The Impact of Food Safety Third-Party Certifications on China's Food Exports to the United States

Yuqing Zheng

Research Economist, Food and Nutrition Policy Research Program,

RTI International, 3040 Cornwallis Road,

Research Triangle Park, NC 27709-2194,

Office (919) 541-6536, E-mail: yuqzheng@rti.org

Mary K. Muth

Senior Research Economist,

Food and Nutrition Policy Research Program, RTI International

Jenna Brophy

Economist, Food and Nutrition Policy Research Program, RTI International

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

1. Introduction

Food producers and manufacturers have shown increasing interests in obtaining third-party certifications (TPC). For example, the latest International Organization for Standardization (ISO) Survey of Certifications reveals that ISO's management system standards for quality, environment, medical devices, food safety, and information security had an overall increase in certificates of 6.2% from 2009 to 2010. The biggest increase in certification was to the sector-specific ISO 22000:2005, ISO's management system standard for food safety, which was up by 34%. The top three for growth in 2010 were Japan, China and the Czech Republic.

In this paper, we empirically examine the impact of food safety TPC on food exports to the United States with a focus on China considering China is one of the top trading partners of the United States. Our interests in this issue stems for two reasons. First, the impact of TPC on a country's food exports could be ambiguous, which necessitates an empirical study on this issue. On one hand, obtaining a food safety TPC requires going through expensive procedures such as auditing and document review. As a result, high cost of compliance associated with TPC may exclude smaller producers from export value chains (Dolan and Humphrey, 2000). On the other hand, TPC can act as catalysts for upgrading, enhance international competitiveness, and reduce technical trade barriers imposed especially by developed countries. Therefore, how food safety TPC can affect international trade is of particular interests to food producers and manufacturers and the government. However, this issue has received little attention in the economics and trade literature.

Second, we are especially interested in the case of the United States because examining the impact of food safety TPC on food exports to the United States can provide timely, important information to U.S. policy makers as well. The Food and Drug Administration (FDA) Food Safety Modernization Act (FSMA) (Public Law 111-353, signed into law on January 4, 2011) provides FDA with the enhanced ability to achieve greater oversight of the safety of imported foods. A main feature of the legislation on imported food safety is the use of TPC. More specifically, FDA may establish a program through

which qualified third parties can certify that foreign food facilities comply with U.S. food safety standards, and has the authority to require that high-risk imported foods be accompanied by a credible TPC. The policy implication of this study is straightforward. If food safety TPC promotes trade, the expected effect of FSMA will not only be a quality improvement in food exported to the United States, but also far-reaching changes in trade patterns, depending on the adoption rate of food safety TPC in the trading partners of United States.

2. Literature on How Food Safety Standards Affect Exports

Many researchers have examined the relationship between food safety standards and food exports. We report the major published studies on this issue in Table 1. As Table 1 show, there are largely three measures of food safety standards used by researchers: (1) sanitary and phyto-sanitary (SPS) measures and maximum residual limit (MRL) of pesticides, (2) the number of notifications under SPS and the number of detained shipments, (3) requirements for food safety management systems, and (4) requirements for food safety TPC.

Most of the published studies in Table 1 examined the impact of SPS measures and MRL of pesticides imposed by importing countries on the volume of food these countries import. For example, Otsuki et al. (2001a) found that the implementation of the new aflatoxin standard in the European Union (EU) would have a negative impact on African exports of cereals, dried fruits and nuts to Europe. Otsuki et al. (2001b) estimated the impact of changes in aflatoxin standards on trade flows of groundnut products from African countries to European countries. They found that that a 10% tighter aflatoxin standard in EU countries would reduce groundnut imports by 11%. Similarly, Wilson and Otsuki (2004) found that a 10% tighter restriction on the pesticide chlorpyrifos residues by Organization for Economic Cooperation and Development (OECD) countries would lead to a decrease in banana imports by 16.3%. More recently, Wei et al. (2012) found that China's tea exports would have been significantly restricted if importing countries increase requirements for tea safety standards concerning regulatory pesticides. Calvin and Krissoff

(1998) conducted a similar study that examined the trade and welfare impact s of removing phyto-sanitary barriers on U.S.-Japanese apple trade.

