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Standards-as-Barriers versus Standards-as-Catalysts: Assessing the Impact of HACCP Implementation on U.S. Seafood Imports

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JEL Classification: Q18, F14, L51

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The United States mandated a Hazard Analysis Critical Control Points (HACCP) food safety standard for seafood in 1997. Panel model results for the period 1990 to 2004 suggest that HACCP introduction had a negative and significant impact on overall seafood imports from the top 33 suppliers. While the effect for developed countries was positive, the negative HACCP effect for developing countries supports the view of "standards-as-barriers" versus "standards-as-catalysts." When the effect is analyzed at an individual country level a different perspective emerges. Regardless of development status, leading seafood exporters generally gained sales volume with the U.S., while most other smaller trading partners faced losses or stagnant sales.

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As one of the world's largest producers and importers of fishery products, the issue of seafood safety is of particular concern to the United States. Approximately 15 percent of the estimated 76 million foodborne illnesses that occur every year in the U.S. are attributed to seafood consumption (Mead et al. 1999). 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.

In considering the effect of higher food safety standards, such as HACCP implementation, the conventional wisdom in the literature held that increased food safety standards in developed countries amount to "standards-as-barriers" to trade that are frequently used as protectionist tools that disadvantage developing countries. They may especially discriminate against developing countries if, contrary to the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) under the World Trade Organization (WTO), 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 evaluate these two hypotheses by analyzing the impact of mandatory HACCP measures introduced in 1997 on imports to the U.S. by the 35 largest seafood exporting countries, of which 27 are developing and 8 developed countries. The data set includes the pre-HACCP period 1990-1997 and the post-HACCP period 1998-2004. We test the hypotheses by analyzing the overall impact of HACCP adoption on U.S. seafood imports and whether there was a differential effect for developed and developing country exporters over time. We then test for HACCP trade effects at the individual country level, allowing for differential effects not categorized by development status. Our results contribute to the discussion of the impact of changing food safety standards on the competitiveness of developing countries in international trade and especially of the dynamics of market share distribution.

The paper is organized as follows. Section 2 reviews the relevant literature on food safety with an emphasis on empirical studies of 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 and the implications of adoption of the HACCP system. Section 4 introduces the econometric gravity equation approach, followed by the description of the panel data set. Results are discussed in Section 5 and conclusions in the final section.

Food Safety and Trade: Empirical Evidence

There is a fairly extensive literature on the general effects of food safety standards and the SPS Agreement on developing countries (see, e.g., Henson, Brouder, and Mitullah 2000; Buzby 2003; Garcia-Martinez and Poole 2004; Josling, Roberts, and Orden 2004; World Bank 2005). In addition, Pinstrup-Andersen (2000), Unnevehr (2000, 2003), Jaffee and Henson (2004), Henson and Mittulah (2004), Maertens and Swinnen (2006) and Caswell and Bach (Forthcoming) 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 may amount to protectionist non-tariff barriers to trade for many developing countries.

Jaffee and Henson (2004) and the World Bank (2005) argue that standards can act to impede trade flows by explicit bans but more probably through prohibitive costs of compliance, particularly for poorer countries. The inevitable investment and recurrent 'costs of compliance' to penetrate high income markets could undermine the competitive position of many developing countries or narrow the profitability of high-value food exports. However, Jaffee and Henson (2004) and the World Bank (2005) highlight potential opportunities arising from developments in standards. Certain countries may be able to use the new standards environment to their competitive advantage and increase their market shares in trade. This possibility depends on closing gaps between growing consumer and standards requirements in developed countries and the modernization of supply chain structures in export oriented industries in 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. The issue requires close analysis of the dynamics of particular markets, products, and countries in order to understand how changing food safety standards affect exports from developing countries.

To date only a few contributions in the economics literature have used empirical data to estimate the impact of national and international food safety regulations on trade flows (Paarlberg and Lee 1998; Calvin and Krissoff 1998; Otsuki, Wilson, and Sewadeh 2001; Wilson and Otsuki 2004; Maskus, Otsuki, and Wilson 2005; Peterson and Orden 2005). A common result is that changes in food safety regulations and more stringent safety standards set by developed countries tend to deter trade supporting the view of "standards-as-barriers." Overall, changes in trade patterns related to standards take place within the context of broader changes. For example, Carrere (2006) finds that the effects of regional trade agreements on trade flows have become quite powerful in explaining changing patterns of food trade.

Seafood markets have attracted less attention even though seafood consumption accounts for a disproportionate share of foodborne illnesses in the United States (U.S. GAO 2001) and other OECD countries (Cato and Lima dos Santos 1998). Martínez-Zaroso and Nowak-Lehmann (2004) explore the export potential of MECOSUR countries in a liberalized European Union market. This issue is of particular economic importance because agricultural and fishery products make up about 40 percent of total MERCOSUR exports to the EU. Panel model results suggest strong correlations between the overall level of EU market protectionism and the growth rate of MECOSUR exports. In particular, the authors found the category of fishery products faced high barriers to trade from EU protection.

Alberini et al. (2005) explore the implications of U.S. Food and Drug Administration (FDA) inspection of seafood imports under the HACCP regulation. Based on a theoretical model of enforcement, the authors econometrically reject the hypothesis that the FDA performed targeted inspections based on actual HACCP requirements or past compliance of firms, which generally supports the view of "standards-as-barriers." However, the results suggest the compliance strategies of firms are largely influenced by 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 for 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. This trade friction led to a significant decrease in U.S. shrimp prices and caused a U.S. anti-dumping case against six Asian shrimp exporting countries. Finally, Peridy, Guillotreau, and Bernard (2000) apply a panel model to analyze the economic factors affecting seafood imports into France. However, the influence of food safety standards is not central because the impact of trade barriers is reflected in a very broad manner that does not account for the effects of safety regulations.

