Measuring the Effect of Food Safety Standards on China's Agricultural Exports

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Abstract: According to China's recent experiences in agricultural trade disputes with the developed countries, China's exports might be constrained by nontariff barriers. The significance of these barriers is assessed in regression analyses by using a gravity model of agricultural product trade to test the effect of the residue standards on China's export of vegetables (Chlorpyrifos MRL) and aquatic products (Oxytetracycline MRL). The results show that food safety standards imposed by importing countries have a negative and statistically significant effect on China's export of agricultural products. The trade effect of food safety standards is much larger than that of the import tariff. JEL no. F13, F14
Keywords: Gravity model; food standards; tariff equivalent

1 Introduction

Since 2002, China's agricultural trade has increased rapidly, reaching US$50.44 billion in 2005,[1] and as expected[2] China has dramatically increased imports of land-intensive agricultural products, particularly cereals (mainly wheat), vegetable oils and vegetable oilseeds (mainly palm oil and soybeans), and raw materials for textiles (mainly cotton and wool). China has also increased exports of labour-intensive agricultural products, particularly processed agricultural products, but at a slower pace. From 2002 to 2005, the annual growth rate of agricultural imports was 31.53 per cent while that of agricultural exports was 11.65 per cent. As a result, in 2004 and 2005 agricultural imports exceeded agricultural exports and China reported

Remark: This paper is part of the research results of ADP/98-128 Project extension funded by the Australia Council for International Agricultural Research (ACIAR). Jun Yang is funded by the ACIAR ADP/98-128 Project extension. Please address correspondence to Professor Christopher Findlay, School of Economics, University of Adelaide, Adelaide, SA 5005 Australia; e-mail: christopher.findlay@adelaide.edu.au

[1] All the trade values used in this paper are at 2000 constant US$ prices.

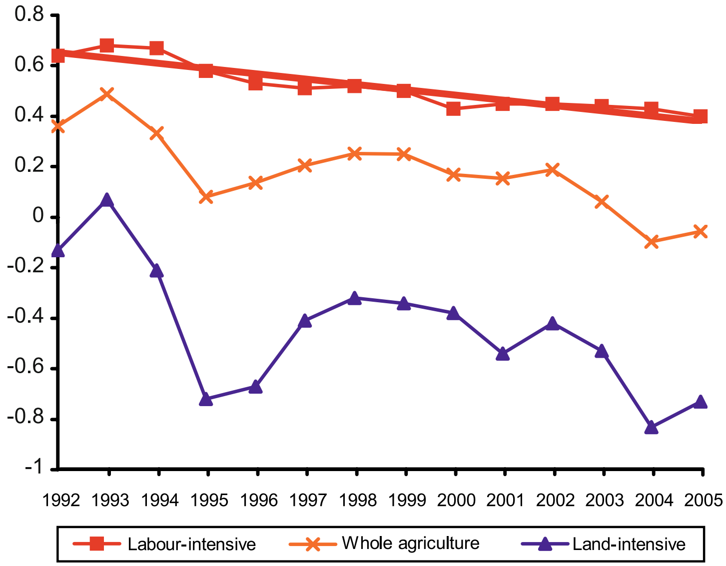
[2] Among others for example, Anderson (1997), Cheng (1997), Development Research Centre (1998), Huang (1998), Huang and Chen (1999), and Wang (1997).

 DOI: 10.1007/s10290-008-0138-z

its first two consecutive years of a deficit in agricultural trade since the 1990s (Chen 2006).[3]

From 1992 to 2005, China's comparative advantage revealed by the net export ratio (NER) in agriculture changed gradually. As shown in Figure 1, China's revealed comparative advantage in the whole agricultural sector declined, especially after 2002, and since 2004 China's agricultural sector as a whole has lost comparative advantage in international trade. Also since the 1990s, and especially since the early 2000s, China's comparative advantage revealed by NER in labour-intensive agricultural products has been declining dramatically (Chen 2006).

Figure 1: *China's Revealed Comparative Advantage Indices (NER) of Whole Agricultural Sector and Products by Factor Intensity of Production*



Source: Chen (2006).

Undoubtedly, the changes in revealed comparative advantage in agriculture have mainly been the result of China's fast economic growth, dramatic

[3] The definition of agricultural trade in this paper and Chen (2006) include HS Chapters 1 to 24, plus HS Headings of 4101 to 4103 (hides and skins), 4301 (raw fur-skins), 5001 to 5003 (raw silk and silk waste), 5101 to 5103 (wool and animal hair), 5201 to 5203 (raw cotton, waste and cotton carded or combed), 5301 (raw flax), and 5302 (raw hemp).

structural changes and continued increase in per capita income. However, other factors could also affect China's revealed comparative advantage in agriculture. The revealed comparative advantage indices are not only created by underlying economic forces but are often significantly affected by government policies with respect to international trade. This problem has been more serious for trade in agricultural products. In particular, the developed countries have resorted to sanitary and phytosanitary (SPS) measures for animal and plant health and technical barriers to trade (TBT) to block and restrict agricultural imports, especially from developing countries where food safety and technical standards are often low as compared to those of developed countries. This has seriously affected the developing countries' exports of agricultural products in which they have a comparative advantage.