The second measure represents the degree to which a food safety standard is enforced rather than a direct measure of stringency for food safety standard such as the MRL of pesticide. Specifically, Disdier et al. (2008) analyzed the impact of the total number of notifications under SPS and technical barriers to trade agreements and found that they significantly reduced developing countries' exports to OECD countries, but did not affect trade between OECD members. Jongwanich (2009) examined the impact of food safety standards measured by the number of detained shipments in the U.S. market on processed food exports in developing countries. The results show that stricter food safety standards imposed by developed countries could impede processed food exports from developing countries.

The third measured used is requirements for food safety management systems. Anders and Caswell (2009) show that the introduction of Hazard Analysis Critical Control Points (HACCP) food safety standard for seafood in the United States had a negative impact on overall imports from the top thirty-three supplier countries, especially on imports from developing countries. On the contrary, Liu and Yue (2012) found that the implementation of the EU HACCP standard increased EU orange juice imports.

Regarding the fourth measure, requirements for TPC, we are aware of only one study examining the impact of TPC on food exports. Using firm level data, Henson et al. (2010) found that GLOBALGAP (GAP stands for Good Agricultural Practices) certification had a positive and robust effect on firm export sales performance for the fresh produce industry in sub-Saharan Africa countries. The estimated export sales effect is 2.7 million euros per certification.

Table 1. Major Published Studies on the Relationship between Food Safety Standards and Food Exports

Authors	Product	Flow of Exports	Measure of Food Safety Standards	Data Period	Model
Calvin and Krissoff (1998)	Apple	U.S. to Japan	Phytosanitary barriers	1994–1997	Simulation method
Otsuki et al. (2001a)	Cereals, dried fruits, and nuts	African countries to European countries	Maximum Aflatoxin level imposed by importing countries	1989–1998	Gravity (OLS)
Otsuki et al. (2001b)	Groundnut	African countries to European countries	Maximum Aflatoxin level imposed by importing countries	1989–1998	Gravity (OLS)
Wilson and Otsuki (2004)	Bananas and plaintains	Major exporters to 11 OECD countries	Maximum residual limit of pesticides imposed by importing countries	1997–1999	Gravity (OLS)
Disdier et al. (2008)	All food products	Developing countries to OECD counties	Notifications under Sanitary and Phyto-Sanitary and Technical Barriers to Trade agreements,	2004	Gravity (OLS)
Anders and Caswell (2009)	Seafood	ROW to the United States	Hazard Analysis Critical Control Point (HACCP) standard	1990–2004	Gravity (OLS and Maximum Likelihood Estimator)
Jongwanich (2009)	Processed foods	Developing countries to ROW	Number of detained shipments in the U.S. market	2002–2004	OLS
Henson et al. (2010)	Fresh produce	Sub-Saharan Africa to ROW	Whether a firm obtains GLOBALGAP certification (firm level data)	2000–2006	Matching estimators
Wei et al. (2012)	Tea	China to ROW	Maximum residual limit of pesticides imposed by importing countries	1996–2009	Gravity (OLS)
Liu and Yue (2012)	Orange juice	ROW to EU	HACCP	2002–2008	Two Stage Least Squares
This study	All food products	ROW to the United States	Numbers of sites/facilities certified to ISO 22000, GLOBALGAP, and BRC in exporting countries	2010	Gravity (OLS, Tobit, PPML)

Note: ROW denotes the rest of world. OECD denotes Organization for Economic Cooperation and Development.

To our knowledge, no study has examined the relationship between a country's food exports and the requirements for TPC in that country. This study aims to fill the void. The aim of this paper is to examine the extent to which food exports to the United States is affected through certifications to three major private standards: ISO 22000, GLOBALGAP, and BRC (the British Retail Consortium Global) Standard for Food Safety. By doing so, we not only quantify the impacts of TPC on aggregate trade but also identify which standard has the most substantial impact.