Empirical work on the implications of increased food safety standards contributes to the understanding of the economic determinants that affect trade in fishery products. However, whether these standards operate predominantly as barriers or catalysts is largely unresolved. Much of the analysis of U.S. HACCP requirements for seafood has focused on domestic implications, such as the costs and benefits of HACCP adoption. The analysis here estimates the magnitude of import changes emerging from stricter food safety standards in the form of mandatory HACCP requirements and provides direct tests of the hypotheses of "standards-as-barriers" versus "standards-as-catalysts" for developing country exports.

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 to nearly $8 billion in the past 15 years (NMFS 2005b). 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. Overall seafood consumption in the United States has increased over 50 percent since 1980.

By 1998 imported seafood comprised 63 percent of U.S. consumption. The share of imports reached a peak of 76 percent of edible seafood consumption in 2002 (NMFS 2005b). Import volume has increased from 1997-2004 for both developing and developed countries. Out of the largest 35 seafood exporters that supplied approximately 95% of the U.S. imports from 1996 to 2004, 27 are developing countries[1] that account for 67 percent of edible seafood imports (USDA/FAS 2004), and 8 are developed countries[2]. The net foreign exchange receipts derived from fish in developing countries increased from $11.6 billion in 1992 to $17.4 billion in 2002. In 2002, developing countries accounted for more than 49 percent of the total worldwide value of seafood exports (FAO 2004).

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, even though companies had to incur additional costs

[1]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 Viet Nam.
[2]Australia, Canada, Denmark, Iceland, Japan, New Zealand, Norway, and the United Kingdom.

for HACCP plan design, control and record keeping procedures, sanitation procedures, and training of employees (Colatore and Caswell 2000). The FDA has acknowledged that the introduction of HACCP has proven to be complex, as many elements were largely unfamiliar to processors, in particular those in major exporting countries. Unnevehr (2000) points out that HACCP systems vary widely among developed countries; this poses challenges for exporting countries.

We hypothesize that all else equal the introduction of mandatory HACCP has had a negative effect on imports of seafood into the United States. If standards act as barriers for developing country exporters, there should be a differential negative effect for these countries when compared to developed countries. Developing country exporters may deflect export flows to other countries because of increased compliance costs for the U.S. market, which deprives them of their comparative trade advantage (World Bank 2005, Debaere 2005). U.S. importers may choose not to buy from developing countries as safety levels may be lower overall or harder to verify. However, if standards act as catalysts for developing countries as a group, we would expect no differential negative effect due to HACCP for these countries. Alternatively, it may be that standards operate as a barrier or catalyst at the country level independent of development status. In this case, we would expect to see differential effects on exports for countries based on country characteristics such as the size of the export industry and whether they already had relatively high food safety standards, could mobilize to meet HACCP requirements, or had lower compliance costs. Further, we examine whether these effects differ in the short run immediately after the new standards went into effect versus the longer term.

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, Wilson, and Otsuki (2001) summarize alternative approaches to estimating the impact of standards in general on trade. Previous studies by Swann, Temple, and Shurmer (1996); van Beers and van den Bergh (1997); Peridy, Guillotreau, and Bernard (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 including standards 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, an econometric approach does not predetermine the direction of the effect of standards, in particular with regard to food safety standards, and other trade determinants. Thus it can be used for various hypothesis tests.

The model uses a variant of the classic gravity equation to analyze the effects of the U.S. HACCP food safety standard on bilateral trade flows. Logarithms of bilateral trade flows, both in real values and quantities, are regressed on the size of each exporting country's seafood sector, introduced as a measure of "mass;" geographical distance;

foreign exchange rate; and U.S. GDP as a proxy for domestic seafood demand. The trade effect of mandatory HACCP in the U.S. is introduced through a policy variable. The model also includes variables that explore the effects of regional trade agreements on seafood trade flows into the United States.

The general gravity model is specified as:

$$\ln Imports_{it}^{x} = \alpha_0 + \alpha_1 (Time) + \alpha_2 (HACCP_{it}) + \alpha_3 \ln(GDP_t) + \alpha_4 \ln(Size_{it}) + \alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_i) + \alpha_7 (MERCOSUR) + \alpha_8 (NAFTA) + \alpha_9 (ASEAN) + \alpha_{10} (APEC) + \alpha_{11} (ANDEAN) + \alpha_{12} \ln(Geo) + \varepsilon_i \quad (1)$$

$Imports^{x}_{it}$ denotes the imports of seafood from country i to the United States in a particular year t for the years 1990-2004 (NMFS 2005a, 2005b). Superscript x stands for either the volume of imports ($Imports^{Q}_{it}$) or the dollar value of imported seafood ($Imports^{\$}_{it}$). The error ε_i is assumed to be normally distributed with mean zero. Table 1 presents definitions and descriptive statistics of the dependent and independent variables. Trade data for Korea and Vietnam were incomplete and dropped yielding a panel-data set of the 33 leading exporters to the U.S.

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; it equals one for 1998 to 2004 and 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 exporting country. It is the sum of seafood imports and exports from the FAO's database "fishstat plus" (FAO 2005). Alternatively, "mass" is measured by *Export*, the value of exports of total goods and services of each country. *Exchange* is the market exchange rate between the U.S. dollar and the domestic currency of each exporting country, while *Distance* is the geographical measure of distance from the United States.

