Assessing the Impact of Stricter Food Safety Standards on Trade:

HACCP in U.S. Seafood Trade with the Developing World

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Abstract:

Health risks associated with seafood products prompted the introduction of mandatory HACCP in the seafood industry in the United States in 1997. This paper quantifies the trade impact of this introduction by analyzing patterns of seafood imports to the U.S. over the period 1990 to 2004. The results of a gravity model using panel data suggest that HACCP had a negative and significant impact on overall seafood imports from the top 33 developing and developed countries selling into the U.S. For developing countries, the results support the view of "standards-as-barriers" versus "standards-as-catalysts" as the negative HACCP effect was experienced by developing countries, while the effect for developed countries was positive.

1 Introduction

The incidence of foodborne illness due to bacterial contamination has made concerns more widespread about food safety, the setting of stricter standards, and the means of enforcing mandatory regulations. Moreover, the potentially rapid spread of safety hazards through global trade has highlighted deficiencies in national food control systems in developed countries (GAO 2005). These concerns have pushed countries to develop more effective food safety systems. From the point of view of many industrialized countries, the diversity of regulatory standards and programs across countries is a major regulatory challenge, particularly with regard to differences between developed and developing countries.

For the United States, one of the worlds' largest producers and importers of fishery products, the issue of seafood safety has been of particular concern. Approximately 15 percent of an estimated 76 million foodborne illnesses that occur every year in the U.S. are associated with seafood consumption (GAO 2001). The risks associated with domestic and imported products motivated the introduction of a mandatory Hazard Analysis Critical Control Points (HACCP) approach to food safety regulation in seafood processing in 1997.

The World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) encourages member countries to harmonize national standards with the standards of the joint FAO and WHO Codex Alimentarius Commission. The agreement permits importing countries to impose measures more stringent than international standards and allows measures to be taken to limit or even ban imports based on scientific justification. In the United States, the Food and Drug Administration (FDA) is assigned to inspect samples of imported seafood at the port of entry and refuses adulterated shipments. Although such systems are intended to prevent potential contamination risks from entering a country, they can also cause an unjustified non-tariff trade barrier that protects domestic industries.

A potential hurdle arises in the international fishery products trade because seafood is primarily produced and exported by developing countries where sufficient food supply at low prices often ranks as a higher consideration than international food safety standards (Henson et al. 2000). With regard to seafood trade, and food trade in general, the conventional wisdom in the literature held that increased food safety standards in developed countries amount to "standards-as-barriers" to trade that are used as protectionist tools. This especially holds for the majority of mandatory standards under the SPS Agreement that might discriminate against developing countries, especially if, contrary to the agreement, the effective level of enforcement is more rigorous for imports than for domestic supplies. On the other hand, a more recent and less pessimistic view of the role of food safety standards in trade emphasizes the opportunities provided by emerging requirements and the possibility that developing countries could use them to increase their competitive advantages. This “standards-as-catalysts” view argues that compliance with new food standards may provide various incentives for countries to modernize their export-oriented sectors, as well as to strengthen the levels of food and health standards at the national level.

We contribute to this discussion by investigating the impact of stricter food safety measures on U.S. seafood trade. Based on a gravity equation model of trade flow analysis, we investigate the impact on the seafood trade of mandatory HACCP measures introduced in 1997 using data on imports to the U.S. by the 35 largest seafood exporting countries, of which 27 are developing countries and 8 are developed countries. The data set includes the pre-HACCP period of 1990 to 1997 and the post-HACCP period of 1998 to 2004. We test both the overall impact of HACCP on U.S. seafood imports and the whether there is a difference in the relative impact for developed and developing country exporters. This allows a direct empirical test of whether the “standards-as-barriers” or the ”standards-as-catalysts” view more closely fits the observed trade impacts.

The paper is organized as follows. Section 2 reviews the relevant literature on food safety with an emphasis on empirical studies that deal with the potential impact of increased food safety standards on international trade and the seafood market. Section 3 outlines recent developments in U.S. seafood trade followed by a discussion in Section 4 of the role of the HACCP system in the U.S. seafood industry and the implications of mandatory HACCP enforcement for developed and developing countries. Section 5 introduces the econometric gravity equation approach and its extension, followed by the description of the panel data set. Selected results of the random effects panel regressions are discussed in Section 6 followed by simulations of country specific impacts of HACCP standards on seafood trade. The final section includes conclusions and recommendations.

2 Food Safety and Trade: Empirical Evidence

In international trade theory, it is a well-established result that the trade policy of a large country can directly affect its own as well as other countries' welfare by affecting trade flows through trade creation and trade redirection. There is now a fairly extensive literature on the effects of food safety standards and the SPS Agreement on developing countries. Most of this literature contains general assessments that indicate key issues [Henson et al. (2000), Buzby et al. (2004), Josling et al. (2004), World Bank (2005)].

In addition, Pinstrup-Andersen (2000), Unnevehr (2000, 2003), Jaffe and Henson (2004), Henson and Mittulah (2004), and Caswell and Bach (2005) have discussed the implications of major differences among food safety standards under the SPS Agreement from the point of view of developing countries. These authors agree that stricter national and international food safety measures have the ability to amount to protectionist non-tariff barriers to trade for many developing countries. However, Jaffee and Henson (2004) and the World Bank (2005) have highlighted the potential opportunities that evolve from the development of food safety regulations and differences among importing countries. They suggest that these developments are likely to increase the ability of certain developing countries to use the new standards environment to their competitive advantage. However, both papers conclude that the gap has yet to be bridged between growing consumer and standards requirements in developed countries and modernized supply chain structures in many export oriented industries of developing countries. Jaffee and Henson conclude that the simple black and white argument between food-safety ”standards as barriers” and ”standards as catalysts” is more complex in reality, requiring close analysis of impacts where particular markets, products, and countries are analyzed in order to understand how changing food safety standards provide challenges and opportunities for developing countries.

