# It Happened All at Once:

# Switching Regressions, Gravity Models and Food Safety

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## Introduction

In a world that is relying increasingly more on protectionist tools, recent literature shows that certain strategies, such as increased product standards, serve as non-tariff barriers to trade. While the many risks associated with domestic and imported seafood products make the use of safety standards important, such standards in developed countries frequently disadvantage developing countries by imposing standards as trade barriers. As a result, non-tariff measures are assuming greater importance in research and policy making. This is particularly true for the aquaculture and fisheries sector. As one of the world's largest producers and importers of aquaculture and fisheries products, the issue of seafood safety is of particular concern to the United States.

Despite the negative effects of some product standards on developing countries, they are not always protectionist in intent. While some argue that increasing standards are harmful to developing countries' economies, others have shown that standards can be a catalyst for diversification and a stronger economy (Moenius, 2004). However, product standards can also impact the marginal and or fixed costs of foreign exporters, and can thereby disadvantage domestic industries (Czubala et al., 2009). Developing countries have not largely been involved in talks on Mutual Recognition Agreements (MRAs), Regional Trade Agreements (RTAs) and other agreements designed to mitigate compliance costs. This gives reason to believe that this problem is particularly relevant to developing country exporters. Recent trade theory suggests that fixed cost measures such as product standards might play an important role in explaining the pattern of bilateral trade (Helpman, Melitz and Rubistein, 2008). The growing importance of seafood and aquaculture to the economies of the developing and developed world alike gives reason for further research regarding standards as barriers versus standards as catalysts. For developing countries, further research and policy making is of particular importance as fish and fish products are a primary source of protein and income for much of the developing world. Therefore, we consider the trade effects of implementation of US HACCP.

**Background on HACCP**

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

Seafood is one of the most globally traded food products, and its consumption accounts for a large proportion of food-borne illnesses (GAO 2001). Emerging food and health standards are implemented on seafood trade, including the mandatory Hazard Analysis Critical Control Points (HACCP) in the US. While the full implantation began December 1997, the Federal Register published a proposed rule in January 1994 for the establishment of HACCP for both domestic and international suppliers of fish to US consumers. While the literature of food safety provides substantial evidence that HACCP had a negative effect on seafood trade, what was the effect of the implementation and discussion of HACCP over time?

**Literature Review**

Though the literature is growing rapidly, the relative scarcity of quantitative analysis on product standards is surprising. Moenius (2004) considers a range of industries across a number of developed markets. Czubala et al. (2009) examine the impact of EU standards on African exports of textiles. Portugal-Perez et al. (2009) have extended the analysis to electrical products (Moenius, 2007), but they do not examine the potential for impacts across developing and developed countries.

Although the literature is wrought with qualitative, anecdotal evidence that suggest similar mechanisms may be at work in the food and agriculture sector, quantitative evidence remains scarce. Swinnen and Maertens (2007) consider the importance of increasing and tightening food standards in trade and the effects the increased proliferation has on poor, developing countries without empirical evidence. As Anders and Caswell (2009) note, there is fairly extensive qualitative literature on the general effects of food safety and the World Trade Organization's (WTO) Agreement on Technical Barriers to Trade (TBT) and the Agreement on Sanitary and Phytosanitary Measures (SPS). Disdier, Fontagne and Mimouni (2008) found evidence that technical regulations can reduce developing countries exports. Moenius (2004, 2006) found that private standards in food and agriculture could have similar effects. More recently, Anders and Caswell (2009) have shown that stricter US food safety standards for seafood have had negative impacts on many developing countries.