Five variables account for membership in particular regional trade agreements: *MERCOSUR*, *NAFTA*, *ASEAN*, *APEC*, and *ANDEAN*. *Geo* is a classification variable, indicating geographical connection between seafood exporters and the United States that may involve historic ties. As we could not identify clear colonial ties for the United States, this variable has three levels controlling for the omitted variable problem of country ties in trade flow analysis: trade relations with Asian and Pacific countries are captured in *Geo1*, while Latin American countries are included in *Geo2*, and Northern countries are in *Geo3*. South Africa is the only African seafood exporting country in the data set; it is included in the Asia/Pacific country group.

The hypotheses for the signs of the first derivatives of the general model variables are:

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

$$\partial Imports/\partial Export > 0;\ \partial Imports/\partial Exchange < 0;\ \partial Imports/\partial Distance < 0.$$

We hypothesize that all else equal adoption of the *HACCP* standard has had a negative impact on U.S. seafood imports, while increases in *GDP* have had a positive impact. The size of the exporting country's economy (*Size* or *Export*) is hypothesized to have a positive impact, while the foreign exchange rate to the U.S. Dollar *Exchange* is expected to show a negative sign. The impact of geographical *Distance* is hypothesized to be negative. All other signs are ambiguous; there are different hypotheses on the influence of time, trade agreements, and geographical connection.

Empirical Analysis of HACCP Effects on Seafood Imports

The panel of fishery product import data is estimated across 33 exporting countries for the time period 1990-2004 using alternative model specifications based on the general gravity model in equation (1). Tests compare changes in patterns of imports into the United States for all, developed, and developing countries after mandatory HACCP implementation, short-run (1998 to 1999) versus longer-run (1998-2004) effects for developed and developing countries, and individual country level effects.

Model 1 is the benchmark specification of the gravity equation. It controls for the impact of mandatory HACCP requirements for seafood on trade flows into the United States. Other included variables are a time trend (*Time*), the "mass" of the importing country (*GDP*), the size of the exporting country's seafood sector (*Size*), exchange rate (*Exchange*), and the geographical distance (*Distance*):

$$\begin{aligned} \ln Imports_{it}^{x} &= \alpha_0 + \alpha_1(Time) + \alpha_2(HACCP_{it}) + \alpha_3 \ln(GDP_t) + \alpha_3 \ln(Size_{it}) + \\ &\alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_i) + \varepsilon_i \end{aligned} \quad (2)$$

Model 2 adds variables for regional trade agreements (*MERCUSOR*, *NAFTA*, *ASEAN*, *APEC*, and *ANDEAN*) allowing for tests of whether these agreements have significant effects on seafood imports into the Unites States:

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

Model 3 introduces alternative specifications for two types of variables in order to test the robustness of the results. The value of a country's total export of goods and services (*Export*) is used as an alternative to test whether the size of an exporting country had a differential effect on seafood trade with the U.S. The variables *Geo1* and *Geo2* are used as an alternative specification of country-group specific effects on seafood trade previously represented by the regional trade agreement variables. *Geo1* includes Latin American fishery product exporters, *Geo2* is the Asian-Pacific country group, and *Geo3* is Northern European fishery exporters:

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

The panel nature of the data may introduce heterogeneity biases requiring appropriate econometric methods to separate time-series and cross-sectional effects. Initial ordinary least squares panel estimates revealed significant first-order serial correlation. We therefore apply Exact Maximum Likelihood estimators (ExactML). The parameter estimates are corrected for first-order serial correlation of the residuals and stationarity of the time series properties is imposed (Beach and MacKinnon 1978). Given the large number of country-pair relations in the data set taken from a larger population, we treat the corresponding country effects as random. However, Hausman test results are reported with each regression model.

The choice of the estimation procedure is motivated by different factors. First, fixed effect models are inappropriate when time and product invariant variables such as geographical distance are included, because fixed effects estimators eliminate all time invariant variation (Egger and Pfaffermayr 2004; Peridy, Guillotreau, and Bernard 2000). Consequently, random effects estimators are more appropriate given the importance of the distance variable for trade flow analysis. 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. While Otsuki, Wilson, and Sewadeh (2001); Wilson and Otsuki (2004); and Blind and Jungmittag (2005) apply fixed effects models, Egger and Pfaffermayr (2004) and Peridy, Guillotreau, and Bernard (2000), among others, doubt the appropriateness of such models in trade flow analysis. This is especially the case, when time invariant geographical distance variables are included in gravity equations, which is the most prominent example.

Overall Effects of HACCP Implementation

Table 2 presents estimation results for Models 1-3 in two groups. The first uses dollar value of imported seafood as the dependent variable, while the second uses the volume of imported seafood. The random effects estimates of the gravity models are generally well behaved. Double-logarithmic specifications generated the best parameter estimates in all models and allow for the direct interpretation of coefficient elasticities. Statistically significant F-tests reject the null hypothesis of equivalence of OLS and fixed-effects models at the 95-percent level. Fixed-effects models were largely outperformed by random-effects models as indicated by the Hausman tests.

The results presented in Table 2 support the hypothesis that, all else equal, mandatory HACCP implementation had an overall negative and significant effect on seafood imports into the United States. The elasticities of HACCP effects across model specifications are calculated from the estimated model coefficients for this dummy variable using the procedure proposed by Halvorsen and Palmquist (1980) in order to produce a theoretically consistent interpretation of the estimated magnitudes. HACCP elasticities range from -0.13 to -0.35 percent with respect to the value of imported seafood products. This effect translates to an average annual loss in trade value of $11.4 and $30.6 million, respectively. Import volumes declined up to -0.34 percent or an average decrease of 5,535 metric tons. Thus for importers as a whole HACCP posed a significant barrier to selling into the U.S. market. In comparison, the gravity equation panel model of Peridy, Guillotreau, and Bernard (2000) shows a significantly negative but rather marginal (-0.092) impact of trade barriers on aggregate seafood imports into France from 1988-1994.