Although a number of studies recognize the relevance of food safety standards with respect to international trade flows [Unnevehr and Jensen (1999), Hooker and Caswell (1999), Henson and Loader (1999), Henson et al. (2000), Unnevehr (2000), Garcia-Martinez and Poole (2004), Unnevehr and Roberts(2004), Henson and Mittulah (2004)], only a few studies in the economics literature have used empirical data to estimate the impact of national and international food safety regulations on trade flows. Among the quantitative studies of trade diversion and redirection effects resulting from food safety measures, Paarlberg and Lee (1998) and Calvin and Krissoff (1998) apply partial equilibrium approaches to estimate the welfare effects of food safety standards, assuming hypothetical relationships between food safety, demand, and supply conditions. Under simplifying assumptions, both papers show that phytosanitary barriers deterred trade and led to considerable rents due to the protection of domestic markets.

Otsuki, Wilson and Sewadeh (2001) employ a gravity-equation model to estimate the impact of changes in European alfatoxin standards on African exports of cereals, dried fruits, and vegetables. Wilson and Otsuki (2004) explore the impact of stricter pesticide standards for bananas on trade flows between developing countries and OECD importing countries. Their results suggest that the implementation of new aflatoxin and pesticide standards results in overall negative trade affects for developing countries. For example, Wilson and Otsuki report that a 1 percent increase in regulatory stringency leads to a decrease in banana trade of 1.6 percent. More recently, Maskus et al. (2005) estimated the costs of compliance with product standards for firms in developing countries. Based on firm level data the study concluded that overall costs of standard compliance were non-trivial and could potentially constitute barriers to trade for firms thus reducing export success.

Seafood products have attracted less attention. In the literature on the impacts of food safety regulations on international trade flows even though seafood consumption accounts for a disproportionately large share of foodborne illnesses in the United States (GAO 2001) and other OECD countries (Cato 1998). Martinez-Zaroso and Nowak-Lehmann (2004) explore the export potential of MECOSUR countries in a liberalized EU market. This issue is of particular economic importance since agricultural and fishery products make up about 2/5 of MERCOSUR's total exports to the EU. Applying a panel analysis technique the study reveals strong correlations between the overall level of EU market protectionism and the growth rate of MECOSUR exports. In particular, the category of fishery products faced high barriers to trade from EU protection.

Among the few studies that mainly focus on safety issues for fishery products in international trade, Alberini et al. (2005) explore the implications of FDA inspection of seafood imports under the HACCP regulation. Based on a theoretical model of enforcement, the authors econometrically rejected the hypothesis that the FDA performed targeted inspections based on actual HACCP requirements or past compliance of firms. However, the results reveal that a firm’s compliance strategy largely focuses on the threat of inspection of sanitary standards for seafood.

Debaere (2005) investigates the impact of changing trade policies, in particular the EU zero tolerance policy of antibiotics, on the global shrimp market. The author shows empirically that the EU policy, mainly the loss of Thailand's preferential status in the EU, enforced differences in international safety standards for shrimp leading to a disruption of trade flows from Europe towards the U.S. Debaere quantifies the size of the trade frictions that led to significantly decreased U.S. shrimp prices and caused a U.S. anti-dumping case against six Asian shrimp exporting countries. However, the study is highly case specific and therefore does not directly contribute to the question of the overall trade impact emanating from food safety standards in seafood trade.

Peridy et al. (2005) apply a panel model to the analysis of the economic factors affecting seafood imports into France. Specifying the gravity equation at the disaggregate product level the authors develop insights into the economic determinants of French seafood imports. However, the influence of food safety standards is not central to the analysis, since the impact of trade barriers is reflected in a very broad manner that does not account for the effects of safety regulations with regard to seafood trade.

In summary, the empirical evidence on the implications of increased food safety standards has addressed important questions that contribute to the understanding of whether standards act as barriers or catalysts to trade. However, the dichotomy of the impact of food safety standards is still largely unresolved with regard to international seafood trade. Much of the analysis of seafood HACCP requirements within the United States has focused on the national implications of food safety regulations. Hence, many studies have concentrated either on explaining the principles of HACCP and its implementation, or on estimating the costs and benefits arising from different technologies in the improvement of food safety[1]. Therefore, to our knowledge the following analysis is the first to estimate the magnitude of trade changes emerging from stricter food safety standards in the form of HACCP requirements for seafood implemented in the United States.

3 U.S. Seafood Trade, International Food Safety, and HACCP

Although the United States is one of the world's largest exporters of seafood, its annual trade deficit in fishery products has been rising over the past 15 years. This deficit is the largest for any agricultural product and the second largest, after petroleum, for any natural resources product. Seafood from foreign countries is filling a growing share of the United States seafood market, as the expanding U.S. population and increasing awareness of the health benefits of seafood continue to promote consumer demand. Figure 1 shows the pattern experienced in the U.S. of rising imports and growing trade deficits. The annual growth rate in the trade deficit is estimated at 1.8 percent in the period 1990-2003. Starting from a deficit of $ 2.4 billion in 1990, the gap between exports and imports increased to a maximum of $ 7.8 billion in 2003.

The U.S. supply of edible seafood has gone up steadily in recent years. However, by 1998 imported seafood comprised 63 percent of consumption. The share of imports increased to 68 percent in 2000 and reached a peak of 76 percent of edible seafood consumption in 2002. Import volume has increased from 1997-2004 for both developing and developed countries. This pattern can be attributed to very low or non-existent tariffs on most fishery product imports, where products are not available from national resources in sufficient quantities. Additionally, trade restrictions overall have lessened due to on-going WTO negotiations. This trend in increased imports has been also been supported by a steady increase in overall seafood

[1] Golan et al. (2004) provide a comprehensive review of food safety innovations in the United States.

consumption in the United States, which has increased over 50 percent since 1980 and is still on the rise.

