China Economic Review 23 (2012) 253–264

Contents lists available at SciVerse ScienceDirect

China Economic Review

The impacts of food safety standards on China's tea exports

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ARTICLE INFO

Article history:
Received 14 June 2011
Received in revised form 17 November 2011
Accepted 17 November 2011
Available online 26 November 2011

JEL classifications:
F13
O2
Q17
Q18

Keywords:
Food safety standards
Sanitary and Phytosanitary measures
Maximum residual limit
Tea
Export

ABSTRACT

There have been growing concerns about the effects of food safety standards on agricultural trade throughout the world. The objective of this paper is to assess the impacts of food safety standards on tea exports from China, the world's largest tea producer and exporter. To achieve this objective, the paper discusses the trends and nature of China's tea production and export, analyzes changes on tea safety standards indicated by Sanitary and Phytosanitary (SPS) measures, Maximum Residual Limit (MRL) of pesticides and the coverage of tea safety standards concerning regulatory pesticides in major importing countries, and quantitatively estimates the impacts of food safety standards on China's tea export based on a gravity model. The results show that the MRL of pesticides (e.g., endosulfan, fenvalerate and flucythrinate) imposed by importing countries have significantly affected China's tea exports. The results also show that China's tea exports have been significantly restricted when importing countries increase coverage of tea safety standards concerning regulatory pesticides.

1. Introduction

Although average tariff rates on agricultural products have been declining over the past decade, food safety standards, particularly Sanitary and Phytosanitary (SPS) measures, are becoming major barriers to agricultural trade. Between 1996 and 2009, the global average tariff rates (simple average rates) on agricultural products declined from 14.6% to 10.8%,[1] whereas the number of total SPS notifications[2] (all types of notifications) across the world on agricultural products (HS01-HS24) increased considerably, from 136 in 1996 to 564 in 2009.[3] The increasing number of SPS notifications indicates that food safety standards have become stricter in many importing countries. This shift could have potentially wide-ranging effects for exporters (Otsuki, Wilson, & Sewadeh, 2001). For example, recent studies have shown that food safety standards have significantly affected exports of agricultural commodities from developing to developed countries (Disdier, Fontagné, & Mimouni, 2008).

There have been growing concerns about the effects of food safety standards on China's agricultural exports. China's external trade environment has changed remarkably. From a country that was once insulated from world markets, China is now deeply integrated in the global food markets. Tariffs have fallen, and trade barriers have gradually been removed. The most remarkable

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[1] Estimated based on WTO's TRAINS data, 2010.

[2] Under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement), importing countries must notify the WTO when they apply SPS measures to an imported commodity.

[3] Estimated based on WTO's SPS-IMS data, 2010.

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doi:10.1016/j.chieco.2011.11.002

movement was China's accession to the World Trade Organization (WTO) in 2001 (Anderson, Huang, & Ianchovichina, 2004). Although rapid growth of China's agricultural imports was expected after China's accession to the WTO, China had not substantially increased its exports of those labor-intensive products with competitive advantages (e.g., vegetables, fruits, tea, aquatic products, and processed foods) (Huang & Gale, 2006; Shan & Jiang, 2005; You & Cui, 2006). Indeed, China, a net agricultural exporter for more than two decades before the early 2000s, has been a net agricultural importer since 2004. Although there are many factors that may affect China's agricultural exports, food safety standards have been identified as one of the major barriers to China's agricultural exports by policy makers (MOFCOM, 2009, pp. 111–124) and some scholars (Chen, Yang, & Findlay, 2008; Dong & Jensen, 2004). In some cases, China's agricultural products were actually banned from import in some countries due to food safety standards. For example, Japan banned the import of spinach from China in May 2003 because of pesticide residue concerns (Wu, 2004), and the Europe Union (EU) prohibited the import of animal-based processed food from China for a similar reason in early 2002 (Chen et al., 2008).

