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Sven M. Anders and Julie A. Caswell

The United States mandated a Hazard Analysis Critical Control Points (HACCP) food safety standard for seafood in 1997. Panel model results for 1990 to 2004 suggest that HACCP introduction had a negative and significant impact on overall imports from the top thirty-three suppliers. While the effect for developed countries was positive, the negative effect for developing countries supports the view of "standards as barriers" versus "standards as catalysts." A different perspective emerges from individual country-level analysis. Regardless of development status, leading seafood exporters generally experienced a positive HACCP effect, while most other smaller trading partners faced a negative effect.

Key words: developed and developing countries, food standards, international trade.

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. 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, the conventional wisdom in the literature held that such standards in developed countries amount to "standards as barriers" to trade that are frequently used as protectionist tools that disadvantage developing countries. A more recent and less pessimistic view emphasizes the opportunities provided by emerging food safety standards 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 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 United States by the thirty-five largest seafood exporting countries, of which twenty-six are developing and nine developed countries. The data set includes the pre-HACCP period 1990–97 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.

Food Safety and Trade: Empirical Evidence

There is a fairly extensive literature on the general effects of food safety standards and the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) under the World Trade Organization (WTO) on developing countries. For example,

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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 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 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 standards, markets, products, and countries.

To date, only a few studies 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 more stringent food 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 MERCOSUR countries in a liberalized European Union (EU) market. 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.

Debaere (2005) empirically investigates the impact of changing trade policies, in particular the EU zero tolerance policy for antibiotics, on the global shrimp market. He shows that the EU policy, mainly the loss of Thailand's preferential status in the EU, enforced differences in international safety standards leading to a disruption of trade flows from Europe toward the United States. This led to a significant decrease in U.S. shrimp prices and caused a U.S. antidumping 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 safety regulations.

Whether food safety standards operate predominantly as barriers or catalysts is largely unresolved in the empirical work to date. 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 fifteen years (NMFS 2005b). Seafood from foreign countries is filling a growing share of the U.S. seafood market, which has grown over 50% since 1980.

By 1998 imported seafood comprised 63% of U.S. consumption. The share of imports reached a peak of 76% of edible seafood consumption in 2002 (NMFS 2005b). Import volume has increased from 1997 to 2004 for both developing and developed countries. Out of the largest thirty-five seafood exporters that supplied approximately 95% of the U.S. imports from 1996 to 2004, twenty-six are developing countries[1] that account for 71% of edible seafood imports (USDA/FAS 2004) and nine

[1] Argentina, Bahamas, Bangladesh, Brazil, Chile, China, Colombia, Costa Rica, Ecuador, Guyana, Honduras, India, Indonesia, Korea, Mexico, Nicaragua, Panama, Peru, Philippines, Russian Federation, South Africa, Taiwan, Thailand, Trinidad and Tobago, Venezuela, and Viet Nam.

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% of the total worldwide value of seafood exports (FAO 2004).

In 1997, a mandatory HACCP requirement was adopted for the seafood industry in the United States. We hypothesize that, all else equal, the introduction of mandatory HACCP had a negative effect on U.S. seafood imports. If standards act as barriers for developing country exporters, there should be a differential negative effect for these countries when compared to developed countries. 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.

Our model uses a variant of the classic gravity equation to analyze the effects of the U.S. HACCP food safety standard on logarithms of bilateral trade flows. The general gravity model is specified as

(1)

$$
\begin{aligned}
\ln \mathit{Imports}_{it}^{x} &= \alpha_0 + \alpha_1(\mathit{Time}_t) + \alpha_2(\mathit{HACCP}_{it}) \\
&\quad + \alpha_3 \ln(\mathit{GDP}_t) + \alpha_4 \ln(\mathit{Size}_{it}) \\
&\quad + \alpha_5 \ln(\mathit{Exchange}_{it}) + \alpha_6 \ln(\mathit{Distance}_i) \\
&\quad + \alpha_7 (\mathit{MERCOSUR}_i) + \alpha_8 (\mathit{NAFTA}_i) \\
&\quad + \alpha_9 \ln(\mathit{ASEAN}_i) + \alpha_{10} \ln(\mathit{APEC}_i) \\
&\quad + \alpha_{11} \ln(\mathit{ANDEAN}_i) + \alpha_{12} \ln(\mathit{GEO}_i) + \varepsilon_i .
\end{aligned}
$$