As the U.S. seafood industry has come to rely more heavily on global resources to fill the gap between domestic seafood supply and growing demand, developing countries have remained important trading partners, with increasing volumes of sales into the U.S. market. Table 1 shows that 35 countries supplied approximately 95 percent of the U.S. import market from 1996 to 2004 (BICO 2004)[2]. The average concentration of import supply shares of the 8 developed countries was 27.5 percent, while the leading 27 developing countries accounted for approximately 67 percent of edible seafood imports into the United States. For nine consecutive years from 1996 to 2004, edible fishery product imports from developing economies were valued at approximately 2.5 to 2.8 times those from developed countries. In fact, "fish is the most important food product exported by developing countries and it comes well before coffee, bananas, and tea" according to FAO fisheries experts (FAO 1998). The net foreign exchange receipts derived from fish in developing countries increased from $11.6 billion in 1992 to $17.4 billion in 2002, illustrating the active part played by the developing country group in trade of fish and fish products. In 2002, they accounted for more than 49 percent of the total worldwide value of seafood exports, with net export revenues estimated at $8.2 billion (FAO 2004).

Food safety issues related to the international trade in fishery products are more complex than for other commodity markets due to a greater variety in harvest methods, production areas, and regional markets. These factors make seafood a highly non-homogenous product. However, there seems to be no direct empirical evidence that imported seafood has higher food safety risks

[2] The 35 countries include 8 developed countries (Canada, Iceland, Japan, Norway, New Zealand, Australia, Denmark and United Kingdom) and 27 developing countries (Argentina, Bahamas, Bangladesh, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Guyana, Honduras, India, Indonesia, Korea, Mexico, Nicaragua, Panama, Peru, Philippines, Russian Federation, Singapore, South Africa, Taiwan, Thailand, Trinidad and Tobago, Venezuela and Vietnam).

per se. On the other hand, there oftentimes is a lack of reliable information on safety characteristics compared to domestic products, as emphasized by Pinstrup-Andersen (2000) and Donovan et al. (2001)[3].

In 1997, a mandatory HACCP requirement replaced the prior regulatory system for the seafood industry in the United States. At the time of its implementation, HACCP was seen as a win-win proposition although companies had to incur costs for HACCP plan design, additional control and record keeping procedures, additional sanitation procedures, and training of employees (Colatore and Caswell, 2000). FDA has acknowledged that the introduction of HACCP has proven to be complex, as many elements were largely unfamiliar to most domestic processors but also to processors in major exporting countries. Unnevehr (2000) points out that HACCP systems vary widely among developed countries and discusses the controversy about their use as public sector concepts for food safety regulation. HACCP standards may pose an additional significant hurdle to seafood suppliers above and beyond their current quality assurance systems. At the same time, the growing and diverse adoption of mandatory HACCP programs by governments means that it is an SPS measure that may affect international trade in a non-negligible way.

We hypothesize that the introduction of mandatory HACCP has had a significant effect on seafood trade flows into the United States. For example, developing country exporters may have chosen to export to other countries rather than the U.S. because of increased compliance costs for the U.S. market, which deprive them of their comparative trade advantage. The World Bank (2005) has estimated that the costs of food safety interventions in export-oriented seafood industries in developing countries are becoming significant for those who attempt to penetrate

[3] According to the FDA, 80 percent of domestic food-manufacturing facilities are found to be in compliance with HACCP requirements, while some 30 percent of inspected foreign facilities have significant system defects (GAO 2001).

high-income food markets. Moreover, U.S. importers may choose not to buy from developing countries as safety levels may be lower overall, be harder to verify, and involve greater risks of failure to comply with safety standards when inspections are made at the port of entry. On the other hand, countries that have relatively high food safety standards themselves or that meet U.S. HACCP requirements may be able to increase their export volume at the expense of others and gain an increased competitive advantage.

We test whether the data in the case of mandatory HACCP adoption in the U.S. supports the "standards-as-barriers" or "standards-as-catalysts" views of the trade impact on exporting developing countries. To quantify the effects of mandatory HACCP requirements on an individual country level is difficult and has largely been explored to date via case studies [Swann et al. (1996), Donovan et al. (2001), Otsuki et al. (2001a)]. However, looking at this particular impact from a more multilateral point of view using available panel data is increasingly important given the new trade agenda.

5 The Panel Model Approach to Analysis of HACCP Trade Impacts

Different methodological approaches have been applied to disentangle the complicated trade effects of food safety standards. Maskus et al. (2001) summarized alternative approaches to estimating the impact of standards on trade. We apply an econometric panel approach to quantify the effects of mandatory HACCP requirements on U.S. seafood trade (Hsiao 1986). As discussed earlier, the studies of Paarlberg and Lee (1998) and Calvin and Krissoff (1998) applied partial equilibrium approaches to analyze the demand, supply, and welfare effects of food safety standards.

Previous studies by Swann et al. (1996), van Beers and van den Bergh (1997), Peridy et al. (2000) and Wilson and Otsuki (2004) discuss the advantages of econometric methods, especially the gravity equation approach, for the analysis of standards in international trade. Evenett and Keller (1998) supply evidence of the accuracy of the gravity equation in predicting various theoretical trade models as the equation can be derived from Ricardo, Heckscher-Ohlin-Samuelson, or increasing return to scale models (Bergstrand 1989).

