5.39***	2.03***	-
	(12.45)	(6.41)	-
$NAFTA_{ijt}$	-2.14***	-2.14***	-2.14***
	(-3.42)	(-3.42)	(-3.42)
EU_{ijt}	2.42***	2.42***	2.42***
	(22.20)	(22.20)	(22.20)
CONSTANT	5.48***	7.15***	10.87
	(17.95)	(87.34)	35.65
R^2	0.94	0.94	0.94
F statistics	72.4	72.4	72.4
N	7532	7532	7532

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

$^{+}$Indicates values imposed by model construction (Baier and Bergstrand, 2007)

Table 4. Estimation Results of the Model 4 for Individual Seafood Product

Variable	Fresh Fish			Dried Fish			Crustacean and Mollusks		
	1	2	3	4	5	6	7	8	9
$USHACCP_{ijt}$	-1.67***	-0.19	-1.48**	0.43	6.24***	8.41***	-0.10	1.58***	-0.34
	(-4.25)	(-0.38)	(-2.55)	(0.78)	(3.03)	(3.94)	(-0.22)	(2.93)	(-0.56)
$NON\text{-}USHACCP_{ijt}$	-	1.48***	0.19	-	5.81***	7.98***	-	1.68***	-0.24
	-	(4.36)	(0.40)	-	(2.87)	(3.91)	-	(4.94)	(-0.53)
$EUMRPL_{ijt}$	-9.77***	-1.26***	-4.97***	-4.27***	1.54	3.71**	-1.87***	0.23	-1.69***
	(-10.04)	(-3.76)	(-11.12)	(-2.94)	(1.07)	(2.55)	(-3.80)	(0.57)	(-3.43)
$NON\text{-}EUMRPL_{ijt}$	-8.51***	-	-3.71***	-5.81***	-	2.17***	-2.10***	-	-1.92***
	(-9.16)	-	(-10.86)	(-2.87)	-	(4.51)	(-6.09)	-	(-5.57)
$JPLAW_{ijt}$	-7.23***	1.74***	-2.42***	-6.56***	-0.74	1.95	-0.57	-2.17***	-1.32***
	(-6.99)	(3.51)	(-6.12)	(-4.33)	(-0.49)	(1.33)	(-0.93)	(-3.97)	(-2.84)
$NON\text{-}JPLAW_{ijt}$	-4.81***	4.16***	-	-8.51***	-2.70***	-	0.76	-0.85**	-
	(-4.88)	(11.98)	-	(-4.17)	(-5.71)	-	(1.64)	(-2.47)	-
$NAFTA_{ijt}$	-1.05	-1.05	-1.05	-2.38	-2.38	-2.38	-1.92***	-1.92***	-1.92***
	(-1.23)	(-1.23)	(-1.23)	(-1.21)	(-1.21)	(-1.21)	(-2.75)	(-2.75)	(-2.75)
EU_{ijt}	3.11***	3.11***	3.11***	0.84***	0.84***	0.84***	2.64***	2.64***	2.64***
	(20.57)	(20.57)	(20.57)	(3.21)	(3.21)	(3.21)	(14.19)	(14.19)	(14.19)
CONSTANT	14.40***	5.89***	9.60***	14.13***	8.32***	6.15***	8.04***	5.94***	7.86***
	(15.57)	(61.44)	(28.89)	(7.06)	(29.48)	(15.83)	(24.63)	(48.96)	(24.08)
R^2	0.94			0.93			0.93		
F	57.61			34.06			42.63		
N	6020			2884			4564		
Chow test			H0: $\beta_{34} = \beta_{35}$:		H0: $\beta_{34}= \beta_{36}$			H0: $\beta_{35}= \beta_{36}$:	
		F[860,7184]=22.52***			F[1058, 8468]=12.42)***			F[860, 5728]=19.48***	

Notes: Each model is estimated with NON_USHACP_{ijt}, NON_EUMRPL_{ijt}, and NON_JPLAW_{ijt} as the base, respectively; Numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.