The benchmark Model 1 and alternative Models 2 and 3 support a positive time trend in seafood imports into the United States with respect to both values and quantities of seafood. Real GDP per capita, as a proxy of U.S. per-capita demand, shows a similar effect. Our results indicate that a one percent increase in U.S. per-capita GDP led to a 0.59 percent increase in the value of seafood imports. The magnitude of the volume effect on seafood imports with an increase of up to 0.53 percent is of similar magnitude.

The geographical distance variable shows the hypothesized negative effect on seafood trade in all model specifications with the exception of Model 2 for the dollar value of imports. The elasticity estimates indicate trade effects from increasing transport and transaction costs. However, the magnitudes of these distance effects tend to be lower then those of Peridy, Guillotreau, and Bernard (2000) who report a significant distance elasticity of -0.742 for seafood imports into France.

The 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 the total value of fishery trade, has a significant and positive effect on its ability to penetrate the U.S. market. This trade facilitating effect is confirmed in the alternative specifications for the dollar value of total exports in goods and services (*Export*) as a proxy of country i's export orientation. A one percent increase in a country's value of total exports is associated with an increase of seafood exports (value and volume) of around 0.32 percent.

The effect of the foreign exchange rate to the U.S. dollar on seafood imports are inconclusive across model specifications. This contrasts with a theoretically plausible and significant positive exchange rate elasticity of 0.97 reported by Martínez-Zarzoso and Nowak-Lehmann (2004) for seafood exports by MERCOSUR countries. Peridy, Guillotreau, and Bernard (2000) report a nominal exchange rate elasticity of -0.54.

The inclusion of regional trade agreement and geographical classification variables in Models 2 and 3 provide insights into important factors that impact seafood trade flows. To the best of our knowledge this study is the first to explore the effects of regional trade agreements and geographical connections among countries on seafood trade flows. The results indicate that these factors are significant in explaining flows of seafood exports to the United States. For both dependent variables the results reveal significant positive effects of relevant trade agreements. NAFTA has the greatest positive impact of 9.5 percent on the value of U.S. seafood imports, while exports of APEC-members are about 2.6 percent higher in terms of volumes[3].

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. Their

[3]Due to insignificant results the variable *MERCOSUR* was been dropped from Model 2 for both specifications of the independent variable.

export advantage is 1.7 percent in value of product and 2.5 percent in export volume. In contrast, the group of Asian/Pacific countries (*Geo2*) has a smaller positive competitive advantage compared to their European competitors.

Developing and Developed Country Effects of HACCP Implementation

To specifically address the “standards-as-barriers” versus “standards-as-catalysts” views, we test for differential HACCP effects between developing and developed countries with separate panel regressions of the benchmark Model 1. The model allows a focus on the differential impact of HACCP on country groups and countries, while accounting for other major factors that affect seafood trade with the U.S.

The “standards as barriers” view hypothesizes a differential negative effect of HACCP adoption for developing countries. In contrast, developed countries, which largely account for the enforcement of enhanced food quality and safety standards, may experience a less negative or a positive effect of HACCP introduction on exports to the U.S. Industrialized countries are assumed to have the resources to adapt more quickly to increases in standards. Moreover, a drop in exports from developing countries in the post-HACCP period may allow developed countries to add market share in seafood trade with the United States.

The estimates of HACCP elasticities for U.S. seafood imports for the entire period of 1990-2004 (referred to as the long run) from all, developing, and developed countries are reported in the upper panel of table 3. As discussed above, HACCP implementation had a significantly negative effect on trade flows across all exporting countries when measured over the entire long-run time period from 1990-2004 and with controls for other determinants of seafood trade such as time, GDP, distance, and export orientation.

Similarly, the point elasticities of the HACCP trade-flow effects for developing countries are consistently negative and significant over this period. Parameter values indicate decreased trade flows to the U.S. that exceed overall HACCP impact levels for all countries. Developing countries' relative loss in seafood trade with the U.S. is -0.9 percent of export value, while export volumes dropped about -0.6 percent. This translates to an average annual loss in export value of $56.6 million and an average drop in volume of 7,885 metric tons. In contrast, the effect for developed countries is positive but not statistically significant for the dollar value of imports and positive and significant in terms of volume of seafood imports, which increased by about 0.5 percent or equivalently 2,244 metric tons.

Comparing results, Otsuki, Wilson, and Sewadeh (2001) also found a negative impact of stricter standards on exports to the EU from developing countries in Africa. Their elasticity estimate indicates that tighter standards for Aflatoxin B1 in the EU resulted in significant negative trade-flow effects for imports of fruits, nuts, and vegetables from African countries. Wilson and Otsuki (2004) found a significant negative elasticity effect on imports from the introduction by the EU of a new pesticide standard for bananas. European banana imports rise by 1.6 percent with a decrease in the level of standards stringency of one percent. Overall, these results support the finding that enhanced food safety standards in developed countries can act as barriers resulting in significant reductions in exports from developing countries.

For countries with limited investment resources, it could be argued that the successful adoption of food safety standards is a matter of time. For example, Donovan, Caswell, and Salay (2001) report a transition period of two months up to five years for the implementation and full compliance with HACCP standards in the Brazilian fishery processing industry As a consequence, countries that are immediately in compliance may expand their market shares at the expense of to those who are not—at least in the short run.

To explore differential effects over time, we compare HACCP elasticities estimated over the entire longer-run period 1990-2004, which includes seven years under the HACCP requirement (shown in the upper panel of table 3), to those over the shorter run period 1990-1999 (shown in the lower panel of table 3), which includes the first two years of the HACCP requirement. The results reveal significant differences in the magnitude of HACCP effects between the long and short run. For all countries, the short-run HACCP elasticities are of greater magnitude for both the dollar value and volume of seafood imports. The overall long term pattern of a negative HACCP effect on developing and a positive effect on developed countries holds in the short term as well. Moreover, the results do not show that the negative effect for developing countries began to be mitigated in the longer run; the HACPP effects for the two periods do not show a significant difference. Overall, the results based on comparisons of developing versus developed countries as groups support the hypothesis of "standards as barriers."