A major advantage of an econometric approach based on the gravity equation is the ability to examine relationships that are most relevant for international seafood trade between policy variables and determinants of bilateral trade flows, such as tariff and non-tariff trade barriers; transport costs, proxied by the geographical distance between trade partners; exchange rates; or the size of the importing and exporting economies. Moreover, the econometric approach does not predetermine the direction of the effect of standards and other trade determinants; thus it can be used for hypothesis testing. It also allows the direct estimation of elasticities of trade flows with regard to food safety standards and other determinants. Additionally, the panel nature of the data set allows the investigation of differing effects of stricter safety standard measures across countries.

The model we specify is a variant of the classic gravity equation of bilateral trade analysis. It includes the size of each exporting country’s seafood sector introduced as a measure of “mass”, geographical distances to the U.S., foreign exchange rates, and the size of the U.S. economy. In addition, we introduce a policy variable for the implementation of mandatory HACCP in the U.S. to explicitly account for the impact of this safety standard on trade. The model includes variables that explore the effects of international trade agreements on seafood trade flows into the United States. The dependent variables are quantitative import volumes and monetary values of seafood imports into the U.S.

The specification of the gravity model is:

$$\begin{aligned} \ln Imports_{it}^{x} &= \alpha_0 + \alpha_1 (Time) + \alpha_2 (HACCP_t) + \alpha_3 \ln(GDP_t) + \alpha_4 \ln(Size_{it}) + \\ &\alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_{it}) + \alpha_7 (Developed) + \alpha_8 (MERCOSUR) + \\ &\alpha_9 (NAFTA) + \alpha_{10} (ASEAN) + \alpha_{11} (APEC) + \alpha_{12} (ANDEN) + \alpha_{13} \ln(Geo) + \varepsilon_i \end{aligned} \quad (1)$$

All variables are in logarithm so the coefficients represent elasticities. $Imports^{x}_{it}$ denotes the imports of seafood from country i to the United States in a particular year t. Superscript x stands for either the volume of imports ($Imports^{Q}_{it}$) or the dollar value of imported seafood ($Imports^{\$}_{it}$). These data were obtained from the Fisheries Statistics & Economics Division of the National Marine Fisheries Service (NMFS 2005, 2005a) for the years 1990 and 2004. Table 2 presents definitions and descriptive statistics of the dependent and independent variables. Trade data for Korea and Vietnam where incomplete and were dropped form the data set. The panel-data set covers 33 countries in the period of 1990 to 2004.

Time has the value 1 to 14 for the 14 years of observations. *HACCP* reflects the implementation and enforcement of HACCP requirements by the FDA effective in 1998. Consequently this dummy variable equals one for the years 1998 to 2004 and is zero in previous years. *GDP*, as a proxy of income, is the real per capita GDP of the United States in 2000 U.S. dollars. *Size* is a proxy for the importance of international seafood trade in each country and was computed by adding up the quantities of aggregate seafood imports and exports. Seafood trade data are available online from the FAO's database "fishstat plus" (FAO 2005). Alternatively, the export value of total goods and services of each country is measured by *Export* and may also be used as a proxy of trade activity. *Exchange* is the market exchange rate between the U.S. dollar and the domestic currency of each exporting country, while *Distance* measures the geographical distance in miles between each country and the United States.

Develop is a dummy variable reflecting development status. It equals one for the eight developed countries and is zero for the twenty-five developing countries. To account for international trade agreements that could affect seafood trade with the U.S., the dummy variables *MERCOSUR*, *NAFTA*, *ASEAN*, *APEC* and *ANDEN* are set equal to one when the country belongs to a particular trade agreement. *Geo* is a classification variable, indicating geographical connection between seafood exporters and the United States. As we could not identify clear colonial ties for the United States this variable has three levels: Trade relations with Asian and Pacific countries are captured in *Geo1*, while the group of South American countries is included in *Geo2*, and Northern countries make up the *Geo3* group[4]. The hypotheses on the signs of the first derivatives of the model variables are:

$\partial Imports/\partial HACCP < 0$; $\partial Imports/\partial GDPpc > 0$; $\partial Imports/\partial Size > 0$;

$\partial Imports/\partial Distance < 0$; $\partial Imports/\partial Export > 0$; $\partial Imports/\partial Developed > 0$;

$\partial Imports/\partial Exchange > 0$.

We hypothesize that adoption of the HACCP standard has had a negative impact on U.S. seafood imports. In addition, we hypothesize a positive sign for the variable *Developed* since developed countries among the seafood exporters to the U.S. are expected to already enforce higher food safety standards and to face lower barriers to comply with U.S. food safety requirements. The impact of geographical distance is assumed to be negative, while the size of the exporting countries economy *Exports*, the developing status *Developed* and the foreign exchange rate to the U.S. Dollar *Exchange* are hypothesized to have a positive sign. All other

[4] South Africa is the only African seafood exporting country in the data set. Instead of creating an additional country group, South Africa is included in the Asia/Pacific country group.

signs are ambiguous; there exist differential hypotheses on the influence of time, trade agreements, and geographical connection.

6 Empirical Analysis of HACCP Effects on Seafood Trade

Our primary interest is in the magnitude and significance of the trade flow effect of HACCP requirements on U.S. seafood trade. Therefore the panel of fishery product import data is estimated across 33 fishery product exporting countries for the time period 1990-2004. In order to examine the importance and robustness of a number of model coefficients, the general gravity equation (1) is estimated in alternative specifications for the two dependent variables of quantitative import volumes and dollar values of seafood imports into the United States. In order to account for major differences in the effects of HACCP on developed and developing countries, and therefore explicitly test the “standards as barriers” versus “standards as catalyst” hypotheses, separate regressions are performed on the subgroups of developed and developing countries.