A number of empirical studies have attempted to quantify the trade effects of emerging food safety standards. Otsuki, Wilson and Sewadeh (2001), Wilson and Otuki (2003 and 2004) employed the gravity model to provide evidence that EU standards negatively affected agricultural exports. Disdier, Fontagne and Mimouni (2008) provided evidence that sanitary and phytosanitary (SPS) measures, which include food safety regulations, and technical barriers to trade (TBT) have negative effects on the trade of products, especially those from developing countries. Using secondary data analysis and a survey, Cato and dos Santos (1998) estimated that Bangladesh frozen shrimp processors experienced a loss in total revenue of $14.6 million (in 1997 dollars) as consequence of the ban by the EU. Debaere (2005) provided evidence that the declaration of zero tolerance for antibiotics by the EU diverted shrimp exports of Thailand from the EU to the US.   Anders and Caswell (2009) investigated the impact of the mandatory application of HACCP in the US on seafood exports from the top 33 countries, and they found that HACCP adoption by the US reduced its import value of seafood from -2.95% and -45.00% (a re-evaluation by the authors base on Halvorsen and Palmquist (1980)).

The work of Anders and Caswell (2009), Disdier, Fontagne and Mimouni (2008), Otsuki, Wilson and Sewdah (2001) and Wilson and Outsuki (2003 and 2004) used the traditional gravity model.  However theoretical and empirical extensions show that their analysis may have problems because of the omission of zero trade.  Additionally, this literature has not given much consideration to the time of NTBs as illustrated above, HACCP, as well as other NTBs do not happen all at once.  These policies evolve and the evolution may have effects that need further investigation.

**Hypotheses**

This paper looks at the impact of US HACCP on the export performance of seafood exporting countries. We extend the relevant literature by looking at more nuanced hypotheses:

1. HACCP has a negative effect on trade flows.
2. The effects of food safety regulations are not instantaneous.
3. HACCP regulations fundamentally changed the market for imports into the US.
4. Zero trade matters for analysis.

**Methodology and Data**

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

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

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

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

In our model we are not looking at bilateral trade, so we are not able implement the Anderson and van Wincoop (2003) specification. We follow the Anders and Caswell (2009) approach to estimate the effect of HACCP with analysis of imports into the US over a 16 year period. We consider random effects on a balance panel of positive, nonzero imports into the US. We use many of the variables of Anders and Caswell (2009). We deviate from this method in that we use real GDP as oppose to real per capita GDP. We present both random and fixed effects modeling. Our data set includes 142 exporters as compared to their 33 exporters. More importantly, we consider random and fixed effect models that include zero and nonzero trade.

The traditional gravity model in panels with random effects (with fixed effects the constant parameters fall out such as distance) is below:

$$\begin{aligned} \ln x_{USjt} = \alpha_0 + \alpha_1 \ln y_{jt} + \alpha_2 \ln y_{USt} + \alpha_3 \ln dist_{ij} + \alpha_4 \ln Size_{ij} \\ + \alpha_5 HACCP_{USt} + \alpha_3 \ln Size_{jt} + \alpha_4 ANDEAN_{jt} + \alpha_5 APEC_{jt} \\ + \alpha_6 ASEAN_{jt} + \alpha_7 MERCOSUR_{jt} + \alpha_8 NAFTA_{jt} + \varepsilon_{USjt} \end{aligned} \tag{5}$$

where $HACCP_{USt}$ equals one between 1998 to 2007, the period of the imposition of US HACCP; $\ln Size_{jt}$ is the natural log of the sum of the fish imports and exports of the exporter. $ANDEAN$, $APEC$, $ASEAN$, $MERCOSUR$, and $NAFTA$ are dummy variables for exporter membership in the agreements.

The empirical analysis begins with the hypothesis that zero trade matters. The trade literature is beginning to appreciate the effects that zero trade may have on parameter estimates (Helpman Melitz and Rubinstein (2008), Santos Silva and Tenreyro (2006), Witold, Shepherd, and Wilson (2009), among others). In particular Santos Silva and Tenreyro (2006), argue that problem with log-linearization in the traditional gravity model is that "it is incompatible with the existence of zeros in trade data, which led to several unsatisfactory solutions, including truncation of the sample (that is, elimination of zero-trade pairs) and further nonlinear transformations of the dependent variable." (p. 653)

We then proceeded in two directions. First, we considered the random and fixed effects models with balanced panels and only nonzero trade flows (83 countries). We use these models as the base model. Second, we considered balanced panels of the zero and nonzero trade flows (142 countries) with Poisson regression models based in part on Santos Silva and Tenreyro (2006). We use this model as the model for our discussion.