In the case of China, Chinese farmers and exporters had anticipated a large, positive impact on domestic production and the export of agricultural products with accession to the World Trade Association (WTO), especially for labour-intensive agricultural products such as vegetables, fruits, animal products, and fish and aquatic products. In fact, these products have been hardest hit by the application of SPS standards. Our question is whether this has limited the growth in these agricultural exports by China.

Therefore, this paper examines and measures the impact of food safety standards on China's agricultural exports. Section 2 presents some empirical evidence of SPS and TBT measures affecting China's agricultural exports in recent years. Section 3 discusses the methodology of the study. Section 4 presents the specification of variables and data sources. Section 5 conducts an econometric analysis of the impact of SPS and TBT standards on China's agricultural exports for selected agricultural products. Section 6 discusses the effect of food safety standards on China's agricultural exports and compares the effect of food safety standards and import tariffs on China's agricultural exports. Section 7 concludes the paper and discusses some policy implications.

2 Empirical Evidence of the Impact of SPS and TBT Measures on China's Agricultural Exports

According to Chinese government official sources, SPS and TBT measures have resulted in huge direct losses for China's agricultural exports. In 2001, about US$7 billion worth of Chinese exports were affected by SPS and TBT measures. In early 2002, the EU began to ban imports of Chinese animal-derived food, and seafood and aquatic products, resulting in a 70 per cent slump in China's aquatic product exports during the second half of that year (MOFCOM 2005). Also, China's Ministry of Commerce (MOFCOM) found that about 90 per cent of China's exporters of foodstuffs, domestic produce, and animal by-products were affected by foreign technical trade barriers and suffered losses totalling US$9 billion in 2002 (*China Daily* 2003).

China's recent experience with SPS barriers have been mainly with the EU, Japan and the United States.[4] These three economies accounted for 41, 30 and 24 per cent respectively of China's trade losses attributed to SPS measures in 2002 (Zhu 2003). In other examples, (Dong and Jensen 2004), in November 2001, 300 metric tons (mt) of shrimp shipped from Zhoushan in the Zhejiang province to the EU were discovered to contain 0.2 parts per billion of Chloramphenicol. As a result, the EU suspended imports of Chinese products of animal origin intended for human consumption or for use in animal feeds. Affected products included rabbit meat, poultry meat, and crustaceans such as shrimp and prawns. Later, other countries, including Hungary, Russia and Japan, implemented stricter inspections of poultry meat from China. As a consequence, exports of poultry meat from China declined by about 33 per cent in 2002 compared with the previous year.

In 2002 Japan tightened the Maximum Residual Limit (MRL) of the pesticide Chlorpyrifos in spinach from 0.1 ppm to 0.01 ppm. As a result, in July 2002 Japan blocked imports of frozen spinach from China after finding pesticides. Prior to this ban, imports from China were around US$30 million to US$35 million, accounted for 99 per cent of Japan's annual imports of 40,000 to 50,000 mt of spinach. Japan's restriction on Chinese exports of frozen spinach lasted until February 2003. In May 2003, after detecting higher-than-permitted pesticide residue, Japan again advised importers not to import Chinese frozen spinach, and this import ban was not lifted until June 2004. China's export of spinach to Japan dropped dramatically, from the highest level of US$33.89 million in 2001, to US$14.3 million in 2002 and US$3.95 million in 2003. In 2004 and 2005, China's export of spinach to Japan recovered slightly, but it was still lower than the 1994 export level.[5]

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[4] These three economies on average accounted for 52 per cent of China's total agricultural exports in the period 2002–2004, of which Japan accounted for 31 per cent, the EU for 11 per cent and the United States for 10 per cent.

[5] The United Nations Statistics Division, Commodity Trade Statistics Database, COMTRADE.

Japan, which is China's largest agricultural product export market, has introduced the *Positive List System for Agricultural Chemical Residues in Foods* (Ministry of Health, Labour and Welfare of Japan 2006), which took effect on 29 May 2006. Agricultural chemicals include pesticides, feed additives and veterinary drugs in a total of 797 categories. The system sets 53862 MRL standards. A uniform limit will be applied to agricultural chemicals for which MRLs are not established. The uniform limit is 0.01 ppm, which means for 100 mt of agricultural products, the agricultural chemical residuals cannot exceed 1 gram.

From August 2002 to July 2003, the United States Food and Drug Administration (U.S. FDA) refused entry to 1,285 shipments of Chinese foodstuffs. Agricultural and aquatic products accounted for 630 of these shipments, or nearly half of all refusals (Dong and Jensen 2004). Most recently, from June 2005 to May 2006, the U.S. FDA refused 1,925 Chinese shipments from entry into the United States, of which 945 shipments were agricultural products, accounting for 49 per cent of the total refusals (U.S. FDA 2006). Most refusals result from violations of SPS measures. Excessive pesticide residues, low food hygiene, unsafe additives, contamination, and misuse of veterinary drugs have been major issues.

3 Methodology and Econometric Model

We aim to measure the effect of food safety standards on China's exports of two groups of agricultural commodities—vegetables, and fish and aquatic products. These two categories of agricultural products were selected because not only are they very important in China's agricultural exports,[6] but also they are the main targets of SPS regulations.

We apply a gravity model in which the interaction between two areas is a function of the concentration of relevant variables in the two areas, and of the distance between them.[7] Tinbergen (1962) pioneered its use in a study of the levels of bilateral trade flows. Linnemann (1966) elaborated the Tinbergen model and his results implicitly suggested that the relative distance is important in the determination of trade levels. Leamer (1974)

[6] Vegetables, fish and aquatic products accounted for 11.38 and 16.23 per cent of China's total agricultural export in 2005 respectively.