Table 1 presents definitions and descriptive statistics of the dependent and independent variables. $\mathit{Imports}_{it}^{x}$ 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 ($\mathit{Imports}_{it}^{Q}$) or the dollar value of imported seafood ($\mathit{Imports}_{it}^{\$}$). The error ε_i is assumed to be normally distributed with mean zero. Trade data for Korea and Vietnam were incomplete and dropped, yielding a panel data set of the thirty-three leading exporters to the United States.

Time has the value one to fourteen for the fourteen years of observations. *HACCP* reflects the implementation and enforcement of HACCP requirements by FDA; it equals one for 1998 to 2004 and zero in previous years. Ideally, a more fine-grained policy variable would be desirable that captures how effectively and quickly HACCP requirements were put in place in different exporting countries and how effective import inspection systems were in determining compliance with HACCP. However, data do not exist for such a variable. Here, *GDP*, as a proxy for U.S. seafood demand, is the real per capita GDP of the United States in 2000 U.S. dollars, and *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 FAO's database (FAO 2005).[3] 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, and *Distance*

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

[3] Using *Size* as a measure of an exporting country's significance in seafood trade with the United States, a common variable in gravity models, may cause endogeneity problems and potentially bias HACCP estimates. The coefficient of correlation between *Size* and the value (volume) of shipments to the United States from country i is 0.34 (0.38). However, when we instrument for *Size* using *Export*, the instrumental variable model estimates of HACCP effects were largely unchanged.

Table 1. Definitions of Variables and Sample Statistics

Variables	Variable Description	Mean	Standard Deviation
	Dependent Variables		
$Imports^x_{it}$	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		
$Time_t$	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 (1,000 U.S. $)	29.53	7.01
$Size_{it}$	Total annual volume of seafood imports and exports of country *i* (million metric tons)	143.16	1.51
$Export_{it}$	Annual export value of total goods and services of country *i* (billion U.S. $)	60.58	95.05
$Exchange_{it}$	Real exchange rate between U.S. $ and domestic currency *i* (value of one dollar in terms of domestic currency *i*)	697.50	2,706.34
$Distance_i$	Geographical distance between country *i* and the United States (thousand miles)	4.92	2.97
$MERCOSUR_i$	Dummy variable for MERCOSUR member countries: Argentina, Brazil	0.06	0.24
$NAFTA_i$	Dummy variable for NAFTA members countries: Mexico, Canada	0.04	0.21
$ASEAN_i$	Dummy variable for ASEAN member countries: Indonesia, Philippines, Singapore, Thailand	0.12	0.32
$APEC_i$	Dummy variable for APEC member countries: Australia, Canada, Chile, China, Indonesia, Japan, Mexico, New Zealand, Peru, Philippines, Russia, Singapore, Taiwan, Thailand	0.37	0.48
$ANDEAN_i$	Dummy variable for ANDEAN member countries: Colombia, Ecuador, Peru, Venezuela	0.12	0.32
Geo_i	Geographical connection between fishery exporting countries (South America = 1; Australasia = 2; Europe and Canada = 3)	1.76	0.73

is the geographical measure of distance from the United States.

Five variables account for membership in regional trade agreements: *MERCOSUR*, *NAFTA*, *ASEAN*, *APEC*, and *ANDEAN*; they equal one in years when the agreement was in force in country *i* and zero otherwise. Also, *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 groups of geographically homogeneous countries controlling for the omitted variable problem of country ties in trade flow analysis: South American countries are captured in *Geo1*, Australasian countries are included in *Geo2*, and European countries and Canada are in *Geo3*. South Africa is the only African seafood exporting country in the data set; it is included in the Australasian country group.