Country-Specific Effects of HACCP Implementation

While the previous results support the "standards-as-barriers" hypothesis, these results may mask differences in country-level effects within the developing and developed country groups. Henson, Brouder, and Mitullah (2000) and Henson and Mittulah (2004) suggest that a number of seafood exporting countries have experienced considerable problems of complying with food safety requirements. At the same time, other countries have managed to comply and increase market shares in high-value markets despite the existence and enforcement of stricter standards.

We estimated pooled time-series cross-section regressions of the country-level effects of HACCP requirements using the benchmark Model 1 by combining the random and fixed HACCP effects of the 33 countries exporting to the U.S. This allows estimation of the country-specific impact of HACCP enforcement, accounting for the combined random- and fixed-effect impact of HACCP on each country when other major determinants of seafood trade are controlled. Table 4 shows country-level pre-HACCP seafood imports and estimates of the short-run (1990-1999) and long run (1990-2004) trade flow effects of HACCP. These effects are heterogeneous among developing and developed countries, and in some cases in the short versus the long run.

A surprisingly clear pattern of individual country trade responses emerges based on the pre-HACCP size of the country's seafood exports to the United States. The larger exporters gained from the introduction of stricter food-safety regulations. Twelve of the top 15 suppliers of seafood to the U.S. had strictly increasing trade flow patterns in the short- and long-run post-HACCP periods. In contrast, ten of the 18 smaller exporters experienced negative short- and long-run HACCP effects, while an additional 4 experienced a negative long-term effect. Developing and developed countries are both fully represented among the large and small exporters, and thus among the gainers and losers, in the post-HACCP adoption period.

Comparison of short- and long-term effects at the country level underscores that the aggregate analysis that shows developing countries losing and developed countries gaining under HACCP may be misleading. Among the 25 developing countries that were in the top 33 exporters to the U.S., 10 showed long-term gains and 15 showed losses under HACCP, all else equal. As noted, gainers are concentrated among large exporters and losers among small exporters. Among these smaller exporters, the magnitudes of negative trade flow effects across developing countries range from -$6.9 to -$44.8 million based on the 1997 pre-HACCP export values of seafood products. Meanwhile, among the 8 developed countries 6 showed gains and 2 losses in the long-run.

While the HACCP effect for developed countries was predominantly positive, developing countries had a mixed experience. Considered on a country level, neither the “standards-as-barriers” or “standards-as-catalysts” hypothesis fits developing countries as a whole. Instead, the data suggest that among developing countries increased standards act as a catalyst for larger, more established exporting countries and a barrier for smaller exporters. To our knowledge, this analysis is the first to present estimates of the country-specific impacts of stricter food-safety standards across a broad panel of bilateral trade relations with the U.S. Analyzing trade effects at a disaggregate, country level provides valuable information on the impacts of stricter food-safety regulations that is not available from a more aggregate analysis.

Conclusions

Foodborne safety risks associated with domestic and imported seafood products motivated the introduction of 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 such as this are intended to reduce potential risks. However, they can also create non-tariff trade barriers and significant trade redirections. 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 products. We apply panel-data on seafood imports to the U.S. by the 33 largest exporting countries between 1990 and 2004. Twenty-five of these countries are developing, while 8 are developed. The results of extended gravity models indicate a significantly negative impact of the HACCP standard on U.S. seafood imports across all 33 exporting countries. The results are robust in terms of product values and trade volumes. Comparison of trade effects for developing versus developed countries at an aggregate level supports the "standards-as-barriers" hypothesis. While developing countries as a group suffered significant trade reductions under HACCP, developed countries, again as a group, gained under HACCP.

A different picture emerges, however, based on estimates of country-specific HACCP impacts. These reveal considerable differences across countries with regard to the pattern of short- and long-run post-HACCP trade-flow effects. A clear majority of the larger seafood exporting countries gained increasing trade with the U.S., all else equal, in the post HACCP period. In contrast, most smaller exporters experienced short- and long-run trade losses after the U.S. HACCP standard was adopted. Developing countries were among both groups, suggesting that "standards-as-catalysts" applies to larger, more established exporters among developing countries and "standards-as-barriers" to smaller exporters.

Overall, the results emphasize the importance of more detailed quantitative economic modeling to inform the discussion of the role of food safety standards as non-tariff barriers in international trade, especially for developing countries. Economic analysis of the trade effects of increased food safety measures can be useful in the development of more effective food safety systems, in particular by developed countries. Such analysis can also support measurement of the welfare effects of food safety standards for individual developing countries.

References

Alberini, A., E. Lichtenberg, D. Mancini, and G.I. Galinato. 2005. "Was It Something I Ate? Implementation of the FDA Seafood HACCP Program." Working Paper WP 05-03, Dept. of Agr. and Res. Econ., University of Maryland, College Park.

Beach, C.M., and J.G. MacKinnon. 1978. "A Maximum Likelihood Procedure for Regression with Autocorrelated Errors." *Econometrica* 46:51-58.

Bergstrand, J.H. 1989. "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence." *Review of Economics and Statistics* 23:143-153.

Blind, G., and A. Jungmittag. 2005. "Trade and the Impact of Innovations and Standards: The Case of Germany and the UK." *Applied Economics* 37:1385-1398.

Buzby, J.C., ed. 2003. *International Trade and Food Safety: Economic Theory and Case Studies*. Washington DC: U.S. Department of Agriculture, ERS Agr. Econ. Rep. 828, November.