[7] For an earlier survey of the use of gravity models in the analysis of trade flows, see Leamer and Stern (1970). For a recent discussion of the use of gravity models in the analysis of trade flows, see Drysdale and Garnaut (1994).

used the framework laid out in his earlier work with Stern to test the adequacy of traditional trade theory, alongside more recent theory which stresses the importance of scale economies. Some economists have also used the gravity model in studies of regional trade blocs, regional trade bias and home country trade bias.[8]

The theoretical validity of the gravity model has been examined by Niedercorn and Bechdolt (1969) within the framework of utility theory. Deardorff (1995) demonstrated that the model is compatible with neoclassical models. The gravity model has also been derived in an imperfect competition/differentiated product framework.[9] Anderson and van Wincoop (2003) argued that estimated gravity equations do not have a theoretical foundation and that their estimation suffers from omitted variables bias. They derived the theoretical gravity equation based on the CES utility function. The key implication of the theoretical gravity equation is that trade between regions depends on the bilateral barrier between them relative to average trade barriers that both regions face with all their trading partners (multilateral resistance).

The gravity model has also been used to estimate the impact of product standards and food safety standards on trade flows. Moenius (2000) used the gravity model to provide a framework for estimating the effect of product standards on trade flows. Otsuki et al. (2001) used it to estimate the impact of the EU's new aflatoxin standards on food imports from Africa. The study suggests that the implementation of the new standard will have a negative impact on African exports of cereals, dried fruits and nuts to Europe.

Wilson et al. (2003) used the gravity model to examine the impact of drug residue standards on trade in beef and found that Tetracycline standard in beef has a negative and significant impact on world trade in beef. The study predicts that if international standards set by CODEX were followed in antibiotics, global trade in beef would rise by over US$3.2 billion.

Using the gravity model to examine Japan's stricter pesticide residue limit on vegetables exports from China, Sun et al. (2005) found that Japan's

[8] There are many such studies, among others for example Wolf and Weinschrott (1973), Deardorff (1984), Messinger (1993), Frankel (1994), Wei and Frankel (1994), Wei (1996), McCallum (1995), Helliwell and McCallum (1995), Helliwell (1996, 1997, 1998), Hillberry (1998, 1999, 2002), Anderson and Smith (1999a, 1999b), Hummels (1999), Evans (2000a, 2000b), Wolf (2000), Head and Ries (2001), Hillberry and Hummels (2002), Anderson and van Wincoop (2003), and Chen (2004).

[9] For more detailed discussion, see Anderson (1979), Helpman and Krugman (1985), and Bergstrand (1989).

stricter Chlorpyrifos standard has a negative impact on China's vegetables export to Japan.

The model used in this study can be written as:

$$EX_{ij}^{k} = f(X_i, X_j, R_{ij}) , \tag{1}$$

where EX_{ij}^{k} is the export value of commodity k from exporting country i to importing country j, X_i are exporting country variables, X_j are importing country variables and R_{ij} are resistance variables.

In this study, the exporting country *i*s China and the exporting country variable, X_i, is the output of China in commodity k. The importing country variable, X_j, is the GDP of importing country j.

The resistance variables include three factors: distance (*DIST*) between China and importing country j, *MRL* standards of pesticide or veterinary in commodity k imposed by importing country j and the import tariff rate (*TRF*) on commodity k imposed by importing country j.

Anderson and van Wincoop (2003) show that bilateral trade depends on both origin and destination price levels, which are themselves related to the existence of trade barriers (multilateral resistance). In our gravity equation, we ignored the relative prices and therefore the multilateral resistance variables and so our gravity equation could lead to biased estimates. We solve this problem by using importer-specific fixed-effects.[10]

Therefore the model estimated in this study is:

$$\begin{aligned} \ln EX_{ij}^{k} = \beta_j + \beta_1 \ln OPT_i^{k} + \beta_2 \ln GDP_j + \beta_3 \ln DIST_{ij} \\ + \beta_4 \ln MRL_j^{k} + \beta_5 \ln TRF_j^{k} + \varepsilon_{ij}^{k} . \end{aligned} \tag{2}$$

4 Specification of Variables and Data Sources

The dependent variables (*EX*) for all the models are the export value of a commodity or commodity group from China to an importing country at 2000 constant US dollars.[11] The classification of commodities is based on the HS 1992 system. The export data are from the UNCOMTRADE database. The commodity groups included in the study are vegetables (07), and fish

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[10] See Hummels (1999), Hillerry and Hummels (2002), and Rose and van Wincoop (2001).

[11] The export values are recorded in current US dollars which are deflated into 2000 constant US dollars by using US GDP deflator.

and aquatic products (03). The commodities included in the study are garlic (070320), onions (070310, 071220), and spinach (070970, 071030). In practice, we run two aggregate commodity group models (vegetables, fish and aquatic products) and three individual commodity-specific models (garlic, onions, and spinach). The period covered in the study is from 1992 to 2004.