Regarding the signs of the first derivatives of the independent variables, we hypothesize that, all else equal, adoption of the *HACCP* standard has had a negative impact on U.S. seafood imports, while increases in U.S. *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 thirty-three exporting countries for the time period 1990–2004 using alternative model specifications based on the general gravity model in equation (1). 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*), a proxy for U.S. seafood demand (*GDP*), the size of the exporting country's seafood sector (*Size*), exchange rate (*Exchange*), and geographical distance (*Distance*):

(2)

$$\begin{aligned}\ln Imports^x_{it} &= \alpha_0 + \alpha_1(Time_t) + \alpha_2(HACCP_{it}) \\ &\quad + \alpha_3 \ln(GDP_t) + \alpha_3 \ln(Size_{it}) \\ &\quad + \alpha_5 \ln(Exchange_{it}) \\ &\quad + \alpha_6 \ln(Distance_i) + \varepsilon_i .\end{aligned}$$

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

(3)

$$\begin{aligned}\ln Imports^x_{it} &= \alpha_0 + \alpha_1(Time_t) + \alpha_2(HACCP_{it}) \\ &\quad + \alpha_3 \ln(GDP_t) + \alpha_4 \ln(Size_{it}) \\ &\quad + \alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_i) \\ &\quad + \alpha_7(MERCOSUR_i) + \alpha_8(NAFTA_i) \\ &\quad + \alpha_9(ASEAN_i) + \alpha_{10}(APEC_i) \\ &\quad + \alpha_{11}(ANDEAN_i) + \varepsilon_i .\end{aligned}$$

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 United States. 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:

(4)

$$\begin{aligned}\ln Imports^x_{it} &= \alpha_0 + \alpha_1(Time_t) + \alpha_2(HACCP_{it}) \\ &\quad + \alpha_3 \ln(GDP_t) + \alpha_4 \ln(Export_{it}) \\ &\quad + \alpha_5 \ln(Exchange_{it}) + \alpha_6 \ln(Distance_i) \\ &\quad + \alpha_7(Geo1_i) + \alpha_8(Geo2_i) + \varepsilon_i .\end{aligned}$$

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 (OLS) 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 (Peridy, Guillotreau, and Bernard 2000; Egger and Pfaffermayr 2004). 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.

Table 2. Gravity Model Random-Effects 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	0.041***	0.043***	0.019*	0.030***	0.040***	0.008
	(4.43)	(4.96)	(1.94)	(2.60)	(3.89)	(0.80)
HACCP	−0.598***	−0.408***	−0.036	−0.420***	−0.331***	−0.020
	(−5.71)	(−4.08)	(−0.34)	(−3.29)	(−2.84)	(−0.17)
GDP	0.622***	0.442***	0.101***	0.528***	0.353***	0.022
	(17.68)	(11.04)	(3.57)	(12.62)	(7.62)	(0.77)
Size	0.406***	0.255***		0.426***	0.261***	
	(11.16)	(6.59)		(9.76)	(5.73)	
Export			0.324***			0.275***
			(7.33)			(5.76)
Exchange	−0.013	−0.019	0.043	0.007	−0.003	0.073**
	(−0.62)	(−0.71)	(1.64)	(0.28)	(−0.08)	(2.52)
Distance	−0.212**	−0.010	−0.684***	−0.110	−0.246*	−0.719***
	(−2.48)	(−0.08)	(−5.24)	(−1.10)	(−1.90)	(−4.83)
NAFTA		1.41***			0.459***	
		(4.09)			(2.35)	
ASEAN		0.685***			0.816***	
		(3.56)			(3.68)	
APEC		0.793***			1.35***	
		(4.39)			(6.47)	
ANDEAN		0.502**			0.331	
		(2.21)			(1.28)	
GEO1			1.082***			1.557***
			(4.56)			(5.74)
GEO2			0.015			0.066
			(0.07)			(0.30)
Rho ρ	0.84	0.85	0.85	0.79	0.83	0.82
DW	1.71	1.63	1.67	1.74	1.76	1.74
Hausman	0.60	4.73	0.96	0.15	0.87	0.14
Adj. R^2	0.77	0.79	0.76	0.74	0.78	0.72
No.	492	492	492	492	492	492
F[b]	10.97	16.73	24.15	17.25	15.98	23.82