3. The World-Wide Food Safety TPC Market

TPC has become a significant regulatory mechanism in the global agrifood system. As evidenced by the FSMA, the responsibility of producing safer food has been shifting from public to private governance. Hatanaka et al. (2005) offer a thorough discussion on the rise of TPC and the role and implications for key stakeholder groups including supermarket chains, producers, and non-governmental organizations. The main private standards used by the certification bodies to certify food producing and manufacturing facilities in the area of food safety and their main geographical range are

- ISO 22000 (international market)
- GLOBALGAP (European market)
- BRC (British market and Scandinavian market to a less extent)
- IFS (the International Featured Standards, German and French Market)
- SQF (Safe Quality Food, American and Australian market)
- Dutch HACCP (Hazard Analysis and Critical Control Point, Dutch Market)
- FSSC 22000 (Food Safety System Certification [an ISO 22000 based system], international market)
- PrimusGFS (United States and broadly speaking North America).

We obtained data on the numbers of sites/facilities in a country certified according to three major food safety standards—ISO 22000, GLOBALGAP, and BRC—for the year of 2010. The data on certifications came from the ISO Survey of Certifications 2010, GLOBALGAP 2010 Annual Report, and personal communications from the standard holder of BRC, respectively.

Comparable data on the other standards were not available to us (we were not able to obtain data on IFS, Dutch HACCP, or FSSC 22000. The data on SQF and PrimusGFS are available for the current year but not for 2010).

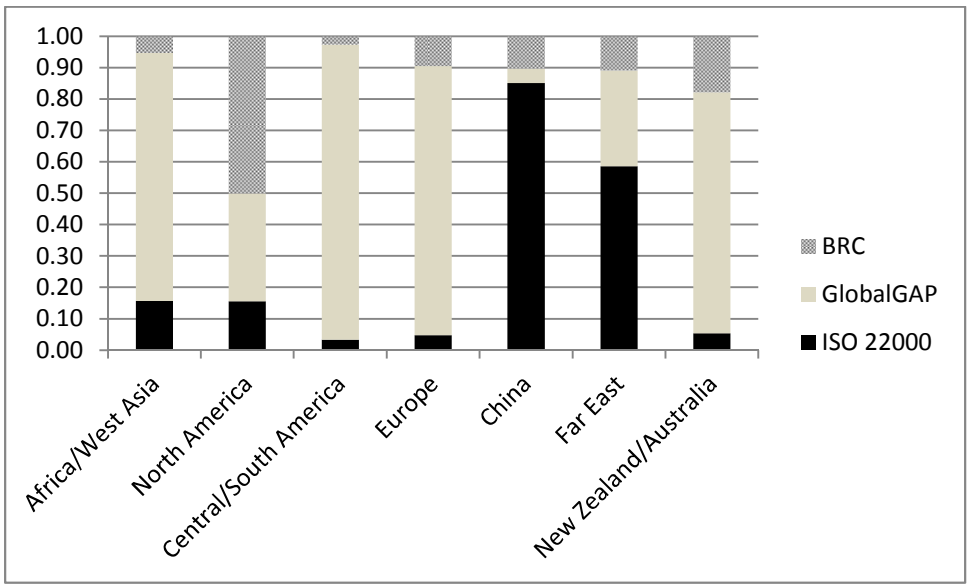
The data are aggregated into 7 regions as shown in Table 2. The seven regions are Africa/West Asia, North America Central/South America, Europe, China, Far East, and New Zealand/Australia. Surprisingly, North America in total have only 1,466 sites certified according to the three leading food safety standards, compared to a total of 128,344 sites across all regions.

Table 2. A Breakdown of 2010 World-Wide Certified Sites by 7 Regions

	ISO 22000	GLOBALGAP	BRC	*Total*
Africa/West Asia	1,749	8,782	586	11,117
North America	229	504	733	1,466
Central/South America	349	9,446	261	10,056
Europe	4,549	80,648	8,871	94,068
China	4,778	255	577	5,610
Far East	2,186	1,132	405	3,723
New Zealand/Australia	125	1,769	410	2,304
Total	13,965	102,536	11,843	128,344

Based on these data, we present in Figure 1 the market shares of ISO 22000, GLOBALGAP, and BRC by region. Because the data for other standards are not publicly available, the market shares here are solely based on our data on the three standards. As Figure 1 show, there are significant differences in the geographic coverage of the three leading standards. Three patterns emerge. First, ISO 22000 is the major food safety standard used by China and countries in the Far East (Taiwan, Thailand, etc.). Second, GLOBALGAP is the dominant food safety standard used in Africa/West Asia, Central/South America, Europe, and New Zealand/Australia. Third, BRC has half of the market share in North America, trailed by GLOBALGAP (a third), and ISO 22000.