The output of a commodity or commodity group of China, denoted as *OPT*, is used as the mass factor in the model. We argue that it is more appropriate to use the output (*OPT*) of China in a commodity rather than China's GDP as the mass factor in the gravity model in this study.[12] This factor captures the supply side effect on the export of the commodity. The output of a commodity represents the potential capacity for export. This variable is expected to be positive to China's export of the commodity under study. The output in current year might be endogenous as it could be affected by the current export opportunities. However, we argue that the current export would have no effect on the output of last year. To avoid the potential endogeneity problem output is lagged one year.[13] Data for output of a commodity or commodity group are from the FAO statistical database.[14]

The importing country's gross domestic product, denoted as *GDP*, is used as another mass factor in the model. This factor captures the purchasing power and the market size of the importing country, the demand side effect of the commodity. This mass factor is expected to have a positive effect on China's export of the commodity under study.[15] Data for the importing country's GDP are from the World Development Indicators (WDI) database, and are at 2002 constant US dollars.

Bilateral distance between China and an importing country, denoted as *DIST*, is used as a resistance factor in the model. In this study, the bilateral

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[12] See Evans (2001) and Hillberry (2002) for a discussion about the output variable instead of aggregate state GDP in the regression.

[13] We conducted a Hausman specification test, the hypothesis of exogeneity of the current output variable could not be rejected at standard significant level. The difference of the regression results with the current output variable and with the one-year time lag output variable is very small. However, to ensure exogeneity, in this study the one-year time lag output variable is used.

[14] See http://faostat.fao.org/faostat.htm

[15] We acknowledge that if the importing country has a large output of a particular commodity, that might have a negative impact on the exporting country's export of that particular commodity to the importing country's market. However, we argue that in general a larger country (measured by GDP) would import more than a smaller country in all commodities.

distance is the geographical distance between the capital cities of the two countries and the data are from CEPII.[16]

The import tariff, denoted as *TRF*, is used as another resistance factor in the model. The expected effect of the import tariff is negative on China's exports of the agricultural commodities under study. Import tariff rates imposed by importing countries on each agricultural commodity are taken from the database of the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS) within the World Integrated Trade Solution (WITS) developed by the World Bank.

Finally, the maximum residual limit standard of pesticide or veterinary, denoted as *MRL*, is used as another resistance factor to investigate the effect of food safety standards on China's export of agricultural commodities under study. Two MRL standards are examined. In the case of vegetables, we test the effect of Chlorpyrifos MRL standard on China's export of vegetables. In the case of fish and aquatic products, we test the effect of Oxytetracycline MRL standard on China's export of fish and aquatic products.

Chlorpyrifos is a broad-spectrum insecticide that is effective in controlling a variety of insects. Animals and humans exposed to it exhibit stomach poison symptoms; in plants the poison effects are confined in the tissue where it comes into direct contact with the plant, and is not transported to other plant parts.[17] *Oxytetracycline* is an antibiotic drug produced by a micro-organism[18] and is approved as a medicated fish feed in the United States where its use is restricted to certain fish species, to certain diseases, and to certain water temperatures. It can reduce disease-related mortality and improve fish health but in humans the concern about exposure is the development to resistance to antibiotics.

In the aggregate commodity model of vegetables, the value of the MRL of Chlorpyrifos for an importing country *i*s the simple average value of the MRL of Chlorpyrifos in seven categories of vegetables imposed by that importing country. The seven categories of vegetables are: onions, shallots, garlic, etc. (0703), cabbages, cauliflowers, etc. (0704), dried leguminous vegetables, shelled (0713), carrots etc. (0706), dry onions (071220), shelled or unshelled beans, frozen (071022), and spinach (070970, 071030). These seven categories of vegetables accounted for 47 per cent of China's total export of vegetables during the period from 2002 to 2004.

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16 See http://www.cepii.fr/anglaisgraph/bdd/distances.htm

17 For more information, see http://muweb.millersville.edu/~ces/research/TURCHI.pdf

18 For more information, see http://www.epa.gov/oppsrrd1/REDs/factsheets/0655fact.pdf and http://www.umesc.usgs.gov/aquatic/drug_research/oxytetracycline.html

The values of MRLs of Chlorpyrifos on vegetables are mainly from the international MRL database of the Food and Drug Administration of the Department of Agriculture of the United States (FDA),[19] the CODEX database on pesticides of the Food and Agriculture Organisation of the United Nation (FAO),[20] and the MRL database of the China National Food Safety Resource (NFSR).[21] As the databases have no historical information and lack some data on certain countries, we found other useful information by checking government documents in different countries.[22]

The values of the MRLs of Oxytetracycline on fish and aquatic products are from various sources, including CODEX databases on veterinary drugs of the FAO and the Web site of the Australian Department of Agriculture, Fisheries and Forestry, which has a link to government documents of Australia and other countries.[23]

The variables of the MRL of Chlorpyrifos and the MRL of Oxytetracycline are expected to be positive, since a smaller value of MRL implies a tighter standard. Thus, a positive coefficient implies that tighter standards have a negative effect on China's export of the commodities under study.

The values of the MRL of Chlorpyrifos standard in vegetables and the MRL of Oxytetracycline standard in fish and aquatic products for the selected countries in the regression models are presented in Table 1.