Model 2 is the general specification of the gravity equation including the trade flow effect of mandatory HACCP requirements on seafood trade. The core variables of the gravity equation are the “mass” of the importing country (*GDPpc*), the size of the exporting country’s seafood sector (*Size*), exchange rate (*Exchange*), the geographical distance (*Distance*) and a time trend (*Time*), This model in both specifications of the dependent variable is the benchmark for all other specifications.

$$\begin{aligned} \ln Imports_{it}^{x} &= \alpha_0 + \alpha_1 (Time) + \alpha_2 (HACCP_t) + \alpha_3 \ln(GDPpc_t) + \alpha_3 \ln(Size_{it}) + \\ &\alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_{it}) + \varepsilon_i \end{aligned} \tag{2}$$

Model 3 adds the effect of international trade agreements on seafood imports into the U.S. Moreover, the variable *Developed* allows us to test whether there is a significant difference between the groups of developed and developing countries, directly testing the effects of development status on seafood trade before and after HACCP implementation.

$$\begin{aligned} ln\, Imports_{it}^{x} &= \alpha_0 + \alpha_1 (Time) + \alpha_2 (HACCP_t) + \alpha_3 \ln(GDPpc_t) + \alpha_4 \ln(Size_{it}) + \\ &\alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_{it}) + \alpha_7 (Developed) + \alpha_8 (MERCOSUR) + \\ &\alpha_9 (NAFTA) + \alpha_{10} (ASEAN) + \alpha_{11} (APEC) + \alpha_{12} (ANDEN) + \varepsilon_i \end{aligned} \quad (3)$$

Model 4 substitutes for the variable S*ize*, reflecting the importance of each country's seafood sector, with a broader definition. Here the value of a country's total export of goods and services, *Export*, is used as a proxy for "country size". Furthermore the variables *Geo1* and *Geo2* represent an alternative specification of country specific effects on seafood trade previously represented by trade agreement variables. *Geo1* includes Latin American fishery product exporters to the U.S. and *Geo2* covers the Asian-Pacific country group.

$$\begin{aligned} ln\, Imports_{it}^{x} &= \alpha_0 + \alpha_1 (Time) + \alpha_2 (HACCP_t) + \alpha_3 \ln(GDPpc_t) + \alpha_4 \ln(Export_{it}) + \\ &\alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_{it}) + \alpha_7 (Developed) + \alpha_8 (Geo1) + \alpha_9 (Geo2) + \varepsilon_i \end{aligned} \quad (4)$$

The panel nature of the data may introduce heterogeneity biases, so that appropriate econometric methods are required to separate the time series and cross-sectional effects. The initial ordinary least square estimates revealed significant serial correlation. We therefore applied Exact Maximum Likelihood estimators (ExactML) to random effects models. The parameter estimates are corrected for first-order serial correlation of the residuals and stationarity of the times series properties is imposed (Beach and MacKinnon 1978). Given the large number of country-pair relations in the data set, we treat the corresponding country specific effects as random.

The choice of the estimation procedure is motivated by different factors. First, fixed effect models cannot be estimated with variables that are time and product invariant, such as geographical distance. Random effects models are more appropriate given the importance of this gravity variable in our model. There are good reasons for arguing that country-specific fixed effects come to the fore especially when stricter food standards may boost or hamper trade flows across countries. Of course, such factors are deterministically linked with individual country specifics, which may not be considered as random. However, the studies of Otsuki et al. (2001), Wilson and Otsuki (2004) and Blind and Jungmittag (2005) apply fixed effects models. On the other hand, two recent studies doubt the appropriateness of the use of fixed effects models in trade flow analysis, especially when time invariant geographical distance variables are included in the gravity equation, which is the most prominent example. Egger and Pfaffermayr (2004) and Peridy et al. (2000) among others point out that a fixed effects estimator will wipe out all time invariant variation. Maddala (1987) provides another argument. Random effects models should be favored as many degrees of freedom are saved when the number of individuals (countries in our model) is greater compared to the number of periods.

The gravity model estimates are presented in the following order. First, Models 1a-3a are run over all available observations for the dependent variable of dollar value of imported seafood ($Imports^{\$}_{it}$). Models 1b to 3b are then similarly regressed on the volumes of imported seafood ($Imports^{Q}_{it}$). The results appear in the columns of Table 3. Second, regressions are run separately for the country groups of developed and developing countries. Elasticities of HACCP effects for the entire period 1998-2003 are reported in Table 4.

The results for the aggregate imports of seafood products into the Unites States indicate that the random effects estimates of the gravity models are generally well behaved. The doublelog specifications reveal the best parameter estimates in all models and allow for the direct interpretation of coefficient elasticities. Due to insignificant results the variable *MERCOSUR* has been dropped from specifications (2a) and (2b). Our findings are very interesting with respect to a number of influencing factors with regard to the limited number of empirical studies that have estimated the effects of food-safety standards on international trade flows,

We begin with the discussion of the estimates of the benchmark models 1a and 1b and compare the results to the extended and alternative model specifications. The previously addressed positive time trend in seafood imports into the United States is significantly confirmed with respect to both the values and quantities of seafood. The estimated elasticities are 0.04 and 0.03 in the benchmark models, while the alternative specifications show only slightly varying time trends. This finding is also confirmed by positive and significant elasticities of real per-capita gross-domestic product, as a proxy of U.S. per-capita seafood demand. The estimates are robust across specifications with elasticities around 0.6 and 0.5 in the benchmark models, while the estimates are of smaller magnitude in all other specifications.

The geographical distance variable in model 1a shows a theoretically plausible negative effect on seafood trade. The elasticity of -0.215 is highly significant with regard to the dollar value of imported seafood. Interestingly, the volume of seafood imports in equation 1b does not reflect the impact of geographical distance. While models 3a and 3b reveal significant elasticities of the magnitude of -0.65 percent to -0.79 percent, in models 2a and 2b the distance effect is captured mainly by the effect trade agreements or country groups had on seafood trade with the U.S. Peridy et al. (2000) report a significant distance elasticity of -0.742 for seafood imports into France. Disdier and Head (2005), who perform a meta-analysis of 1467 distance effect estimates in gravity models, report a mean elasticity value of -0.9.