In the two branches we ran models to see the role of the HACCP dummy variable on imports into the US. We then considered a structural break with the imposition of HACCP. While Anders and Caswell (2009) estimate the short and long run effects of HACCP by estimating two models one covering the data from 1992-1999 and the second 1992-2005. We instead consider whether HACCP has a regime changing effect. That is, did HACCP affect the parameter values of the gravity model such that the policy affects an evolution from a pre-regime effect to a transitory effect to a full implementation effect? Therefore, we finally estimated a model of switching regressions. Additionally, we were able to determine when the policy began to have an effect if any.

6) $$\ln x_{USjt} = \alpha_0 + \beta_0\lambda_t$$

$$+ (\alpha_1{+}\lambda_t\beta_1)\ln y_{jt} + (\alpha_2{+}\lambda_t\beta_2)\ln y_{USt} + (\alpha_3{+}\lambda_t\beta_3)\ln dist_{ij}$$

$$+ (\alpha_4{+}\lambda_t\beta_4)\ln Size_{ij} + (\alpha_5{+}\lambda_t\beta_5)HACCP_{USt}$$

$$+ (\alpha_6{+}\lambda_t\beta_6)\ln Size_{jt} + (\alpha_7{+}\lambda_t\beta_7)ANDEAN_{jt}$$

$$+ (\alpha_8{+}\lambda_t\beta_8)APEC_{jt} + (\alpha_9{+}\lambda_t\beta_9)ASEAN_{jt}$$

$$+ (\alpha_{10}{+}\lambda_t\beta_{10})MERCOSUR_{jt} + (\alpha_{11}{+}\lambda_t\beta_{11})NAFTA_{jt} + \varepsilon_{USjt}$$

where $\lambda_t$ represents a transition path of the implementation of HACCP and $\beta_i$ reflects the variables of interest during the adjustment period. This transition path is defined as

(6a) $\lambda_t = 0$ for $t < t_1^*$

(6b) $= [(t - t_1^*)/(t_2^* - t_1^*)]^n$ for $t_1^* \leq t \leq t_2^*$

(6c) $= 1$ for $t > t_2^*$

$t_1^*$ is the beginning of the transition to policy implementation, and $t_2^*$ is the full the implementation of the policy. The period between $t_1^* \leq t \leq t_2^*$ represents the transition period, where $\lambda_t = [(t - t_1^*)/(t_2^* - t_1^*)]^n$. The integer $n$ is the set the shape of the transition (See Figure 1). In this model $t_1^* = 1994$, 1995 or 1996 is the year of the beginning of rule setting for HACCP and $t_2^* = 1998$ is the year of full implementation (Gallet, 1999 and Konno and Fukushige, 2002) We test for best fit of the start year and $n$ with estimate with the smallest AIC .

**Data**

Trade data are collected from the United Nations Commodity Trade Statistics Database. In this database, bilateral trade values and quantities are reconciled for each product category based on reliability indices of exporters and importers. The trade totals are compared with other merchandise trade for all product categories and years (Gehlhar, 2002). The data used for this analysis includes two sets. The data set is aggregated seafood imports into the US (SITC rev.3 code 03). The datasets cover 16 years of data from 1992 to 2007. GDP data are from the World Bank's World Development Indicators. Information on distance, contiguity and common language are obtained from the Centre d'Etudes Prospectives et d'Informations Internationales.

**Results**

We began the gravity model with the random effects like model Anders and Caswell (2009). In this parameterization, we see that GDP of the exporting country is positive and statistically different than zero at the value of 0.25. The GDP of the US is not statistically significant. For the data used here where the US is the only importer, the lack of significance is expected because of the limited variation over the data set. The distance variable is statistically significant at the value of -1.25. These results are common for gravity models of this type. Size is statistically significant and positive suggesting that large seafood traders, in terms of imports and exports, export more fish to the US than smaller fish traders. Of the RTAs only ASEAN is statistically significant. The major deviation from Anders and Caswell (2009) is the statistically insignificance of HACCP. The loss of significance can be the result of many factors, the inclusion of more countries, slightly different time frame (1992-2007 vs 1990-2005), etc.