MRLs differ for a variety of reasons, including the impact of good agricultural practice (leading to differences in rates of usage), structures of diets in the consuming populations and variations in body weight. The evolution and procedures of the food regulatory system, including the assessment of risks, also affects the choice of MRLs.[24]

5 Regression Results and Explanations

To conduct the econometric regression analysis, we applied the two-stage generalized least squares model which was documented in Parks (1967)

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[19] Available at http://www.mrldatabase.com

[20] Available at http://faostat.fao.org/faostat.htm

[21] Available at http://219.238.178.38/index.asp

[22] These documents are available at http://www.nzfsa.govt.nz/plant/subject/horticulture/residues/index.htm

[23] Available at http://www.affa.gov.au/content/

[24] See Vogt (1994) for a discussion of the process of setting food safety standards, including factors that contribute to the variation in US standards compared to CODEX and those of other countries.

Table 1: *The MRL of the Chlorpyrifos Standard in Vegetables and the MRL of the Oxytetracycline Standard in Fish and Aquatic Products*

Importers	Standard				
	Vegetables (Chlorpyrifos)	Garlic (Chlorpyrifos)	Onions (Chlorpyrifos)	Spinach (Chlorpyrifos)	Fish (Oxytetracycline)
Japan	0.79 ppm (1992–01)	0.05 ppm (1992–01)	0.50 ppm (1992–01)	0.10 ppm (1996–01)	0.20 ppm (1992–05)
	0.11 ppm (2002–05)	0.01 ppm (2002–05)	0.05 ppm (2002–05)	0.01 ppm (2002–05)	—
EU	0.52 ppm (1992–01)	0.05 ppm (1992–05)	0.20 ppm (1992–05)	0.05 ppm (1992–05)	0.10 ppm (1992–05)
	0.10 ppm (2002–05)	—	—	—	—
United States	0.76 ppm (1992–05)	0.50 ppm (1992–05)	0.50 ppm (1992–05)	0.05 ppm (1992–05)	2.00 ppm (1992–05)
Australia	0.10 ppm (2002–05)	0.01 ppm (1992–05)	0.01 ppm (1992–05)	0.01 ppm (1992–05)	0.20 ppm (1992–05)
Korea	0.35 ppm (1992–05)	0.50 ppm (1992–05)	0.50 ppm (1992–05)	0.01 ppm (1992–05)	0.20 ppm (1992–05)
Malaysia	0.38 ppm (1992–05)	0.50 ppm (1992–05)	0.20 ppm (1992–05)	—	0.20 ppm (1992–05)
Philippines	0.48 ppm (1992–05)	0.50 ppm (1992–05)	0.20 ppm (1992–05)	—	0.20 ppm (1992–05)
Hong Kong (China)				1.00 ppm (1992–05)	
Russia	—	—	0.20 ppm (1992–05)	—	—
Vietnam	—	—	0.20 ppm (1992–05)	1.00 ppm (1992–05)	—
Indonesia	0.46 ppm (1992–05)	0.50 ppm (1992–05)	—	—	0.20 ppm (1992–05)
New Zealand	0.20 ppm (1992–05)	0.01 ppm (1992–05)	—	0.01 ppm (1992–05)	0.10 ppm (1992–05)
Thailand	0.48 ppm (1992–05)	0.50 ppm (1992–05)	—	1.00 ppm (1992–05)	0.20 ppm (1992–05)
China	0.36 ppm (2003–05)	0.02 ppm (2003–05)	0.02 ppm (2003–05)	1.00 ppm (2003–05)	0.10 ppm (2001–05)
CODEX	0.52 ppm	—	0.20 ppm	—	0.20 ppm

Note: The Philippines do not have a National Maximum Residue Limit (MRL), but follows CODEX and the ASEAN-harmonized MRL. —means that the country *is* not in the sample for the corresponding regression model because of a lack of relevant data and information. China's and CODEX standards are presented in the table for reference.

Source: As discussed above.

and Kmenta (1997), in which the model assumes an autoregressive error structure of the first order AR(1), along with contemporaneous correlation among cross-sections. The Parks method in SAS System (Version 8) is used to estimate the gravity models. The time period covered in the regressions is from 1992 to 2004 (for the regression of spinach, the time period is from 1996 to 2004 because of a lack of export data prior to 1996). The sample countries are the importers of China's agricultural products for whom the data of MRL standards of Chlorpyrifos and Oxytetracycline are available.[25]

The regression results for the commodity group of vegetables and the individual commodity of garlic, onions and spinach are reported in Table 2. The regressions of all models performed relatively well. The variable of China's output of vegetables (with one-year time lag) is positive and statistically significant for all the models, which indicates that China's export of vegetables will increase with the increase in domestic production capacity. The variable of importing countries' GDP is positive and statistically significant for all models. This implies that larger market size and higher purchasing power in importing countries will increase the demand for Chinese vegetables. The variables of distance and the tariff rate are negative and statistically significant for all models.

The most interesting regression result is that the variable of Chlorpyrifos standards in all models are positive and statistically significant. The magnitude of the effect will be greater for spinach, followed by onions, garlic and the whole group of vegetables. The regression coefficients show that a 10 per cent decrease in the value of Chlorpyrifos MRL, which means a tighter standard, will decrease the value of China's exports by 2.8 per cent for the whole group of vegetables, by 3.2 per cent for garlic, by 2.1 per cent for onions, and by 10.0 per cent for spinach. Apparently, leaf vegetables are highly sensitive to Chlorpyrifos standards.

The regression results for fish and aquatic products are reported in Table 3. The model performed very well with a high explanatory power. All the explanatory variables have the expected signs and are statistically significant.