Despite growing concerns about the effect of food safety standards on China's agricultural exports, few empirical studies have been conducted to investigate this important issue. Sun, Zhou, and Yang (2005) and Chen et al. (2008) are the only two empirical studies of which we are aware.[4] Both studies provided evidence of the significant impact of food safety standards on China's vegetable and aquatic product exports. Have these effects also impacted other agricultural exports from China? Specifically, what are the major food safety standards influencing China's agricultural exports, and how have these food standards affected China's agricultural exports?

The goal of this paper is to provide answers to the above questions by empirically estimating the impact of food safety standards on China's tea exports. The export of China's tea is selected as a case study for several reasons. China is the world's largest tea producer, with an annual production that has accounted for approximately one-third of the world's tea production in recent years (FAO, 2010). China was also the second largest tea exporter in 2009 (FAO, 2010). Moreover, there is growing evidence that safety standards for tea have intensified in importing countries, whereas overall tariff rates on tea imports have declined (Chen, 2004, 2007).

To meet the above goal, the rest of the paper is organized as follows. Section 2 presents an overview of China's tea production and export between 1996 and 2009. Section 3 discusses changes for tea safety indicated by SPS measures, MRL of pesticides (e.g., ndosulfan, fenvalerate, and flucythrinate) and the coverage of regulated pesticides in importing countries. Descriptive analyses of the relationship between regulated pesticides and China's tea exports are also provided in this section. Section 4 develops an empirical model based on a gravity equation to assess the effect of tea safety standards adopted by the importers of China's tea. Section 5 briefly discusses sources of data used in the empirical estimate. Section 6 discusses the results of econometric estimations. The final section of the study discusses potential policy implications.

2. China's tea production and export

China, the world's tea cradle, has experienced an accelerated growth in tea production since the late 1990s. The production of tea increased from 593 thousand tons in 1996 to more than 1.3 million tons in 2009 (Table 1). Its average annual growth rate accelerated from 3.6% between 1996 and 2000, to 5.4% between 2001 and 2005 and to nearly 8% between 2006 and 2009. Indeed, China has been the largest tea producer in the world since the late 1990s. Its share of global tea production increased from 22% in 1996 to 35% in 2009 (Table 1).

Table 1, however, shows that despite the rapid growth in tea production in China, the annual growth rate of tea exports by volume has been experiencing a significant decline since the late 1990s. Between 1996 and 2000, the average annual increase in tea exports was 14 thousand tons, which was more than 60% of the average annual increase in production (23 thousand tons). However, when the annual average production increased by 106 thousand tons between 2006 and 2009, the corresponding annual rise in exports was only 4 thousand tons (Table 1). The average annual growth of tea exports also fell, from 7.6% between 1996 and 2000 to a mere 1.1% between 2006 and 2009.[5] Thus, the increased amounts of tea produced in China in recent years have primarily been consumed domestically.

The declining growth rate of tea exports has raised many concerns in China. Some argue that the falling share of China's tea exports in the international market is due to the increase of tea production, based on the relative comparative advantage in other major tea exporting countries such as Sri Lanka, India, Kenya and Indonesia (Xu, 2006). Others believe that changes in safety standards imposed on China's tea exports are major reasons for the decrease in growth in China's tea exports. Gu and Niu (2007) argued that China's tea exports were severely impacted by Japan's stricter tea safety standards. Sun, Sun, and Zhou (2007) claimed that the EU's changes to MRLs since 2000 imposed additional costs to China's tea production and reduced China's tea exports to the EU by approximately 1%. In the next subsection, we will examine the changes in tea safety standards among the major importers of China's tea and their relationships with tea imports from China.