While we find no direct effect of HACCP, are the parameter estimates constant over this time? That is does the US import in a different manner after HACCP implementation as compared to before implementation? With a simple test for a structural break after HACCP implementation 1998-2007, we find evidence that a structural break occurs at the five percent level $\chi^2_{(10)} = 22.06$. The structural break test indicates that overall the parameters are different before and after HACCP implementation. The break does not indicate if the break is at single point or over a period. Thus, we used switching regressions to indicate the time period of the regime change of HACCP. We also are able to explain trade before HACCP, during the transition of HACCP and the effects of HACCP after full implementation.

The switching regression model for the random effects model in Table 1 suggests that before the implementation of HACCP the effect of GDP on trade of fish products to the US was smaller than the effect of GDP on fish trade over the entire period 0.15< 0.25, similar comparisons can be made for all of the estimates. These casual comparisons are substantiated by the coefficients on the variables designated 96n2, which represent the change in the parameter values over the period of the regime shift. This designation indicates that over the possible $t_1^* = 1994$, 1995 or 1996, the best is 1996 with the shape of the transition $n$=2. For the models with no zero trade we see that the implementation of HACCP promotes trade over the implementation period, the regime shift, an increase in the GDP coefficient by 0.13. However, the coefficient on size falls by 0.14. Similar results occur with the fixed effects model. The implications of this finding suggest that HACCP benefited countries in general, as the effect of GDP increases the about of fish trade. The reduction of the size variable suggests that HACCP hurt countries that were larger players in the international fish market. These results are contrary to the literature. Based on the stated hypotheses of this study, we find evidence from this model that HACCP may have increased trade flows by fundamental changes in the trade relationship of exporters with the US over time.

These results prompted the need to consider zero trade and the specification of the traditional gravity model as suggested by Santos Silva and Tenreyro (2006). The Poisson regression results reported in Table 2 in comparison to those in Table 1 provide results similar to those suggested by Santos Silva and Tenreyro (2006). In particular, the researchers note of their results "Poisson estimates reveal that the coefficients on importer's and exporter's GDPs in the traditional equation are not…close to 1. OLS [they only used cross-sectional data] generates significantly larger estimates, especially on exporter's GDP…" (p. 651). Similar findings occur with the distance variable.

The initial model yields only two statistically significant parameters GDP of exports and distance. Once again HACCP is not directly statistically significant; however, the test for a structural break indicates that the parameter estimates are statistically different$\left(\chi^2_{(19)} = 106.05\right)$at the one percent level between 1992-1997 and 1998-2007.

The best switching regression for the Poisson model is 1996 n=2 as in the previous model. In the Poisson model, the effect of HACCP is almost the opposite of the previous model. The imposition of HACCP has a negative effect on the coefficient for the GDP of the exporter. However HACCP increases the effect of the distance and size variables, and the policy brings into significance the ANDEAN Compact and NAFTA. We see similar effects for the fixed effect model.

In Table 3, we present the statistically significant parameter estimates and the elasticities for the random effects, Poisson model. Additionally, we present these parameters before the implementation of HACCP, the effect of HACCP and the net effect of HACCP. The switching regression model generates theoretically-reasonable parameter estimates and the effects of HACCP. The net parameters $\alpha + \beta$ are consistent with most gravity models. The GDP of the exporter, size, and membership in ASEAN and NAFTA are positive. The distance is negative. The negative effect of membership in the ANDEAN agreement is surprising.

The results of this analysis add new understanding to the effects of HACCP, with implications for other non tariff barriers. Our results suggest that the imposition of HACCP decreased trade as it lowered the positive effect of GDP, a result common in the literature. However, some aspects of HACCP may have facilitated trade in that HACCP lowered the cost of trade as represented by the distance variable. A possible explanation of the trade facilitating feature of HACCP is that the policy provided a way for US consumers to have a greater trust in the imports of products. HACCP may have had a bifurcating effect on trade because the positive effect of HACCP on the size variable. This result suggests that HACCP increased the exports of larger seafood traders relative to smaller traders. Our findings support, in part, the common concern that HACCP, as well as other NTBs, hurt developing countries or more precisely smaller traders. Additionally, we find evidence that HACCP implementation benefit NAFTA and ASEAN exports but hurt those ANDEAN countries.