Calvin, L., and B. Krissoff. 1998. "Technical Barriers to Trade: A Case Study of Phytosanitary Barriers and U.S.-Japanese Apple Trade." *Journal of Agricultural and Resource Economics* 23:351-366.

Carrere, C. 2006. "Revisiting the Effects of Regional Trade Agreements on Trade Flows with Proper Specification of the Gravity Model." *European Economic Review* 50: 223-247.

Caswell, J.A., and C.F. Bach. Forthcoming. "Ethics, Globalization, and Hunger: Food Safety Standards in Rich and Poor Countries." In Per Pinstrup-Anderson, ed. *Ethics,* *Globalization, and Hunger: In Search of Appropriate Policies*. New York, NY: Springer Publishing Company.

Cato, J.C., and C.A. Lima dos Santos. 1998. "European Union 1997 Seafood-Safety Ban: The Economic Impact on Bangladesh Shrimp Processing." *Marine Resource Economics* 13:215-227.

Colatore, C., and J.A. Caswell. 2000. "The Cost of HACCP Implementation in the Seafood Industry: A Case Study of Breaded Fish." In L. Unnevehr, ed. *The Economics of HACCP: Costs and Benefits*. St. Paul, MN: Eagan Press, pp. 45-68.

Debaere, P. 2005. "Small Fish - Big Issues: The Effect of Trade Policy on the Global Shrimp Market." Discussion Paper No. 5254, Center for Economic Policy Research, London, UK.

Disdier, A.-C., and K. Head. 2005. "The Puzzling Persistence of the Distance Effect on Bilateral Trade." Working Paper, University of British Columbia, Canada.

Donovan, J.A., J.A. Caswell, and E. Salay. 2001. "The Effect of Stricter Foreign Regulations on Food Safety Levels in Developing Countries: A Study of Brazil." *Review of Agricultural Economics* 23:163-175.

Egger, P., and M. Pfaffermayr. 2004. "Distance, Trade and FDI: A Hausman-Taylor SUR Approach." *Journal of Applied Econometrics* 19:227-246.

Evenett, S.J., and W. Keller. 1998. "On Theories Explaining the Success of the Gravity Equation." Working Paper No. 6529, National Bureau of Economic Research, Cambridge, MA.

FAO. Food and Agriculture Organization. 2004. "The State of World Fisheries and Aquaculture 2004." (SOFIA), www.fao.org/documents/show_cdr.asp?url_file =/docrep/007/y5600e/y5600e00.htm

FAO. Food and Agriculture Organization. 2005. "FISHSTAT Plus: Universal Software for Fishery Statistical Time Series." Fisheries Commodities Production and Trade 1976-2003, FAO Fisheries, FIGIS (FAO Fisheries Global Information System), Available at: http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp

Garcia-Martinez, M., and N. Poole. 2004. "The Development of Private Fresh Produce Safety Standards: Implications for Developing Mediterranean Exporting Countries." *Food Policy* 29:229-255.

Halvorsen, R., and R. Palmquist. 1980. "The Interpretation of Dummy Variables in Semilogarithmic Equations." *American Economic Review* 70:474-475.

Henson, S., and W. Mittulah. 2004. "Kenyan Exports of Nile Perch: The Impact of Food Safety Standards on an Export-Oriented Supply Chain." Policy Research Working Paper 3349, The World Bank, Washington, DC.

Henson, S., A.M. Brouder, and W. Mitullah. 2000. "Food Safety Requirements and Food Exports from Developing Countries: The Case of Fish Exports from Kenya to the European Union." *American Journal of Agricultural Economics* 82:1159-1169.

Jaffee, S., and S. Henson. 2004. "Standards and Agro-Food Exports from Developing Countries: Rebalancing the Debate." Policy Research Working Paper 3348, The World Bank, Washington, DC.

Leamer. E.E. 1994. "Vector Autoregressions for Causal Inference? The Methodology of Econometrics." Elgar Reference Collection. *International Library of Critical Writings in Econometrics*. Aldershot, U.K.: Elgar, Vol. 6, Vol. 2, pp. 77-125,

Josling, T., D. Roberts, and D. Orden. 2004. *Food Regulation and Trade: Toward a Safe and Open Global System*. Washington, D.C.: Institute for International Economics.

Maertens, M., and F.M. Swinnen. 2006. "Trade, Standards, and Poverty: Evidence from Senegal." Discussion Paper 177/2006, LICOS Centre for Institutions and Economic Performance & Department of Economics, University of Leuven, Belgium.

Martínez-Zarzoso, I., and F.D. Nowak-Lehmann. 2004. "MERCOSUR-European Union Trade: How Important is EU-Trade Liberalisation for MERCOSUR's Exports?" Discussion Paper No. 30, Center for Globalization and Europeanization of the Economy, Georg-August-University Goettingen, Goettingen, Germany.

Maskus, K.E., T. Otsuki, and J.S. Wilson. 2005. "The Cost of Compliance with Product Standards for Firms in Developing Countries: An Econometric Study." Policy Research Working Paper 3590, The World Bank, Washington, DC.

Maskus, K.E., J.S. Wilson, and T. Otsuki. 2001. "An Empirical Framework for Analyzing Technical Regulations and Trade." In K.E. Maskus, and J.S. Wilson, eds. *Quantifying Trade Effect of Technical Barriers: Can it be Done?* Ann Arbor, MI: University of Michigan Press.

Mead, P.S., L. Slutsker, V. Dietz, L.F. McCaig, J.S. Bresee, C. Shapiro, P.M. Griffin, and R.V. Tauxe. 1999. "Food-Related Illness and Death in the United States. *Emerging Infectious Diseases* 5:607-625.