Table 5. Elasticities for Aggregated Seafood and Each Individual Product

Variable	Aggregated seafood		Fresh fish		Dried fish		Crustacean and mollusks	
	%	$mil.	%	$mil.	%	$mil.	%	$mil.
$USHACCP_{ijt}$	-58.91***	-31.01	-81.17***	-22.46	53.92	4.03	-9.55	-2.64
	(-2.55)		(-4.25)		(0.78)		(-0.22)	
$EUMRPL_{ijt}$	-57.77***	-30.41	-71.63***	-19.82	365.91	27.37	25.62	7.09
	(-2.85)		(-3.76)		(1.07)		(0.57)	
$JPLAW_{ijt}$	-79.55***	-41.88	-91.11***	-25.21	604.95	45.26	-73.34***	-20.29
	(-4.53)		(-6.12)		(1.33)		(-2.84)	
$NAFTA_{ijt}$	-88.26***	-46.46	-64.91	-17.96	-90.74	-6.79	-85.29***	-23.60
	(-3.42)		(-1.23)		(-1.21)		(-2.75)	
EU_{ijt}	1,021.58***	537.80	2,151.66***	595.26	130.54***	9.77	1,306.54***	361.47
	(22.2)		(20.57)		(3.21)		(14.19)	

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

Table 6. Estimation Results for Long-run and Short-run HACCP Effects

Variables	Long run (1992-2005)			Short run (1992-2000)		
	Coefficients	Elasticities		Coefficients	Elasticities	
		%	$		%	$
$USHACCP_{ijt}$	-0.92**	-60.07	-14.02	-0.59*	-44.74	-10.10
	(-1.97)			(-1.71)		
$EUMRPL_{ijt}$	-0.86***	-57.68	-13.47	-	-	-
	(-2.06)			-	-	-
$JPLAW_{ijt}$	-1.46***	-76.84	-17.94	-	-	-
	(-3.11)			-	-	-
$NAFTA_{ijt}$	-1.42*	-75.89	-17.71	-1.36	-74.26	-16.76
	(-1.77)			(-1.52)		
EU_{ijt}	2.44***	1041.93	243.22	1.88***	556.73	125.65
	(14.94)			(9.79)		
	2.44					
	(14.94)					
R2	0.80			0.79		
F statistics	34.20			27.97		
N	13,468			8,658		