**Discussion**

We show that HACCP negatively affected trade over time. However our results suggest that the policy had some trade facilitating aspects. These effects are dependent on the status of the exporter, distance from the US, membership in certain trade agreements and size of international engagement in the world seafood market. This analysis shows that nations are affected by the discussion of food safety regulations in advance of the full implementation. These findings provide evidence that food safety regulations have multifarious effects on trade than previously understood. Likewise developing and small exporting countries have a harder time adjusting to the regulation during and after the implementation. Additionally, these results depend on a model that recognizes the effects of excluding zero trade flows. Previous models that overlooked the effect of zero trade even in models of imports alone may significantly bias the effect of NTBs like HACCP.

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**Figure 1. Lambdas over Time**

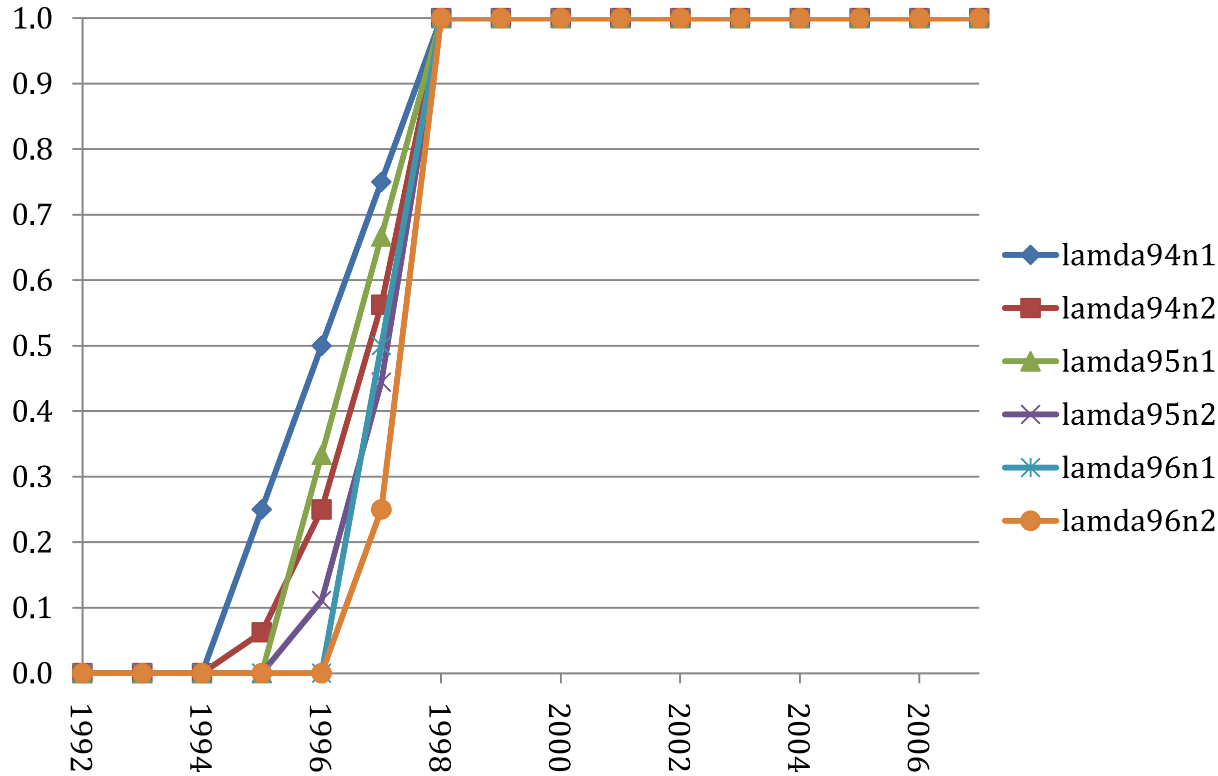

**Table 1. Panel Regressions of Balanced Trade Excluding Zero Trade**

| | Random Effects | Switching Model RE | Switching Model FE |
|---|---|---|---|
| $\ln y_{jt}$ | 0.25*** | 0.15* | 0.97*** |
| | (0.082) | (0.086) | (0.24) |
| $\ln y_{USt}$ | 0.27 | 0.33 | -0.47 |
| | (0.32) | (0.66) | (0.71) |
| $\ln dist_{USj}$ | -1.25*** | -1.37*** | |
| | (0.34) | (0.34) | |
| $\ln Size_{jt}$ | 0.33*** | 0.42*** | 0.41*** |