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[25] We acknowledge that because of the limitations of the data availability on the MRL standards of Chlorpyrifos and Oxytetracycline, some importing countries are missing in the sample. This might lead to potential biases resulting from the missing sample. However, the sample countries in the study accounted for the overwhelming shares of China's export of the commodities under study. For example, the sample countries accounted for 82.5 per cent of vegetables, 72.5 per cent of fish, 81.9 per cent of onions, 58.3 per cent of garlic, and 97.3 per cent of spinach of China's export of these commodities during 1992–2004.

Table 2: *Regression Results for Vegetables (Chlorpyrifos)*

Variables	Vegetables (group)	Garlic	Onions	Spinach
LnOPT_i^k	2.20	3.33	2.24	7.02
	(9.65)***	(9.04)***	(6.28)***	(60.07)***
LnGDP_j	0.82	0.32	0.37	0.83
	(38.30)***	(2.95)***	(5.89)***	(5.93)***
Ln$DIST_{ij}$	−1.27	−1.15	−1.04	−3.12
	(−24.78)***	(−3.86)***	(−5.19)***	(−7.97)***
LnMLR_j^k	0.28	0.32	0.21	1.00
	(9.16)***	(2.98)**	(2.06)**	(8.41)***
LnTRF_j^k	−0.13	−0.12	−0.12	−0.78
	(−5.90)***	(−2.12)**	(−3.62)***	(−8.76)***
R^2	0.95	0.66	0.70	0.98

*, ** and *** imply significance at the 10, 5 and 1 per cent level under the two-tail test respectively. t-statistics are in parentheses.
Note: The countries in the regression of vegetables include Japan, EU (15), the United States, Australia, Korea, Malaysia, the Philippines, Indonesia, Thailand and New Zealand. The countries in the regression of garlic include Japan, EU (15), the United States, Australia, Korea, Malaysia, the Philippines, Indonesia, Thailand and New Zealand. The countries in the regression of onions include Australia, EU (15), Japan, Korea, Malaysia, the Philippines, Russia, the United States and Vietnam. The countries in the regression of spinach include EU (15), Japan, Korea, the United States, Thailand, Vietnam, Hong Kong (China), Australia and New Zealand. Importing country-specific dummies are not reported in the table.

The variable of China's output of fish and aquatic products is positive and statistically significant, indicating that China's export of fish and aquatic products will increase with the increase in domestic production capacity of fish and aquatic products. The variable of importing countries' GDP is positive and statistically significant, indicating that larger market size and higher purchasing power in importing countries will increase the demand for Chinese fish and aquatic products. The distance and the tariff rate variables are negative and significant.

The variable of Oxytetracycline standards is positive and statistically significant. This implies that tighter standards (smaller values) of the MRLs of Oxytetracycline imposed by importing countries have significant negative effects on China's exports of fish and aquatic products. The regression coefficient shows that a 10 per cent decrease in the value of Oxytetracycline MRL will decrease the value of China's export of fish and aquatic products by 2.7 per cent.

Table 3: *Regression Results for Fish Products (Oxytetracycline)*

Variables	Coefficients
$\text{Ln}OPT_i^k$	1.89 (14.49)***
$\text{Ln}GDP_j$	1.02 (14.19)***
$\text{Ln}DIST_{ij}$	−1.54 (−12.65)***
$\text{Ln}MLR_j^k$	0.27 (2.63)**
$\text{Ln}TRF_j^k$	−0.10 (−14.19)***
R^2	0.95

*, ** and *** imply significance at 10, 5 and 1 per cent levels under two-tail test respectively. t-statistics are in parentheses.
Note: The countries in the regression of fish products include Japan, EU (15), the United States, Australia, Korea, Malaysia, the Philippines, Indonesia, Thailand and New Zealand. Importing country-specific dummies are not reported in the table.

6 Measuring the Effect of Food Safety Standards on China's Agricultural Exports

The elasticity of China's export of vegetables and fish and aquatic products with respect to Chlorpyrifos and Oxytetracycline standards that are estimated in the previous regressions can be used to predict changes in export values of China's export of vegetables and fish and aquatic products under different standard setting scenarios.

To conduct the analysis, we first take the CODEX international standards as the baseline standard to examine what would be the effect on China's export of vegetables and fish and aquatic products if the importing countries use the CODEX international standards rather than their own standards. Because the CODEX international standards are not available for garlic and spinach, we use the US standards as the baseline standard. The main reason for choosing these US standards as the baseline is that, compared with the standards of Japan, the EU and other countries, the US system of standard is relatively complete and more moderate.

According to the definition of an elasticity, we have the following equation

$$dEX_{ij}^k/EX_{ij}^k = \beta\left(\left(MRL_{baseline}^k - MRL_j^k\right)/MRL_j^k\right), \tag{3}$$

where $dEX_{ij}^{k} = \left(EX_{ij,baseline}^{k} - EX_{ij}^{k}\right)$ is the predicted change in the export value between the baseline estimated export value and the actual export value of China's exports of commodity k to an importing country j; $EX_{ij,baseline}^{k}$ is the baseline estimated export value of China's exports of commodity k to an importing country j; EX_{ij}^{k} is the actual export value of China's exports of commodity k to an importing country j; β is the estimated elasticity (derived from the regressions) of China's exports of commodity k with respect to MRL standards of pesticide or veterinary drug; $MRL_{baseline}^{k}$ is the baseline MRL standards of pesticide or veterinary drug in commodity k; MRL_{j}^{k} is the importing country j's MRL standard of pesticide or veterinary drug in commodity k. Rearranging (3), we have the following equation and we can use this equation to calculate the changes in export value associated with changes in standards[26]

$$dEX_{ij}^{k} = \beta\left(EX_{ij}^{k}/MRL_{j}^{k}\right) \times \left(MRL_{CODEX,orUS}^{k} - MRL_{j}^{k}\right), \tag{4}$$

where $MRL_{CODEX,orUS}^{k}$ is the CODEX international standard or US standard of pesticide or veterinary drug in commodity k, and the other variables are as defined in (3).