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

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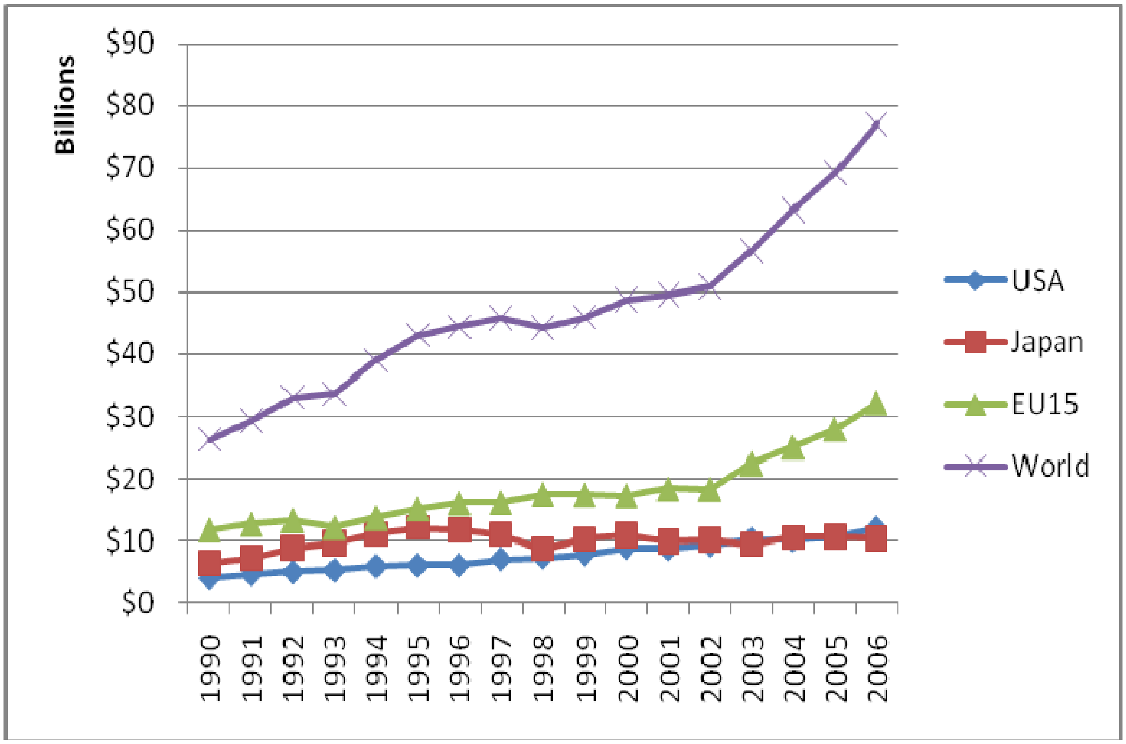
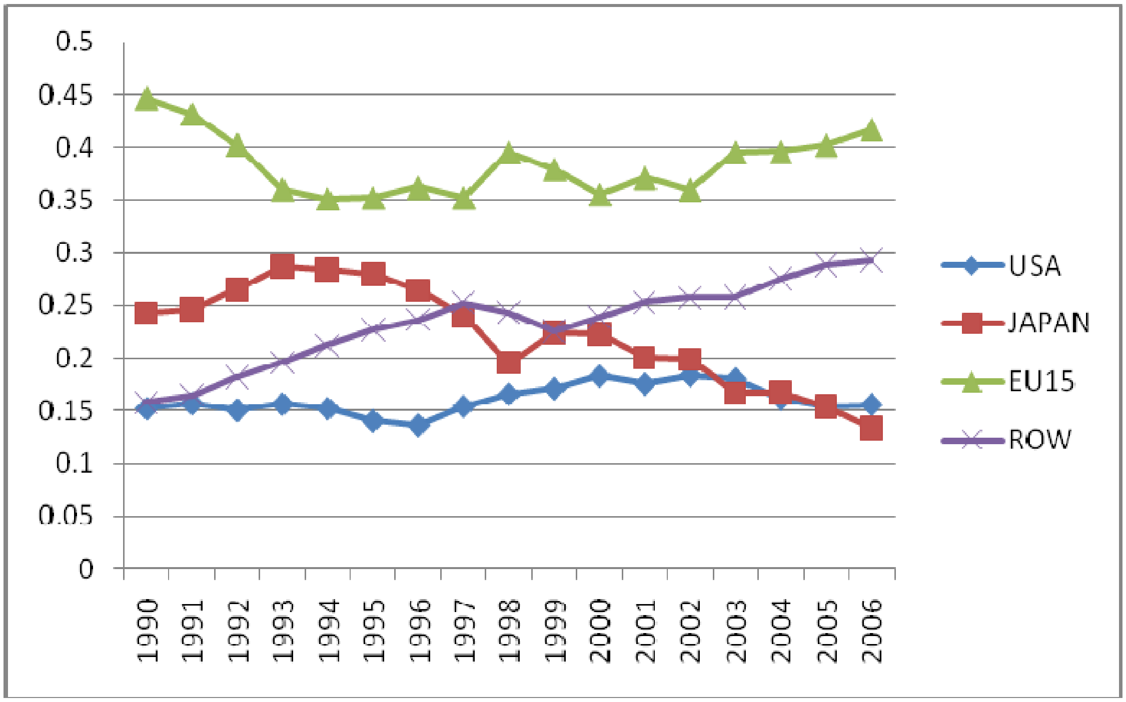
APPENDIX

Figure 1. Seafood Export to the US, Japan, EU15, and World Markets from 1990 to 2006



Source: UNCOMTRADE (SITC REV.3 product code 03)

Figure 2. Shares of World Seafood Export in the USA, JAPAN, EU15, and Rest of the World Markets (ROW) from 1990 to 2006



Source: UNCOMTRADE (SITC REV.3 product code 03)

Table 7. List of Countries Exporting Seafood to the US, EU15, and Japan (1992-2005) Covered in the Dataset

US		JP		EU15	
Argentina	Peru	Argentina	Portugal	Algeria	Mauritius
Australia	Philippines	Australia	Rep. of Korea	Argentina	Mexico
Belgium	Poland	Belgium	Singapore	Australia	Netherlands
Belize	Portugal	Brazil	Spain	Austria	New Zealand
Brazil	Rep. of 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	Trinidad and Tobago	Finland	UK	Croatia	Portugal
Ecuador	Turkey	France		Cyprus	Rep. of 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		New Zealand		Japan	
Netherlands		Norway		Kenya	
New Zealand		Peru		Madagascar	
Norway		Philippines		Malaysia	
Paraguay		Poland		Malta	