| | (0.048) | (0.054) | (0.056) |
| $HACCP_{USt}$ | 0.029 | | |
| | (0.090) | | |
| $ANDEAN_{jt}$ | 0.78 | 1.033* | 0.59 |
| | (0.60) | (0.89) | (0.78) |
| $APEC_{jt}$ | 0.45** | 0.77*** | 0.47* |
| | (0.22) | (0.27) | (0.28) |
| $ASEAN_{jt}$ | 2.72*** | 2.43*** | |
| | (0.88) | (0.89) | |
| $NAFTA_{jt}$ | 0.0072 | -0.31 | -0.18 |
| | (0.55) | (0.61) | (0.63) |
| $MERCOSUR_{jt}$ | 1.58 | 1.80* | |
| | (1.048) | (1.044) | |
| $\lambda_{96z^2t}$ | | -2.49 | 9.55 |
| | | (21.23) | (21.18) |
| $\ln y_{j96z^2t}$ | | 0.13*** | 0.12*** |
| | | (0.033) | (0.033) |
| $\ln y_{US96z^2t}$ | | -0.0017 | -0.14 |
| | | (0.71) | (0.71) |
| $\ln Size_{j96z^2t}$ | | -0.14*** | -0.14*** |
| | | (0.037) | (0.037) |
| $\ln dist_{USj96z^2t}$ | | 0.13 | |
| | | (0.93) | |
| $ANDEAN_{j96z^2t}$ | | -0.33 | -0.26 |
| | | (0.22) | (0.22) |
| $APEC_{96z^2t}$ | | -0.034 | 0.073 |
| | | (0.18) | (0.17) |
| $ASEAN_{j96z^2t}$ | | 0.13 | 0.11 |
| | | (0.24) | (0.23) |
| $NAFTA_{j96z^2t}$ | | 0.088 | -0.21 |
| | | (0.41) | (0.34) |
| $MERCOSUR_{j96z^2t}$ | | -0.24 | |
| | | (0.24) | |
| Constant | 9.00 | 9.72 | 2.092 |
| | (9.76) | (19.88) | (19.66) |

**Table 1 Continued**

| | Random Effects | Switching Model RE | Switching Model FE |
|---|---|---|---|
| $R^2$ *within* | 0.092 | 0.11 | 0.11 |
| $R^2$ *between* | 0.48 | 0.49 | 0.29 |
| $R^2$ *overall* | 0.45 | 0.46 | 0.27 |
| $N$ | 1328 | 1328 | 1328 |
| $\sigma_u$ | 1.73 | 2.41 | 2.91 |
| $\sigma_e$ | 0.75 | 0.98 | 0.74 |
| $\rho$ | 0.84 | 0.86 | 0.93 |