Note: Single asterisk (*), double asterisks (**), and triple asterisks (***) denote significance at 10%, 5%, and 1%, respectively.
[a] Random-effect estimates corrected for first-order serial autocorrelation. The *t*-statistics (in parentheses) computed with White's heteroscedasticity-consistent standard errors.
[b] Critical F value computed according to Leamer (1994, p. 114).

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% level. Fixed-effects models were largely outperformed by random-effects models as indicated by the Hausman tests.[4]

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

[4] The estimation of fixed-effects models revealed parameters values of similar magnitudes. These results are presented in table S1 of the supporting Appendix (Anders and Caswell 2008) to this article.

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 −0.03% to −0.59% with respect to the value of imported seafood products. This effect translates to an average marginal annual loss in trade value of $2.6 and $51.7 million, respectively. The HACCP effect on import volumes was up to −0.42% or an average marginal decrease of 9,537 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 to 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. This underscores an important point that overall imports were increasing; the marginal impact of HACCP was to dampen this trend. Real GDP per capita, as a proxy for U.S. per capita demand, is positively related to seafood imports. Our results indicate that a 1% increase in U.S. per capita GDP led to a 0.62% increase in the value of seafood imports. The volume effect on seafood imports, with an increase of up to 0.53%, 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 than those of Peridy, Guillotreau, and Bernard (2000) who report a significant distance elasticity of −0.74 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 1% increase in a country's value of total exports is associated with an increase of seafood exports (value and volume) of around 0.3%.

The effect on seafood imports of the foreign exchange rate to the U.S. dollar is 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.

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 of Model 2 show significant positive effects of relevant trade agreements for both dependent variables. NAFTA has the greatest positive impact of 1.4% on the value of U.S. seafood imports, while exports of APEC members are about 1.3% higher in terms of volumes.[5]

Model 3, which includes the impact of geographical connections, shows that South American countries (*Geo1*) have better access overall to the U.S. seafood market compared to the residual group of European countries and Canada. Their export advantage is 1.1% in value of product and 1.6% in export volume. In contrast, the group of Australasian countries (*Geo2*) has no significant competitive advantage compared to European countries and Canada.

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 United States.

The "standards as barriers" view hypothesizes a differential negative effect of HACCP adoption for developing countries. In contrast, developed countries, which largely account

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

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	Dollar value of U.S.	−0.598***	−0.748***	0.212
(long run)	Seafood imports	(−5.71)	(−6.62)	(1.36)
	Volume of U.S.	−0.420***	−0.662***	0.436**
	Seafood imports	(−3.29)	(−5.25)	(2.46)
1990–99	Dollar value of U.S.	−0.710***	−0.740***	0.227
(short run)	Seafood imports	(−6.13)	(−5.99)	(1.55)
	Volume of U.S.	−0.604***	−0.694***	0.462***
	Seafood imports	(−4.41)	(−4.59)	(2.62)

Note: Single asterisk (*), double asterisks (**), and triple asterisks (***) denote significance at 10%, 5%, and 1%, respectively.
[a] ExactML random-effect estimates of HACCP elasticities based on Model 1 for 1990–2004 (the long run) and 1990–99 (the short run) subsamples of the panel data set. Results are corrected for first-order serial correlation. The *t*-statistics (in parentheses) computed using White's heteroscedasticity-consistent standard errors.

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 United States. Industrialized countries are assumed to have the resources to adapt more quickly to increases in standards. Moreover, a negative effect on 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 to 2004 and with controls for other determinants of seafood trade such as time, U.S. 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. They exceed the overall negative HACCP impact levels for all countries. Developing countries' relative marginal loss in seafood trade with the United States is −0.75% of export value, while the marginal effect on export volumes is −0.66%. This translates to an average marginal annual loss in export value of $46.1 million and an average marginal loss in volume of 8,026 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, where the marginal effect is 0.44% or equivalently 1,972 metric tons.