Table 4 presents the calculation results for the whole group of vegetables, onions, fish and aquatic products for sample importing countries in the regression. In the calculations, the CODEX international standards are used as the baseline standard.

As Table 4 shows, if the importing countries use the CODEX international standards, China's export of vegetables to Japan, the EU, Australia and New Zealand will increase considerably, by 110, 117, 117 and 44 per cent respectively; those to Korea, Malaysia, Indonesia, Thailand and the Philippines will also increase but by a smaller amount. However, China's export of vegetables to the United States will decline by 9 per cent because the CODEX international standards of Chlorpyrifos on vegetables are tighter than those of the United States.

If the CODEX international standard on onions is adopted by the importing countries, China's exports to Japan will increase by 63 per cent and to Australia it will increase tremendously by 399 per cent. However, China's onion exports to the United States, Korea and Malaysia will decline by 13 per cent because these countries' standards of Chlorpyrifos on onions are looser than the CODEX international standard.

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[26] Otsuki et al. (2001) and Wilson et al. (2003) used this same formula to calculate the predicted changes in trade value associated with changes in standards.

Table 4: *Changes in Value of China's Export of Vegetables, Fish and Aquatic Products (million US dollars at 2000 constant prices)*

	2002	2003	2004	2005	Total	Per cent change[a]
			Whole Group of Vegetables[b]			
Japan	819.35	852.66	987.31	986.46	3645.77	110
EU	241.78	435.61	578.61	721.74	1977.74	117
United States	−8.09	−11.68	−13.78	−16.62	−50.17	−9
Korea	79.97	84.89	101.61	91.49	357.97	13
Malaysia	1.25	2.68	4.22	2.92	11.06	10
Indonesia	0.19	0.54	1.75	0.34	2.81	4
Thailand	0.17	0.32	0.80	1.23	2.53	2
Philippines	0.53	0.61	0.55	0.69	2.39	2
Australia	9.96	12.65	17.47	23.26	63.34	117
New Zealand	0.66	0.68	1.21	1.68	4.22	44
			Onions[c]			
Japan	14.35	20.75	31.83	35.52	102.45	63
United States	−0.12	−0.34	−0.34	−0.38	−1.17	−13
Korea	−0.04	−1.02	−0.43	−0.68	−2.17	−13
Malaysia	−0.36	−0.72	−0.46	−1.45	−2.98	−13
Australia	0.33	0.83	1.08	3.44	5.68	399
			Fish and aquatic products[d]			
EU	47.66	85.88	114.07	142.29	389.90	23
United States	−92.51	−119.52	−126.13	−159.32	−497.48	−21
New Zealand	0.56	0.56	0.60	1.52	3.24	23

[a] The per cent change is defined as the change in export value over the actual export value. The per cent change for the period 2002–2005 is the same. Countries whose standards are the same as the baseline standards (the CODEX international standards) are not reported because the change is zero. — [b] Elasticity: 0.28, CODEX standard of Chlorpyrifos: 0.52 ppm. — [c] Elasticity: 0.21, CODEX standard of Chlorpyrifos: 0.20 ppm. — [d] Elasticity: 0.27, CODEX standard of Oxytetracycline: 0.20 ppm.

Source: Authors' calculation.

In terms of fish and aquatic products, it is interesting to note that China's exports of these products to the United States will fall substantially by 21 per cent if the United States adopts the CODEX international standards of Oxytetracycline on such products because the United States standard on fish and aquatic products is 10 times higher (i.e., looser) than the CODEX international standard. However, China's exports of fish and aquatic products to the EU and New Zealand will increase by 23 per cent if these countries adopt the CODEX international standard of Oxytetracycline on fish and aquatic products.[27]

Using the regression results, we can also estimate the import tariff equivalent of the changes in food safety standards on China's export of vegetables. Based on the information of food safety standards in Table 1 and the estimated ratio of the coefficient on food safety standards to the coefficient on the import tariff, we calculated the import tariff equivalent of the changes in food safety standards in 2002 in Japan and the EU on China's export of vegetables. The calculation results are reported in Table 5. The negative sign of the change in MRL represents a reduction in its value, that is, a stricter food safety standard.

Table 5: *Import Tariff Equivalent of Changes in Food Safety Standards on China's Export of Vegetables to Japan and the EU*

	Changes in MRL in 2002 to the current level (%)	Tariff equivalent changes (%)	Import tariff in 2002 (%)[a]	Equivalent increase in import tariff (%)
Japan				
Group of vegetables	−86	185	5.98	11.08
Garlic	−80	213	3.00	6.40
Onions	−90	158	4.71	7.42
Spinach	−90	115	3.60	4.15
EU				
Group of vegetables	−80	172	8.78	15.13
	Changes in MRL in 2002 to CODEX level (%)	**Tariff equivalent changes (%)**	**Import tariff in 2002 (%)[a]**	**Equivalent increase in import tariff (%)**
Japan				
Group of vegetables	−34	73	5.98	4.38
Onions	−60	105	4.71	4.95
EU				
Group of vegetables	0	0	8.78	0

[a] Simple average import tariff rates calculated from Trade Analysis Information System (TRAINS).