NMFS. National Marine Fisheries Service. 2005a. “Foreign Trade Information: 1990-2004.” Office of Science and Technology, Fisheries Statistics & Economics Division.

NMFS. National Marine Fisheries Service. 2005b. “Imports and Exports of Fishery Products: Annual Summary 1990-2004.” Office of Science and Technology, Fisheries Statistics & Economics Division.

Otsuki, T., J.S. Wilson, and M. Sewadeh. 2001. “Saving Two in a Billion: Quantifying the Trade Effect of European Food Safety Standards on African Exports.” *Food Policy* 26:495-514.

Paarlberg, P.L., and J.G. Lee. 1998. “Import Restrictions in the Presence of a Health Risk: An Illustration Using FMD.” *American Journal of Agricultural Economics* 80:175-183.

Peridy, N., P. Guillotreau, and P. Bernard. 2000. “The Impact of Prices on Seafood Trade: A Panel Data Analysis of the French Seafood Market.” *Marine Resource Economics* 15:45-66.

Peterson, E.B., and D. Orden. 2005. “Effects of Tariffs and Sanitary Barriers on High- and Low-Value Poultry Trade” *Journal of Agricultural and Resource Economics* 30(1): 109-127.

Pinstrup-Andersen, P. 2000. “Food Policy Research for Developing Countries: Emerging Issues and Unfinished Business.” *Food Policy* 25:125-141.

Swann, P., P. Temple, and M. Shurmer. 1996. “Standards and Trade Performance: The UK Experience.” *The Economic Journal* 106:1297-1313.

Unnevehr, L.J., ed. 2003. *Food Safety in Food Security and Food Trade*. Washington, DC: International Food Policy Research Institute (IFPRI).

Unnevehr, L.J. 2000. "Food Safety Issues and Fresh Food Product Exports from LDCs." *Agricultural Economics* 23:231-240.

U.S. GAO (General Accounting Office). 2001. *Food Safety: Federal Oversight of Seafood Does Not Sufficiently Protect Consumers*. Report to the Committee on Agriculture, Nutrition, and Forestry, U.S. Senate, GAO-01-204, January 2001.

U.S. GAO. General Accounting Office. 2004. *FDA's Imported Seafood Safety Program Shows Some Progress, but Further Improvements Are Needed*. Report to Congressional Requesters, U.S. Senate, GAO-04-246, January 2004.

USDA/FAS (FASonline). 2004. "Export/Import Statistics for Bulk, Intermediate, and Consumer Oriented Foods and Beverages." BICO Reports: 1996-2004, http://www.fas.usda.gov/scriptsw/bico/bico_frm.asp.

van Beers, C., and C.J.M. van den Bergh. 1997. "An Empirical Multi-Country Analysis of the Impact of Environmental Regulations on Foreign Trade Flows." *Kyklos* 50:29-46.

Wilson, J.S., and T. Otsuki. 2004. "To Spray or not to Spray: Pesticides, Banana Exports, and Food Safety." *Food Policy* 29:131-146.

World Bank. 2005. "Food Safety and Agricultural Health Standards: Challenges and Opportunities for Developing Country Exports." Report No. 31027, Poverty Reduction & Economic Management Trade Unit, Agriculture and Rural Development Department, The World Bank, Washington, DC.

Table 1: Definitions of Variables and Sample Statistics

Variables	Variable Description	Mean	Standard Deviation
Dependent Variables			
$Imports^{Q}_{it}$	Annual volume of imported seafood into the United States by country i (Million metric tons)	42.77	66.57
$Imports^{\$}_{it}$	Value of annual seafood imports into the United States by country i (Million U.S. Dollars)	216.37	343.70
Independent Variables			
Time	Trend 1990-2004	8.27	4.67
$HACCP_t$	Introduction and enforcement of mandatory HACCP standards in U.S. seafood (1998-2004 = 1)	0.47	0.50
GDP_t	Real per-capita U.S. GDP (1000 US $)	29.53	7.01
$Size_{it}$	Total annual volume of seafood imports and exports of country i (Million metric tons)	1.43	1.51
$Export_{it}$	Annual export value of total goods and services of country i (Billion US Dollars)	60.58	95.05
$Distance_i$	Geographical distance between country i and the U.S. (Thousand Miles)	4.92	2.97
$Exchange_{it}$	Real exchange rate between US$ and domestic currency i (value of one dollar in terms of domestic currency i)	697.50	2706.34
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
ANDEAN	Dummy variable for ANDEAN member countries: Colombia, Ecuador, Peru, Venezuela	0.12	0.32

Table 2: Gravity Model Estimates of HACCP Impacts on U.S. Seafood Imports, 1990-2004[a]

	Dollar Value of Imported Seafood			Volume of Imported Seafood		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Time	0.013[*b] (1.74)[c]	0.029*** (3.71)	0.019*** (2.67)	0.030*** (2.60)	0.039*** (3.84)	0.015 (1.27)
HACCP	-0.434*** (-3.01)	-0.334** (-2.31)	-0.144 (-0.97)	-0.420*** (-3.29)	-0.317*** (-2.73)	-0.087 (-0.67)
GDP	0.593*** (16.56)	0.361*** (8.65)	0.103*** (3.75)	0.528*** (12.62)	0.344*** (7.50)	-0.012 (-0.38)
Distance	-0.133 (-1.54)	0.336*** (0.2.60)	-0.657*** (-5.01)	-0.110 (-1.10)	-0.179 (-1.40)	-0.579*** (-3.71)
Exchange	-0.028 (-1.22)	-0.027 (-0.92)	0.039 (1.50)	0.007 (0.28)	-0.007 (-0.02)	0.046 (1.47)
Size	0.376*** (10.16)	0.336*** (2.60)		0.426*** (9.76)	0.257*** (5.68)	
Export			0.323*** (7.60)			0.314*** (6.12)
NAFTA		2.35*** (6.61)			0.724** (2.14)	
ASEAN		0.530** (2.57)			0.813*** (3.69)	
APEC		0.692*** (3.57)			1.28*** (6.16)	
ANDEAN		0.645*** (2.64)			0.362 (1.40)	
GEO1			1.002*** (4.12)			1.260*** (4.42)
GEO2			-0.053 (-0.24)			0.826*** (34.98)
Rho ρ	0.83	0.85	0.85	0.79	0.83	0.82
DW	1.80	1.58	1.66	1.74	1.76	1.74
Hausman	0.70	4.73	0.12	0.15	0.81	0.14
Adj. R^2	0.76	0.77	0.76	0.74	0.78	0.72
No.	492	492	492	492	492	492
F[d]	19.97	16.93	25.42	17.25	14.81	23.82