Figure 1. Market Shares of ISO 22000, GLOBALGAP, and BRC by Region



4. A Gravity Model to Examine the Impact of TPC

Gravity models have been widely used to model the empirical impact of food safety standards on trade. For example, Table 1 shows that four of the five studies on aggregate trade used gravity models. The only exception is Jongwanich (2009). Tinbergen (1962) pioneered the use of gravity models in empirical specifications of bilateral trade flows. In a gravity model, the volume of trade between two countries is proportional to the product of economic size and measures of trade resistance between them such as geographic distance, colonial relations, and common languages. Accordingly, we follow the literature and use a standard gravity model to examine the impact of food safety TPC on food exports to the United States.

Specifically, the model is specified as follows

(1) $$\ln(FoodExport_i) = \beta_0 + \beta_1 \ln(ISO22000_i) + \beta_2 \ln(GLOBALGAP_i) + \beta_3 \ln(BRC_i) + \beta_4 \ln(GDP_i) + \beta_5 \ln(Dist_i) + \beta_6 \ln(XRate_i) + \beta_7 Contig_i + \beta_8 Colony_i + \beta_9 ComLanguage_i + e_i$$

where *i* indexes countries, $FoodExport_i$ is country *i*'s dollar value of food exports to the United States, $ISO22000_i$, $GLOBALGAP_i$, and BRC_i are the numbers of sites/facilities in country *i* certified to ISO 22000, GLOBALGAP, and BRC, respectively, GDP_i stands for country *i*'s gross domestic product, $Dist_i$ measures country *i*'s distance to the United States, $XRate_i$ is country *i*'s exchange

rate, $Contig_i$, $Colony_i$, and, $ComLanguage_i$ are dummy variables indicating whether country *i* and the United States are contiguous, have ever had a colonial link, and share a common official language, β is parameter to be estimated, and e_i is the error term. Due to data availability for BRC_i, we only focus on 2010 in the regression. Food exports and GDP are measured in thousands of U.S. current dollars.

The data on food exports to the United States came from the United States International Trade Commission (USITC) DataWeb. We collected exports of food and live animals, which corresponds to code zero by the Standard International Trade Classification Revision 4, as the measure of food. Most studies in Table 1 used trade data from United Nations Commodity Trade Statistics Database, known as the UN Comtrade data. We compared the data on food exports to the United States obtained from USITC and UN Comtrade and found that for a number of small countries, the UN Comtrade data show zero trade while the USITC data show otherwise. Therefore, we selected USITC as our source of data for trade. Data on distance, colony, contiguousness, and common language were from Mayer and Zignago (2011, also known as the CEPII GeoDist data). The data on GDP and exchange rate came from the World Bank's (2012) World Development Indicators and Penn World Table, respectively. The total number of observations for our model is 174 countries.

Overall, our use of GDP, distance measures, exchange rate, contiguity, colonial relationships, and language in the model are consistent with the gravity models used by researchers (e.g., Santos Silva and Tenreyro [2006], Helpmann et al. [2008], Francis and Zheng [2012a, 2012b]) to model trade in manufacturing products or all products including food and nonfood products. We modify the standard gravity model for modeling food trade by incorporating TPC data in a situation where food safety has been an increasing concern to the U.S. government, consumers, and importers.

We also estimated the following variation of the gravity model

$$(2)\quad \ln(FoodExport_i) = \beta_0 + \beta_1 \ln(ISO22000_i + GLOBALGAP_i + BRC_i) + \beta_2 \ln(GDP_i) + \beta_3 \ln(Dist_i) + \beta_4 \ln(XRate_i) + \beta_5 Contig_i + \beta_6 Colony_i + \beta_7 ComLanguage_i + e_i$$

where the numbers of sites/facilities certified to the three standards are aggregated into one variable. By estimating equation (2), we examine whether total the number of total certified food sites/facilities in a country facilitates the country's food exports.