Our panel regressions also highlight the significance of the “mass” variable (*Size*) as a major factor in explaining trade flows. The importance of each country’s seafood sector, in terms of imports and exports, has a significant and positive effect on its ability to penetrate international high-income markets for fishery products such as the U.S. The elasticity estimates across model specifications are robust with parameter values in the benchmark specifications of 0.397. This trade facilitating effect is confirmed by the alternative specification using the dollar value of total exports in goods and services (*Export*) as a proxy of export orientation in models 3a and 3b. The elasticity estimates are 0.33 and 0.29, respectively.

Interestingly, an expected negative effect of the foreign exchange rate to the U.S. dollar on seafood imports is only observed in models 2a and 2b. The elasticity estimates state that U.S. seafood imports increased by around 0.065 percent due to a 1 percent increase in the market exchange rate to the US dollar. However, compared to the exchange rate elasticity of 0.97 reported by Martínez-Zarzoso and Nowak-Lehmann (2004) for seafood exports by MERCOSUR countries, the impact of exchange rate fluctuations on U.S. seafood trade is marginal. Peridy et al. (2000) report a nominal exchange rate elasticity of -0.54. In investigating the impact of European safety standards on African food commodity exports, Otsuki et al. (2001) did not include an exchange-rate variable in their panel analysis.

Unlike the more general specification of gravity equations in models 1a and 1b, the alternative specifications in models 2a, 2b, 3a, and 3b are extension that additionally account for various factors that may impact seafood trade flows. To the best of our knowledge this study is the first to explore the effects of trade agreements and geographical connections among fishery nations on seafood trade flows. Our results clearly indicate that these factors are of importance in explaining trade flows. For both dependent variables the results reveal significant positive effects of relevant trade agreements. With regard to U.S. seafood imports the NAFTA free trade agreement has the greatest impact with elasticities around 1.3 and 1.5.

The fact that developing countries account for almost 75 percent of U.S. seafood imports is evident in the statistical results of the model. The negative sign of the variable *Developed* indicates a negative impact on seafood trade of increased development status. Interestingly, the magnitudes of the effect are greatest for absolute trade volumes. Moreover, the impact of geographical connections shows that Latin-American countries (*Geo1*) have better access overall to the U.S. seafood market compared to the residual group of northern countries, which is dominated by European fishery nations. In contrast the group of Asian andPacific countries (*Geo2*) does seem to have a competitive disadvantage compared to European competitors as indicated by a significant negative estimate.

Coming to the core emphasis of the paper, Table 3 shows that the introduction of mandatory HACCP in the processed seafood market in the U.S. had a significantly negative effect on trade flows across all exporting countries. The estimated elasticities in the benchmark specifications of models 1a and 1b are -0.61 and -0.47, respectively, indicating that the HACCP standard posed a significant trade barrier to seafood import supply. However, under the enforcement of HACCP, U.S. seafood imports declined differently, depending upon whether absolute monetary values or volumes of imported seafood are considered. Table 3 shows that the overall effect on the values of seafood imports was greater then on the quantities of seafood imports. However, the HACCP variable is of the expected sign but insignificant in both specifications of model 3. Comparing our findings with previous estimates on the impact of food-safety standards on trade flows, Otsuki et al. (2001) found a negative impact of stricter EU aflatoxin standards on cereal exports and particularly on fruits, nuts and vegetable exports by

African countries into the EU. The elasticity estimate is -1.075 for the category of cereals and -0.433 for fruits, nuts and vegetable exports. With regard to the introduction of a new pesticide standard by the EU, Wilson and Wilson and Otsuki (2004) estimate a significant negative elasticity effect of this safety standard on EU banana imports. The gravity equation panel model on seafood trade of Peridy et al. (2000) shows a significantly negative impact of trade barriers on aggregate as well as product specific seafood imports into France. However, the presented trade-barriers elasticity for the period of 1988-1994 of -0.012 is rather marginal.

With regard to the dichotomy of HACCP as “standards-as-barriers” or “standards-as-catalysts” to trade, our results support the hypothesis of an overall negative impact of the introduction of the HACCP standard on seafood imports into the U.S. Previous studies did not fully exploit panel data to test for country-specific effects, specifically with regard to the impact of food-safety standards on export flows from developing versus developed countries. To test for differential effects the panel dataset is divided between developed and developing economies with separate panel regressions of all models. The estimates of HACCP elasticities on U.S. seafood imports from developing and developed countries are reported in Table 4, together with the previously found aggregate HACCP standard elasticities (total).

The point elasticities of the HACCP trade flow effects for the group of developing countries is consistently negative and significant. Parameter values indicate declining trade flows of 0.64 percent to 0.75 percent from developing country seafood exporters to the U.S. in the post 1998 period. Furthermore, Table 4 shows significant opposite HACCP effects for the group of developed countries. In the aftermath of the introduction of HACCP, seafood exports from developed countries increased significantly by 0.27 percent to 0.64 percent depending on the model specification.

With regard to the dichotomy of “standards-as-barriers” versus “standards as catalysts,” our results give a remarkably clear answer. While the group of developing countries suffered trade losses due to stricter standards in the United States, developed countries, many of them European economies, significantly increased their export shares in terms of quantitative volumes as well as the value of seafood shipments. This finding underlines the importance of disaggregate analysis of the trade flow effects of standards, particularly when non-homogenous groups of developed and developing countries are considered. Jaffee and Henson (2004), who address this issue in detail, conclude that with a few exceptions where developing countries faced major restrictions from new food safety standards that developing countries have managed to use higher standards successfully to position themselves in a competitive global market. In contrast our findings strongly reject this finding. For the case of seafood, the “standards-as-barriers” hypothesis is more favored.