Although China has exported its tea to more than 140 countries/regions, its importers are fairly concentrated (as shown in Fig. 1). Morocco, Japan, the EU, Hong Kong, and the U.S. are the top five importers, and they accounted for more than half of China's tea export values between 2005 and 2009 (Table 2). Morocco is a leading importer of China's tea. Their average annual

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[4] Sun et al. (2005) used the gravity model to examine the impact of Japan's food safety standards on China's vegetable exports. The results showed that Japan's Maximum Residue Limit (MRL) of chlorpyrifos, an important index for food safety standards, has a negative impact on China's vegetable exports. Chen et al. (2008) also applied a gravity model to assess the impact of the MRL of chlorpyrifos on China's vegetable exports and the MRL of oxytetracycline on aquatic products from China. Their results showed that importers' food safety standards played a more important role in influencing China's agricultural exports than did the import tariff.

[5] Although the annual growth rate of tea export values for China increased from 2.8% in 1996–2000 to 5.8% in 2006–2009, its share in the world total export value has declined equally to match that of its volume shares (Table 1), implying an overall rise in world tea prices for all countries in 1996–2009.

Table 1
Average annual growth rates of China's tea production and exports and its shares in the world, 1996–2009.
Source: Numbers are estimated based on UNCTAD (2010) and the NSBC (2010).

	Production	Export volume	Export value in 2000 price
Actual (1000 tons or million USD)			
1996	593	170	311
2000	683	228	437
2005	935	287	426
2009	1359	303	564
Annual growth rate in China (%)			
1996–2000	3.6	7.6	2.8
2001–2005	5.4	3.9	3.5
2006–2009	7.8	1.1	5.8
China's share in the world (%)			
1996	22.0	26.7	21.2
2000	23.0	20.2	16.6
2005	25.8	17.6	13.9
2009	35.0	19.5	14.6
Average annual increase (1000 tons or million USD)			
1996–2000	23	14	9
2001–2005	50	12	16
2006–2009	106	4	34

tea imports from China accounted for close to 20% of China's total tea exports between 2005 and 2009. Japan and the EU's shares of China's exports were approximately 10%. Germany, France, the United Kingdom, the Netherlands, Poland, and Spain are 6 major EU destinations of China's tea exports. Imports by Hong Kong and the U.S. accounted for approximately 7% of China's tea exports. The top 26 importers (the EU's 25 countries are considered as 1 importer) of China's tea accounted for more than 93% of China's total tea exports between 2006 and 2009 (Table 2).

It is interesting to note that China's tea exports to these countries have experienced diversified trends over the past decade. As shown in Fig. 2, the higher growth rates of China's tea imports are primarily concentrated among countries whose initial imports were relatively small. On the contrary, imports have decreased slightly among many previously significant importers. For example, countries such as Algeria, Mauritania, Ghana, Benin, Niger and the Ukraine have substantially increased their tea imports from China, with average annual growth rates of more than 15% between 1999 and 2009 (last column, Table 2). Other countries, such as Japan, the EU, Tunisia and Afghanistan, have recorded negative average annual growth rates of less than −2% during the same period.