5. Estimations and Findings

Recent contributions to the trade literature on estimation of the gravity model have shown that ignoring the problem of zero trade observations can result in severely biased estimates. However, all the studies cited in Table 1 did not account for this problem. Although our data are relatively disaggregated and have a fairly small proportion of zero observations (less than 10% of total observations, we follow Francis and Zheng (2012a, 2012b) to examine the effect of zero trade observations by presenting three sets of results for both equations (1) and (2).

First, we estimate the model by ordinary least squares (OLS) using the (natural) log of 1 plus food exports to the United States as our dependent variable; second, we estimate by the Tobit model using the log of 1 plus food exports to the United States as our dependent variable (Eaton and Tamura, 1994); third, we estimate using Poisson pseudo maximum likelihood (PPML) as suggested by Santos-Silva and Tenreyro (2007), where the dependent variable is food exports to the United States without taking the log. We also add 1 to the numbers of certified sites/facilities before taking log of them because of zero certified site in many countries. Robust standard errors are produced for all specifications to control for heteroscedasticity.

The estimation results are reported in Table 3. The left panel presents the results corresponding to equation (1). The OLS results show that the adjusted R^2 is 0.53, which is satisfactory for cross-sectional data. We found that all the estimated statistically significant parameters have the correct signs. Specifically we found that higher GDP, cheaper currency, shorter distance of a country to the United States, and having English as the official language is positively associated with the country's food exports to the United States. For example, a 10% increase in a country's GDP is found to be associated with a 3.3% increase in a country's food exporting to the United States.

The main interest of this paper focuses on the estimated parameters for the ISO22000, GLOBALGAP, and BRC, which are all estimated to be statistically significant (the former two are

at the 5% significance level and the latter one is at the 10% significance level). We found that a 10% increase in the number of sites/facilities certified to ISO 22000, GLOBALGAP, and BRC is associated with a 6.6%, 2.3%, and 3.2% increase in a country's food exports to the United States, respectively. The results from the Tobit model are very consistent with the results from the OLS model. This is especially true after we calculated the marginal effects for the Tobit model. These marginal effects, also interpreted as elasticities, are directly comparable with those obtained by the OLS model. For example, the elasticity for GLOBALGAP was estimated to be 0.22 in the Tobit model and 0.23 in the OLS model. The only noticeable difference for the Tobit model is that the colonial-tie dummy becomes significant at the 5% level.

The results from the PPML estimation differ quite a bit from the OLS and Tobit estimates. In particular, the magnitudes of most of the estimated parameters become smaller. For example, the estimated parameters for GLOBALGAP and BRC are 0.16 and 0.20 for the PPML estimation, which are 30% and 40% less than the OLS and Tobit estimates. The estimated parameter for ISO 22000, although still positive, becomes statistically insignificant in the PPML estimation. The smaller parameter estimates obtained by the PPML estimation are consistent with the findings of Santos-Silva and Tenreyro (2007) and Francis and Zheng (2012a, 2012b). This might reflect that in the presence of heteroscedasticity, estimates obtained from log-linearized models can be severely biased. Therefore, we interpret the parameter estimates for certifications obtained from the OLS and Tobit estimations as the upper bound of the impact of TPC on trade and the parameter estimates for certifications obtained from the PPML estimation as the lower bound.

The right panel of Table 3 reports the results corresponding to equation (2), the specification in which all the numbers of sites/facilities certified to the three standards are aggregated into one variable. In this case, the estimated parameter for the combined certification variable is 0.75, 0.76, and 0.40 for the OLS, Tobit (marginal effect), and PPML estimations, respectively. The effects of combined certification are statistically significant at the 5% level in all three specifications. That is to say, a 10% increase in the numbers of sites/facilities certified under ISO 22000, GLOBALGAP, or BRC is associated with an increase of 4 to 7.6% in a country's food exports to the United States.