Source: Authors' calculation.

[27] In general, US standards of Chlorpyrifos on vegetables and Oxytetracycline on fish and aquatic products are more moderate than the standards adopted by most of the sample countries and are also more moderate than the CODEX international standards. We also calculated results using the US standards as the baseline standard. These results are available from the authors.

We first calculated the equivalent increase in import tariff that would lead to the same effect on trade as the changes in the MRL in 2002 to the current level applied by Japan and the EU. As shown in Table 5, the increases in the level of food safety standards by Japan and the EU in 2002 for imported vegetables are equivalent to a 11.08 percentage point increase and a 15.13 percentage point increase in the import tariff rate on China's exports of vegetables respectively.

Table 5 also shows that if Japan and the EU adopted the CODEX standards rather than the stricter standard currently applied, the tariff equivalent effect of the food safety standard changes on China's vegetable exports would be much smaller.

We can also estimate the changes in the value of China's exports of vegetables to Japan and the EU if they had not changed their food safety standards in 2002. As Table 6 shows, China's exports of vegetables would have increased remarkably if Japan and the EU had not changed their food safety standards. For example, China's exports of vegetables to Japan and the EU would be higher by 183 and 118 per cent, with a value of US$1,641 million and US$728 million, respectively, in 2005. China's exports of garlic, onions and spinach would have also increased by a big margin.

China's export of spinach to Japan would have increased by 901 per cent (that is, by a factor of 9) if Japan had not changed its food safety standard, according to the results in Table 6. Is that possible? The average annual growth rate of China's spinach export to Japan for the period 1992–2001

Table 6: *Changes in the Value of China's Export of Vegetables (million US dollars at 2000 constant prices)*

	2002	2003	2004	2005	Total	Per cent change
Japan						
Group of vegetables	1,363	1,419	1,643	1,641	6,066	183
Garlic	25	28	41	35	129	128
Onions	43	62	95	107	307	189
Spinach	129	36	60	86	311	901
EU						
Group of vegetables	244	439	583	728	1,994	118

Note: The per cent change is defined as the change in export value over the actual export value. The per cent change for the period 2002–2005 is the same.

Source: Authors' calculation.

can be used to predict the potential export value for the period from 2003 to 2005. Using that growth rate, the predicted export values are 13.7, 10.3 and 9.0 times the actual export values in 2003, 2004 and 2005 respectively. Therefore, the estimate of the effect of the change in the standard is within a plausible range.

7 Conclusion and Policy Implications

China's recent experiences in agricultural trade disputes with the developed countries, especially Japan, the EU and the United States, suggest that the effects of SPS and TBT barriers are costly to China's exports of agricultural products. To measure their effect, we conducted a series of empirical regression analyses using the gravity model. In these analyses we tested the effect of the Chlorpyrifos MRL standards on China's export of vegetables and the Oxytetracycline MRL standards on China's export of fish and aquatic products. The empirical regression results showed that China's agricultural product trade is sensitive to variations in food safety standards. Higher food safety standards imposed by importing countries have a negative and statistically significant effect on China's exports of agricultural products. Furthermore, the trade effect of the same relative change in food safety standards is much larger than that of a change in the import tariff.

Variation in conditions of agricultural production and the characteristics of the consuming population, all of which are considered in setting food safety standards at a national level mean that differences in national standards are likely to persist, and developing country exporters will have to comply with standards imposed in their developed country markets. At the time of writing, the intensity of the debate over the safety of international traded food products was increasing.[28] Vogt (1994) explains how scientific practice might be adopted to derive standards, but that applications and methods can also vary for legitimate reasons, as do risk assessments based on the same sets of results of any scientific analysis.

More important than harmonization of the standards themselves is, therefore, the removal of uncertainty facing exporters about decision making by import authorities, including the confirmation that decision making to permit imports is also based on scientific methods. However, there are

[28] See for example Andrew Batson, 'Safety supplants quotas as hot-button trade issue', *The Wall Street Journal: Asia*, 16 July 2007, p. 1 and p. 32.

many dimensions to the scientific methods, which also makes it difficult to harmonize their application and which opens their application to abuse for strategic reasons. There is scope for arbitrariness, for example in the extent of sampling, based on assumptions about the extent of edible material in any product, and the location of sampling, which affects results according to the ways in which materials accumulate.

The priorities for international cooperation, and for requests by developing country exporters of their developed country trading partners, might therefore include a) transparency, and b) mutual recognition of testing procedures. Transparency of not only the standards themselves but also of their origins and of testing procedures is important to reduce uncertainty and therefore transactions costs in international trade. Mutual recognition of testing facilities reduces the risk associated with abuse of testing procedures in importing countries, and also reduces the risk that export shipments will be rejected by importing countries. Mutual recognition could apply to either facilities located in exporting countries or those of third parties who act as agents of developing country exporters. These priorities also direct attention to useful areas of cooperation in capacity building between trading partners. They also support the efforts in developing countries to meet the expectations of food safety among their domestic consumers.

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