7 Conclusions

Foodborne safety risks associated with domestic and imported seafood products motivated the introduction of a mandatory HACCP for seafood products in the U.S. in 1997. From the point of view of the U.S. and other developed countries, regulatory standards are intended to reduce potential contamination risks. However, they can also create non-tariff trade barriers. The conventional wisdom is that increased food safety standards in developed countries amount to “standards-as-barriers”, particularly for developing countries. An alternative view sees the potential for “standards-as-catalysts,” as developing countries react to new standards with increased investment in quality assurance.

This paper contributes to this discussion by estimating the trade impact of the 1997 introduction of HACCP in the U.S for domestic and imported seafood imports. We apply panel-data on seafood imports to the U.S. by the 33 largest exporting countries between 1990 and 2004. Twenty-six of these countries are developing, while 8 are developed. The results of an extended specification of the gravity model indicate a significantly negative impact of the HACCP standard on U.S. seafood imports across the 33 exporting countries. The results are robust in terms of absolute trade volumes and product values. The direct empirical test of whether the "standards-as-barriers" or the "standards-as-catalysts" view more closely fits the observed trade impacts strongly confirms the "standards-as-barriers" hypothesis. While developing countries suffered significant trade reductions under HACCP, developed countries gained market share under HACCP.

The results emphasize the importance of quantitative economic modeling to inform the discussion of the role of food safety standards as non-tariff barriers in international trade. Economic analysis of the trade effects of increased food safety measures can also be useful in the development of more effective food safety systems, in particular by developed countries. An area of future research and extension of the analysis is the investigation of HACCP effects at the individual country level. These results could be used to capture the welfare implications of international food safety measures on individual developing countries.

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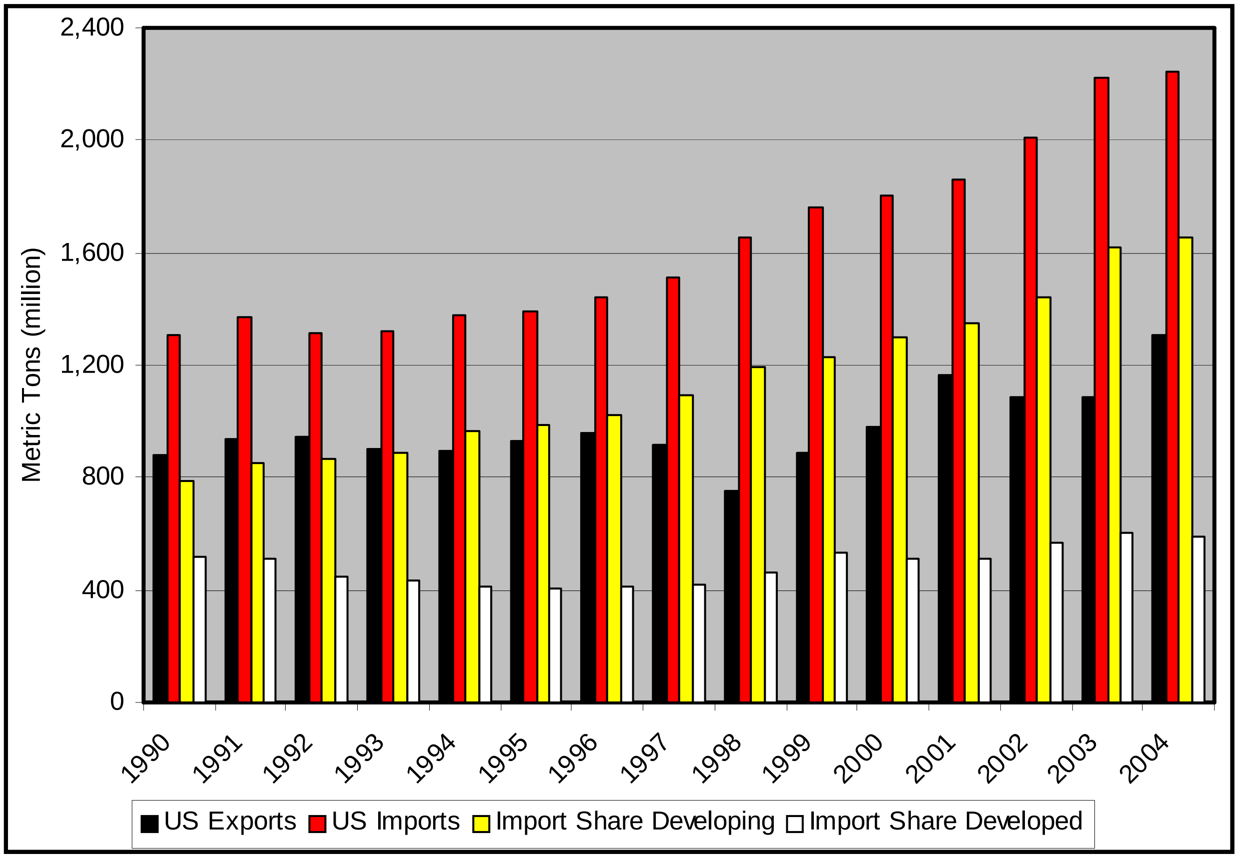
Figure 1: U.S. Seafood Exports and Imports from Developed and Developing Countries 1990-2004[a]



Source: NMFS, 1990-2004.

Table 1: Concentration of Import Supply Shares of U.S. Seafood 1996-2004

Import Concentration Ratios	1996	1997	1998	2000	2001	2002	2003	2004
	(% of total)							
8 Developed Countries	27.3	26.9	27.0	27.4	28.4	28.7	27.4	26.7
27 Developing Countries	66.3	67.3	67.4	67.5	65.0	65.4	67.7	68.6
Leading 35 Suppliers	93.6	94.2	94.4	94.9	93.4	93.1	95.1	95.3

Source: BICO Reports, 1996-2004.