Table 3. The Gravity Model Estimation Results

	Standards as Separate Variables				Combined Standards Variable			
Estimator:	OLS	Tobit	Marginal	PPML	OLS	Tobit	Marginal	PPML
Dependent Variable:	Log (1+T)	Log (1+T)	effect	T	Log (1+T)	Log (1+T)	effect	T
Log (ISO22000+1)	0.66**	0.68**	0.67	0.07	--	--	--	--
	(0.18)	(0.19)		(0.11)	--	--	--	--
log (GLOBALGAP+1)	0.23**	0.23**	0.22	0.16**	--	--	--	--
	(0.10)	(0.11)		(0.06)	--	--	--	--
Log (BRC+1)	0.32*	0.33*	0.33	0.20**	--	--	--	--
	(0.18)	(0.20)		(0.10)	--	--	--	--
Log (ISO22000+GLOBALGAP+BRC+1)	--	--	--	--	0.75**	0.77**	0.76	0.40**
	--	--	--	--	(0.13)	(0.11)		(0.07)
Log GDP	0.33*	0.34**	0.33	0.35**	0.44**	0.46**	0.45	0.31**
	(0.17)	(0.16)		(0.12)	(0.15)	(0.14)		(0.10)
Log exchange rate	0.25**	0.26**	0.26	0.22**	0.21**	0.23**	0.23	0.19**
	(0.07)	(0.08)		(0.04)	(0.08)	(0.08)		(0.04)
Log distance	-1.26**	-1.34**	-1.33	-0.31	-0.90*	-0.96**	-0.95	-0.22
	(0.48)	(0.45)		(0.20)	(0.47)	(0.42)		(0.17)
Contiguity dummy	1.39	1.21	1.20	2.77**	2.63*	2.48	2.45	3.09**
	(1.61)	(2.07)		(0.32)	(1.35)	(2.05)		(.32)
Colonial-tie dummy	-1.72	-2.03*	-2.02	-0.72*	-1.73	-2.07*	-2.05	-0.68*
	(1.55)	(1.11)		(0.43)	(1.57)	(1.10)		(0.37)
Common-language dummy	1.43**	1.45**	1.44	-0.07	1.45**	1.48**	1.46	0.07
	(0.46)	(0.49)		(0.28)	(0.44)	(0.49)		(0.25)
Adjusted R^2	0.53	--	--	--	0.53	--	--	--
Observations	174	174		174	174	174	174	174

Note: T = A country's total food exports to the United States in 2010. PPML = Poisson pseudo maximum likelihood.

** and * denote significance at the 5% and 10% levels, respectively. Standard errors are in parentheses.

6. TPC and China's Food Exports to the United States

According to the United States Department of Agricultural Foreign Agricultural Service Global Agricultural Trade System, China's agricultural product exports to the United States for 2010, 2011, and 2012 were $3.37 billion, $3.99 billion, and $4.53 billion. Multiplying the exports in 2010 by 6.7%, 2.2%, and 3.3% result in $226 million, $74 million, and $111 million, respectively. In 2010, the ISO, GLOBALGAP, and BRC certifications in China were 4,778, 255, and 577 (Table 2). That is to say, each additional ISO, GLOBALGAP, and BRC certification in China can increase China's exports to the United States up to $472,562 (calculation: $226 million / 477), $2,907,451, and $1,927,383, respectively.

7. Conclusions

In this paper, we empirically examine the relationship between food safety TPC on a country's food exports to the United States using data for 2010. We developed a modified gravity model to account for the role TPC plays in facilitating international food trade. Our findings are twofold. First, we found that a 10% increase in the number of sites/facilities certified to ISO 22000, GLOBALGAP, and BRC is associated with an increase of a country's food exports to the United States in the ranges of 0 to 6.7%, 1.6 to 2.2%, and 2 to 3.3%, respectively. Second, when all the numbers of sites/facilities certified to the three standards are aggregated into one variable, a 10% increase in the combined certified sites/facilities is associated with an increase of a country's food exports to the United States in the range of 4 to 7.6%. The upper and lower ranges are defined by the Tobit and PPML estimates respectively.