[a] Random effect estimates corrected for first-order serial autocorrelation. t-statistics (in parentheses) computed with White's heteroscedasticity-consistent standard errors. Critical F value computed according to Leamer (1994, p.114).
***, ** and * statistically significant at the 99%, 95%, and 90% levels, respectively.

Table 3: Overall, Short-, and Long-Run Elasticities of HACCP Effects for All, Developing, and Developed Countries[a]

Estimates of HACCP Elasticities		All Countries	Developing Countries	Developed Countries
1990-2004 (Long Run)	Dollar Value of U.S. Seafood Imports	-0.434*** (-3.01)	-0.921** (-2.23)	0.271 (1.58)
	Volume of U.S. Seafood Imports	-0.420*** (-3.29)	-0.645*** (5.32)	0.496** (2.52)
19990-1999 (Short Run)	Dollar Value of U.S. Seafood Imports	-0.613*** (-3.70)	-0.866* (-1.72)	0.210 (1.42)
	Volume of U.S. Seafood Imports	-0.604*** (-4.41)	-0.709*** (-4.88)	0.449** (2.51)

[a] ExactML random effect estimates of HACCP elasticities based on Model 1 for 1990-2004 (the long run) and 1990-1999 (the short run) sub samples of the panel data set. Results are corrected for first-order serial correlation. t-statistics (in parentheses) computed using White's heteroscedasticity-consistent standard errors.

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

Table 4: Magnitudes of Country-Specific HACCP Effects on U.S. Seafood Sales[a]

	Pre- HACCP Imports to the U.S. (1997)		Short-Run (1998-1999)[b]		Long-Run (1998-2004)	
Country	Rank	(US$ million)	HACCP Impact (US$ million)	Change (%)	HACCP Impact (US$ million)	Change (%)
Canada	1	1305.92	383.1	+29.3	511.47	+39.2
Thailand	2	1166.99	357.27	+30.6	433.95	+37.2
Ecuador	3	714.87	126.12	+17.6	131.85	+18.4
Mexico	4	492.19	113.49	+23.1	72.66	+14.8
China	5	321.19	42.67	+13.3	159.80	+49.7
Chile	6	316.74	76.64	+24.2	231.73	+73.2
Indonesia	7	251.10	46.14	+18.4	160.81	+64.0
Russia	8	230.12	-61.53	-26.7	-31.47	-13.7
Japan	9	203.88	29.48	+14.5	41.32	+20.3
Taiwan	10	187.34	-26.36	-14.1	-15.04	-8.0
Iceland	11	184.30	27.71	+15.0	15.09	+0.8
India	12	170.86	34.34	+20.1	89.15	+52.2
Philippines	13	139.84	36.23	+25.9	59.93	+42.9
Bangladesh	14	134.32	-19.83	-14.8	-43.09	-32.1
New Zealand	15	133.22	17.71	+13.3	53.79	+40.4
Norway	16	125.50	-38.6	-30.8	-81.13	-64.4
Panama	17	112.99	-13.11	-11.6	-18.28	-16.2
Venezuela	18	99.70	-12.89	-12.9	-28.33	-28.4
Honduras	19	99.39	14.68	+14.8	3.11	+0.3
Argentina	20	88.79	0.04	+0.05	-12.81	-14.4
Singapore	21	75.16	-3.81	-5.1	-24.46	-32.5
Costa Rica	22	73.60	0.51	+0.7	-6.86	-9.3
Nicaragua	23	71.39	-10.87	-15.2	-7.79	-10.9
Brazil	24	69.58	1.46	+2.1	33.09	+47.6
Peru	25	65.77	-22.01	-33.7	-44.76	-68.1
Australia	26	53.95	5.37	+9.9	42.80	+99.4
Bahamas	27	39.30	-2.85	-7.1	-13.90	-34.8
Colombia	28	37.02	-9.11	-24.6	-14.39	-38.9
South Africa	29	31.06	3.77	+12.1	-13.21	-42.5
Trinidad and Tobago	30	29.02	2.94	+10.1	-13.22	-45.6
Guyana	31	28.20	-2.16	-7.7	-10.61	-37.6
United Kingdom	32	19.50	-2.92	-14.9	+4.95	+25.4
Denmark	33	17.53	-5.5	-29.7	-8.48	-48.4

[a] Results are obtained through ExactML pooled panel regressions corrected for serial correlation. t-statistics (in parentheses) computed with White's heteroscedasticity-consistent standard errors.
[b] Calculations based on pooled panel regression of benchmark Model 1 for value of seafood imports, n = 330.
[c] Calculation of HACCP effects based on pooled panel regressions of model 1a, n = 495.
[***], [**] and [*] statistically significant at the 99%-, 95%-and 90%-level, respectively.