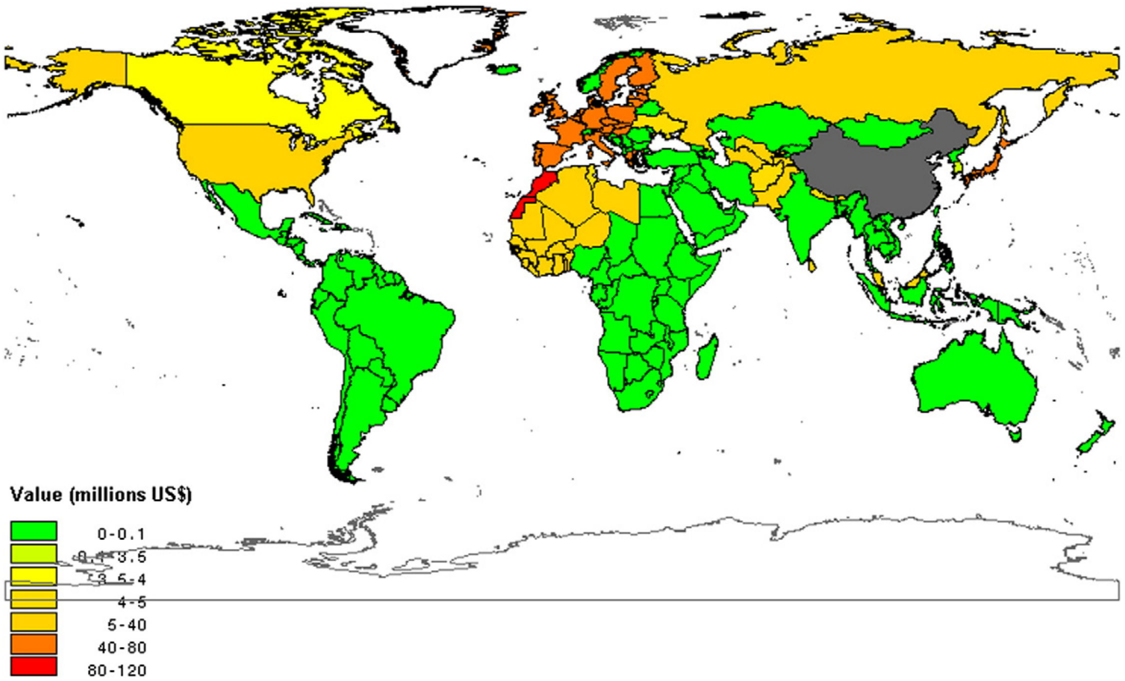


Fig. 1. Average annual tea imports from China by geographical locations in 2005–2009, millions of USD in 2000 real price.
Source: WTO (2010).

Table 2
Annual average exports of tea from China to major importers in 2005–2009 and average annual growth rate in 1999–2009.
Source: WTO (2010).

Rank	Importers	Annual average exports from China in 2005–2009		Annual growth rate of exports from China in 1999–2009
		Value (million in 2000 USD)	Cumulative percentage of export value	
1	Morocco	117.8	19.5	6.4
2	Japan	62.7	29.9	−4.7
3	EU25	52.0	38.5	−2.8
4	Hong Kong	43.5	45.6	3.9
5	United States	37.8	51.9	7.8
6	Russian	30.2	56.9	13.5
7	Algeria	26.3	61.3	20.3
8	Mauritania	26.3	65.6	15.7
9	Ghana	24.6	69.7	39.1
10	Senegal	21.5	73.2	3.3
11	Uzbekistan	18.1	76.2	8.0
12	Mali	14.1	78.6	6.3
13	Togo	10.9	80.4	9.8
14	Benin	9.4	81.9	42.2
15	Pakistan	9.0	83.4	10.1
16	Libya	6.9	84.6	9.5
17	Singapore	6.9	85.7	12.0
18	Gambia	6.7	86.8	−1.6
19	Malaysia	6.3	87.9	0.1
20	Sri Lanka	6.3	88.9	9.4
21	Niger	6.0	89.9	26.8
22	Ukraine	4.9	90.7	19.3
23	Tunisia	4.3	91.4	−8.5
24	Afghanistan	4.2	92.1	−2.7
25	Canada	3.8	92.7	10.9
26	South Korea	3.5	93.3	0.9

South Korea and Malaysia recorded a negligible increase in tea imports from China between 1999 and 2009. What factors determine the different trends of China's tea exports to these importing countries? In the next two sections, we descriptively and quantitatively examine tea safety standards, import tariffs and other factors that may have affected these countries' tea imports from China.