Comparing results, Otsuki, Wilson, and Sewadeh (2001) forecast a negative impact of stricter standards on exports to the EU from developing countries in Africa. Their elasticity estimate predicted that tighter standards for Aflatoxin B1 in the EU would result in significant negative trade flow effects for imports of fruits, nuts, and vegetables from African countries. Jaffe and Henson (2004) later concluded that the effects were negative but not as large as predicted. Wilson and Otsuki (2004) also predicted a significant negative effect on imports from the introduction by the EU of a new pesticide standard for bananas. Our results over the entire period 1990–2004 using a classification of exporting countries as developing or developed provide an *ex post* analysis that supports 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 fish processing industry. As a consequence, countries that are immediately in compliance may expand their market shares at the expense of 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 1990–99 (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. To explore possible differences, we estimated mixed linear panel models (Verbeke and Molenberghs 1997) that merge a vector of unknown fixed effects and a vector of unknown random effects, thus allowing for a simultaneous disclosure of random- and fixed-effect properties of the panel data variables.

In the underlying theoretical mixed-linear model, the dependent variable y denotes the vector of observed y_is. On the right-hand side, X is the known matrix of x_{ij}s, β_is represent the unknown fixed-effects parameter vector, Z is the known matrix of z_is, and γ is a vector of unknown random-effects parameters (De Leeuw 2005). The country-level effects of HACCP requirements were estimated using the benchmark Model 1 with fixed HACCP effects for the thirty-three countries exporting to the United States. Table 4 shows country-level pre-HACCP seafood imports and estimates of the short-run (1990–99) and long-run (1990–2004) total trade flow effects of HACCP when other major determinants of seafood trade are controlled for. 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 fifteen suppliers of seafood to the United States had strictly positive trade flow effects in the short and long run post-HACCP periods. In contrast, ten of the eighteen smaller exporters experienced negative short- and long-run HACCP effects, while an additional four experienced a negative long-term effect. Developing and developed countries are both fully represented among the large and small exporters, and thus among the marginal 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 showing developing countries losing and developed countries gaining relatively under HACCP may be misleading. Among the twenty-four developing countries that were in the top thirty-three exporters to the United States, ten showed long-term gains and fourteen showed losses under HACCP, all else equal. Marginal 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 nine developed countries six showed gains and three 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 United States. 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.

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

Country	Pre- HACCP Imports to the United States (1997)		Short Run[b] (1998–99)		Long Run[c] (1998–2004)	
	Rank	(U.S. $ million)	HACCP Impact (U.S.$ million)	Change (%)	HACCP Impact (U.S. $ million)	Change (%)
Canada	1	1,305.92	383.1	+29.3	511.47	+39.2
Thailand	2	1,166.99	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	−38.60	−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. The *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, $n = 495$.

Conclusions

Food-borne safety risks associated with domestic and imported seafood products motivated the introduction of mandatory HACCP for seafood products in the United States in 1997. From the point of view of the United States and other developed countries, regulatory standards such as this are intended to reduce potential risks. However, they can also create nontariff 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 article contributes to this discussion by estimating the trade impact of the 1997 introduction of HACCP in the United States for domestic and imported seafood products. We apply panel data on seafood imports to the United States by the thirty-three largest exporting countries between 1990 and 2004. Twenty-four of these countries are developing, while nine are developed. The results of extended gravity models indicate a significantly negative impact of the HACCP standard on U.S. seafood imports across all thirty-three exporting countries, dampening the overall growth of these imports. The results are robust in terms of effect on 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 a negative trade effect 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 United States, all else equal, in the post-HACCP period. In contrast, most smaller exporters experienced short- and long-run negative trade effects 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 at the standard, market, product, and country levels to inform the discussion of the role of food safety standards as nontariff 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.

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