Table 2: Definitions of Variables and Sample Statistics

Variables	Variable Description	Mean	Standard Deviation
Dependent Variables			
$Imports^{Q}_{i}$	Annual volume of imported seafood into the United States by country i (Million metric tons)	42.77	66.57
$Imports^{\$}_{i}$	Value of annual seafood imports into the United States by country i (Million US Dollars)	216.37	343.70
Independent Variables			
Time	Trend 1990-2004	8.27	4.67
HACCP	Introduction and enforcement of mandatory HACCP standards in U.S. seafood (1998-2004 = 1)	0.47	0.50
GDPpc	Real per-capita U.S. GDP (1000 US $)	29.53	7.01
Size	Total volume seafood imports and exports of country i (Million metric tons)	1.43	1.51
Export	Export value of total goods and services of country i (Billion US Dollars)	60.58	95.05
Distance	Geographical distance between country i and the U.S. (Thousand Miles)	4.92	2.97
Exchange	Real exchange rate between US$ and domestic currency i (value of one dollar in terms of domestic currency i)	697.50	2706.34
Developed	Development status of country i (developed economy = 1)	0.27	0.44
Geo	Geographical connection between fishery exporting countries (Latin America = 1; Asia/Pacific = 2; Northern = 3)	1.76	0.73
MERCOSUR	Dummy variable for MERCOSUR member countries: Argentina, Brazil	0.06	0.24
NAFTA	Dummy variable for NAFTA members countries: Mexico, Canada	0.061	0.24
ASEAN	Dummy variable for ASEAN member countries: Indonesia, Philippines, Singapore, Thailand	0.12	0.32
APEC	Dummy variable for APEC member countries: Australia, Canada, Chile, China, Indonesia, Japan, Mexico, New Zealand, Peru, Philippines, Russia, Singapore, Taiwan, Thailand	0.42	0.49
ANDEN	Dummy variable for ANDEN member countries: Colombia, Ecuador, Peru, Venezuela	0.12	0.32

Table 3: Gravity Model Estimates of HACCP Impacts on U.S. Seafood Imports 1990-2004[a,b]

Random Effect Panel Estimation for U.S. Seafood Trade						(fully robust standard errors)
	Dependent variable: Dollar Value of Imported Seafood			Dependent variable: Volume of Imported Seafood		
	Model 1a	Model 2a	Model 3a	Model 1b	Model 2b	Model 3b
Time	0.039*** (4.44)	0.045*** (5.47)	0.021** (2.25)	0.031*** (2.99)	0.037*** (3.88)	0.018 (1.63)
HACCP	-0.611*** (-6.18))	-0.507*** (-5.42)	-0.125 (-1.29)	-0.467*** (-4.04)	-0.382*** (-3.52))	-0.005 (-0.04))
GDPpc	0.613*** (17.76)	0.505*** (12.33)	0.137*** (4.89)	0.505*** (12.51)	0.414*** (8.68)	0.045 (1.38)
Dist	-0.215*** (-2.57)	0.096 (0.79)	-0.785*** (-6.21)	-0.003 (-0.11)	-0.131 (0.93)	-0.645*** (-4.34)
Exchange	-0.016 (-0.73)	-0.064** (-2.21)	0.028 (1.08)	-0.042 (-1.39)	-0.069** (-2.05)	0.018 (0.58)
Size	0.396*** (11.16)	0.315*** (8.07)		0.397*** (9.51)	0.329*** (7.21)	
Export			0.331*** (7.69)			0.294*** (5.87)
Developed		-0.487*** (-3.53)	-0.787*** (-4.22)		-0.805*** (-5.05)	-0.931 (-4.27)
NAFTA		1.459*** (4.36)			1.281*** (3.33)	
ASEAN		0.497*** (2.62)			0.429** (1.97)	
APEC		0.583*** (3.14)			0.901*** (4.21)	
ANDEN		0.605*** (2.78)			0.547** (2.18)	
GEO1			1.036*** (4.26)			1.148*** (3.96)
GEO2			-0.569** (-2.38)			-0.470* (-1.67)
Rho	0.88	0.88	0.89	0.86	0.87	0.88
DW	1.76	1.79	1.83	1.89	1.91	1.94
Adj. R^2	0.76	0.80	0.76	0.74	0.77	0.72
No.	492	492	492	492	492	492
F	20.07	19.19	26.82	17.26	15.40	24.9

[a] t-statistics (in parentheses) computed with White's heteroscedasticity-consistent standard errors.
[b] Random effect estimates corrected for first-order serial autocorrelation.
***, ** and * statistically significant at the 99%-, 95%-and 90%-level, respectively.
Critical F value computed according to Leamer (1978, p.114).

Table 4: Elasticities of HACCP effects for developed and developing countries [a]

Group	HACCP Elasticity					
	Dollar Value of U.S. seafood imports			Volume of U.S. seafood imports		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Total	-0.611***	-0.507***	-0.125	-0.467***	-0.382***	-0.005
	(-6.18)	(-5.42)	(-1.29)	(-4.04)	(-3.52)	(-0.04)
Developing	-0.753***	-0.737***	-0.031	-0.646***	-0.661***	-0.068
	(-6.91)	(-6.91)	(-0.27)	(5.32)	(-5.54)	(0.65)
Developed	0.271	0.411**	0.339**	0.496**	0.638***	0.544***
	(1.58)	(2.40)	(2.02	(2.52)	(3.59)	(2.87)

[a] ExactML random effect estimates of elasticities corrected for serial correlation. t-statistics (in parentheses) computed with White's heteroscedasticity-consistent standard errors.

***, ** and * statistically significant at the 99%-, 95%-and 90%-level, respectively.