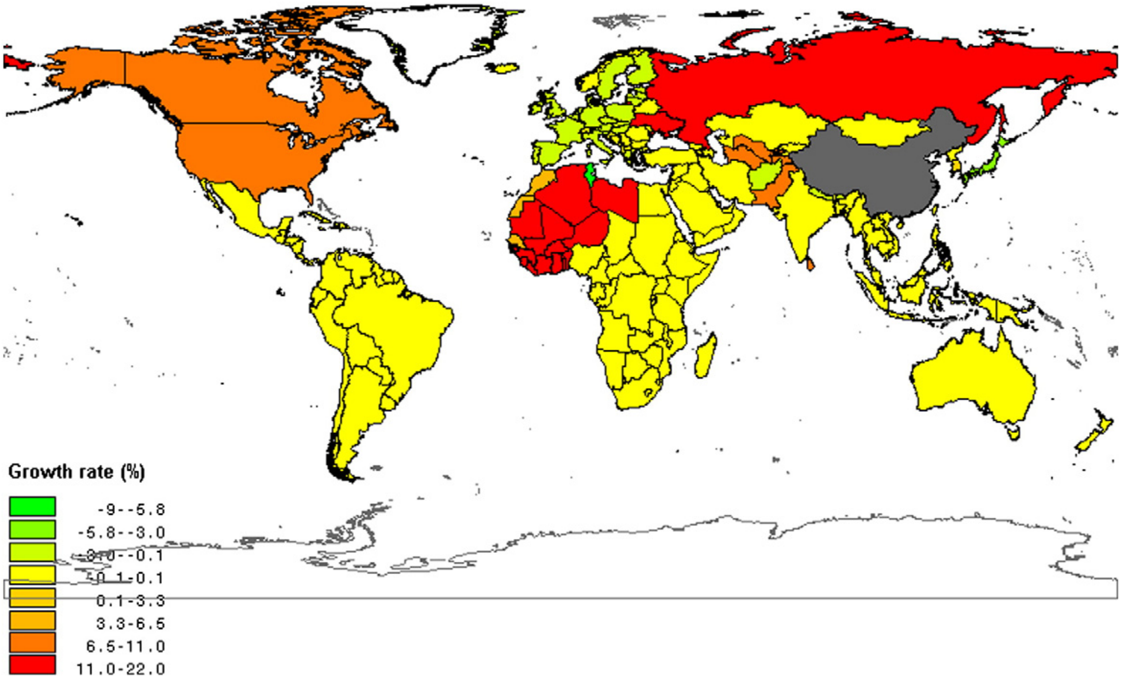


Fig. 2. Average annual growth rate (%) of tea imported from China by geographical location in 1999–2009.
Source: WTO (2010).

3. Tea safety standards and import tariffs

Similar to global trends, China's tea has experienced decreased import tariffs and increased food safety standards among importing countries. Fig. 3 shows that although global average tariff rates imposed on China's tea dropped by 30% between 1996 and 2009, SPS notifications, an important index for food safety standards in importing countries, increased during that same period. Increasing numbers of SPS measures on tea have been adopted by many importing countries since 2001, when China gained access to the WTO. Given these trends, there is a concern that SPS measures may have replaced the restrictive role of tariffs in the tea trade.

Although there is a trend of increase of SPS measures on tea exports, these measures are primarily adopted by developed countries, often for the purpose of protecting human health and the environment. Table 3 presents the annual average number of SPS notifications on tea exports between 1996 and 2009. The results indicate that, among the major importers studied, the EU, Japan, South Korea, and Sri Lanka have implemented SPS notifications on tea exports. Japan issued notifications at least once per year between 1996 and 2000. This increased to five times each year between 2006 and 2009. The EU and Korea also issued SPS notifications in each period, although the increase in notifications occurred only between 1996 and 2005. Sri Lanka is the only developing country that adopted SPS notifications in 2008. Variations in SPS notifications among countries and over time provide a useful database that can be used to estimate the impact of SPS measures on China's tea exports.