Our results suggest that although the high cost of compliance associated with TPC may exclude smaller producers from export value chains, the overall impact of TPC on a country's food exports to the United States is positive. For the case of China, we found that each additional ISO, GLOBALGAP, and BRC certification in China can increase China's exports to the United States up to $472,562 (calculation: $226 million / 477), $2,907,451, and $1,927,383, respectively. Therefore, we expect that the implementation of FSMA might have a substantial impact on food imports of the United States. That is, everything else being held constant, the countries have a higher adoption rate of TPC are expected to enjoy a higher levels of food exports to the United States.

8. References

Anders, S. M., and J. A. Caswell. 2009. "Standards as Barriers versus Standards as Catalysts: Assessing the Impact of HACCP implementation on U.S. Seafood Imports." *American Journal of Agricultural Economics* 91(5): 310–321.

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(2): 351–366.

Disdier, A.-C., L. Fontagné, and M. Mimouni. 2008. "The Impact of Regulations on Agricultural Trade: Evidence from the SPS and TBT Agreements. *American Journal of Agricultural Economics* 90(2), 336–350.

Dolan, C., and J. Humphrey. 2000. Governance and Trade in Fresh Vegetables: The Impact of UK Supermarkets on African Horticultural Industries. Journal of Development Studies, 37, 147–177.

Francis, J., and Y. Zheng. 2012a. "Trade, Geography and Industry Growth in U.S. Manufacturing." *Southern Economic Journal* 78(4): 1222–1241.

_____2012b. "Trade, Geography and the Skill Premium in U.S. Manufacturing." *Economic Inquiry* 50(3): 652–666.

Eaton, J., and A. Tamura. 1994. "Bilateralism and Regionalism in Japanese and U.S. Trade and Foreign Direct Investment Patterns." *Journal of the Japanese and International Economies* 8(4): 478–510.

GLOBALGAP c/o FoodPLUS GmbH. 2010. *GLOBALGAP Annual Report*, available at http://www.globalgap.org/cms/upload/Resources/Publications/Newsletter/101005_AR10_web_doublepages-low.pdf.

Hatanaka, M., C. Bain, L. Busch. 2005. "Third-party Certification in the Global Agrifood System." *Food Policy* 30(3): 354–369.

Helpman, E., M. Melitz, and Y. Rubinstein. 2008. "Estimating Trade Flows: Trading Partners and Trading Volumes." *Quarterly Journal of Economics* 2008 123(2): 441–487.

Henson, S., O. Masakure, J. Cranfield. 2010. "Do Fresh Produce

Exporters in Sub-Saharan Africa Benefit from GlobalGAP Certification?" *World Development* 39(3): 375–386.

International Organization for Standardization. 2010. ISO *Survey of Certifications*, CD ROM.

Jongwanich, J. 2009. "The Impact of Food Safety Standards on Processed Food Exports from Developing Countries." *Food Policy* 34(5): 447–457.

Liu, L., and C. Yue. 2012. "Investigating the Impact of SPS Standards on Trade Using a VES Model." *European Review of Agricultural Economics* 39(3): 511–528.

Mayer, T. and S. Zignago. 2011. "Notes on CEPII's Distances Measures (GeoDist)." CEPII Working Paper 2011-25.

Otsuki, T., J. Wilson, and M. Sewadeh. 2001a. "Saving Two in a Billion: Quantifying the Trade Effect of European Food Safety Standards on African Exports." *Food Policy* 26(5): 495–514.

Otsuki, T., J. Wilson, and M. Sewadeh. 2001b. "What Price Precaution? European Harmonisation of Aflatoxin Regulations and African Groundnut Exports." *European Review of Agricultural Economics* 28(2): 263–284.

Penn World Table, Center for International Comparisons at the University of Pennsylvania, version 7.1.

Santos Silva, J., and S. Tenreyro. 2006. "The Log of Gravity." *The Review of Economics and Statistics* 88(4): 641–658.

Tinbergen, J. 1962. *Shaping the World Economy* (New York: The Twentieth Century Fund).

Wei, G., J. Huang, and J. Yang. 2012. "The Impacts of Food Safety Standards on China's Tea Exports." *China Economic Review* 23(2): 253–264.

Wilson, J., and T. Otsuki. 2004. "To Spray or Not to Spray: Pesticides, Banana Exports, and Food Safety". *Food Policy*, 29(2), 131–146.

World Bank. 2012. *World Development Indicators* (The World Bank).