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

**Table 2. Panel Regressions of Balanced Trade including Zero Trade**

| | Random Effects | Switching Model RE | Switching Model FE |
|---|---|---|---|
| $\ln y_{jt}$ | 0.085*** | 0.092*** | 0.18*** |
| | (0.028) | (0.027) | (0.069) |
| $\ln y_{USt}$ | 0.17 | 0.20 | 0.15 |
| | (0.10) | (0.20) | (0.21) |
| $\ln dist_{ij}$ | -0.19** | -0.25** | |
| | (0.090) | (0.12) | |
| $\ln Size_{jt}$ | 0.0066 | -0.12 | -0.034** |
| | (0.023) | (0.18) | (0.017) |
| $HACCP_{ijt}$ | -0.019 | | |
| | (0.025) | | |
| $ANDEAN_{ijt}$ | 0.085 | 0.18 | 0.19 |
| | (0.071) | (0.21) | (0.25) |
| $APEC_{ijt}$ | 0.012 | 0.097 | 0.047 |
| | (0.036) | (0.076) | (0.077) |
| $ASEAN_{ijt}$ | 0.92 | 0.86*** | 1.15*** |
| | (0.61) | (0.21) | (0.27) |
| $NAFTA_{ijt}$ | -0.041 | -0.12 | -0.0023 |
| | (0.19) | (0.18) | (0.19) |
| $MERCOSUR_{ijt}$ | 0.20 | 0.28 | |
| | (0.14) | (0.40) | |
| $\lambda_{96z^2t}$ | | 0.070 | 2.42 |
| | | (6.31) | (6.35) |
| $\ln y_{j96z^2t}$ | | -0.017* | -0.022** |
| | | (0.0097) | (0.0095) |
| $\ln y_{US96z^2t}$ | | -0.028 | -0.075 |
| | | (0.21) | (0.21) |
| $\ln dist_{ij96z^2t}$ | | 0.097*** | |
| | | (0.028) | |
| $\ln Size_{j96z^2t}$ | | 0.029*** | 0.031*** |
| | | (0.011) | (0.011) |
| $ANDEAN_{ij96z^2t}$ | | -0.18*** | -0.21*** |
| | | (0.065) | (0.064) |
| $APEC_{j96z^2t}$ | | -0.13** | -0.072 |
| | | (0.055) | (0.053) |
| $ASEAN_{j96z^2t}$ | | 0.029 | 0.45 |
| | | (0.068) | (0.068) |
| $NAFTA_{j96z^2t}$ | | 0.24** | -0.021 |
| | | (0.12) | (0.10) |
| $MERCOSUR_{j96z^2t}$ | | -0.11 | |
| | | (0.071) | |
| Constant | -2.98 | -3.36 | |
| | (3.26) | (5.98) | |

**Table 2 Continued**

| | Random Effects | Switching Model RE | Switching Model FE |
|---|---|---|---|
| Log likelihood | -6747.85 | -6730.58 | -5860.073 |
| | $F_{(10,141)} = 5.32^{***}$ | $\chi^2_{(19)} = 106.05^{***}$ | $\chi^2_{(15)} = 80.38$ |
| $N$ | 2272 | 2272 | 2208[a] |

Note: Numbers in parentheses are asymptotic *t*-statistics; ***, **, * indicate significance at 1%, 5%, and 10% level, respectively.
[a]Four countries (64 observations) are dropped because they have zero trade to the US throughout the data set.

**Table 3. Parameters and Elasticities with Switching Regressions (Random Effects)**

| | Before HACCP | HACCP Effect | After HACCP |
|---|---|---|---|
| | $\alpha$ | $\beta$ | $\alpha + \beta$ |
| | | Parameter Estimates | |
| $\ln y_{jt}$ | 0.092 | -0.017 | 0.075 |
| $\ln dist_{USj}$ | -0.25 | 0.097 | -0.15 |
| $\ln Size_{jt}$ | 0 | 0.029 | 0.029 |
| $ANDEAN_{jt}$ | 0 | -0.18 | -0.18 |
| $ASEAN_{jt}$ | 0.86 | 0 | 0.86 |
| $NAFTA_{jt}$ | 0 | 0.24 | 0.24 |
| | | Elasticities | |
| $\ln y_{jt}$ | 9.64 | -1.69 | 7.79 |
| $\ln dist_{USj}$ | -22.12 | 10.19 | -13.93 |
| $\ln Size_{jt}$ | 0 | 2.94 | 2.94 |
| $ANDEAN_{jt}$ | 0 | -16.47 | -16.47 |
| $ASEAN_{jt}$ | 136.32 | 0 | 136.32 |
| $NAFTA_{jt}$ | 0 | 27.12 | 27.12 |