The other indices for food safety standards often used in empirical studies include the MRL of pesticides and coverage of regulated pesticides. The more pesticides that are regulated, the more stringent the tea safety standards are. Exports of tea from China to the EU reached their peak in 1998. China experienced a significant decline in its tea exports to the EU thereafter, when the EU increased its regulated pesticides from six in 1998 to 63 in 1999. The EU also established MRLs for these pesticides, with which imported Chinese tea must comply (Panel A, Fig. 4). The fall in China's exports in the early 2000s was also accompanied by the EU's continuous increase in the number of regulated pesticides: 106 pesticides were regulated in 2001, 180 were regulated in 2003, and 185 were regulated in 2004. Although China experienced a rapid growth in tea exports to the EU after 2005, an increase in 2007 to 227 regulated pesticides may partially account for the decline in China's tea exports in 2009 (Panel A, Fig. 4).

A similar negative correlation between the coverage of regulated pesticides and China's tea exports to Japan, Korea and Sri Lanka is also evidenced and reflected in Panels B, C and D of Fig. 4. In 2006, Japan applied the “Positive List System,” which is considered as the world's strictest food safety standards. There were 273 pesticides in tea imports that have been regulated since 2006. Therefore, it is not surprising that China's tea exports to Japan declined significantly between 2006 and 2009 (Panel B, Fig. 4). By 2009, China's tea exports to Japan were only $40.2 million, which was 43% less than the exports in 2005, the year before the “Positive List System” was implemented. South Korea set tea safety standards for the first time in 2006. These standards included 22 regulated pesticides. With this regulation and new standards for tea imports, China's tea exports to South Korea experienced a dramatic decline, falling from a peak of $6.4 million in 2006 to $2.3 million in 2007 and to only $0.6 million in 2009 (Panel C, Fig. 4). China's tea exports to Sri Lanka were almost zero in 1996; however, they increased to approximately $1 million between 1990 and 2000. This was followed by a fourfold increase between 2000 and 2003, and tea exports reached nearly $7 million in 2008. In 2008, Sri Lanka established new tea safety standards. China's tea exports to Sri Lanka fell by 62% ($4.2 million)

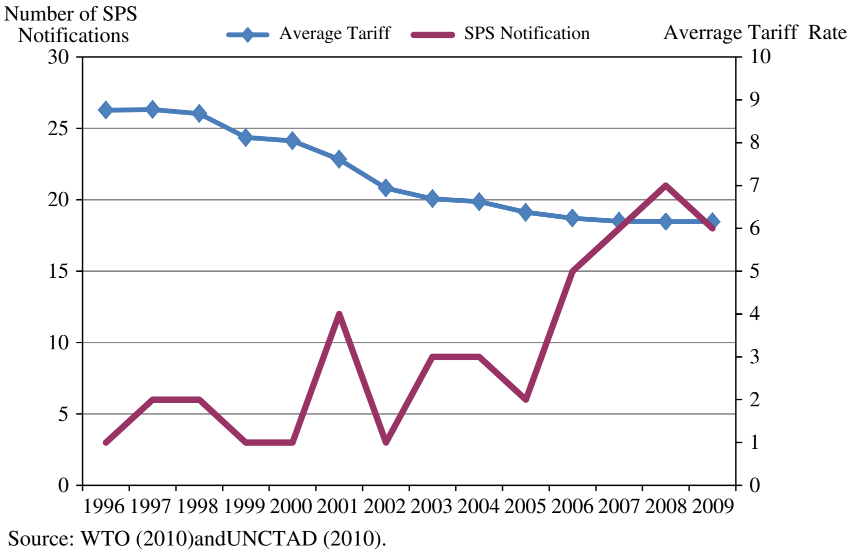


Fig. 3. Average tariff rate (%) and total number of SPS notifications on tea imported from China among 26 major importers, 1996 to 2009. Source: WTO (2010) and UNCTAD (2010).

Table 3
Annual average number of SPS notifications regarding tea among China's major tea importers in 1996–2009.
Source: WTO (2010).

	1996–2000	2001–2005	2006–2009
EU	0.20	1.00	0.50
Japan	1.00	1.00	5.50
Korea	0.25	0.60	0.25
Sri Lanka	0.00	0.00	0.25
Other[a]	0.00	0.00	0.00

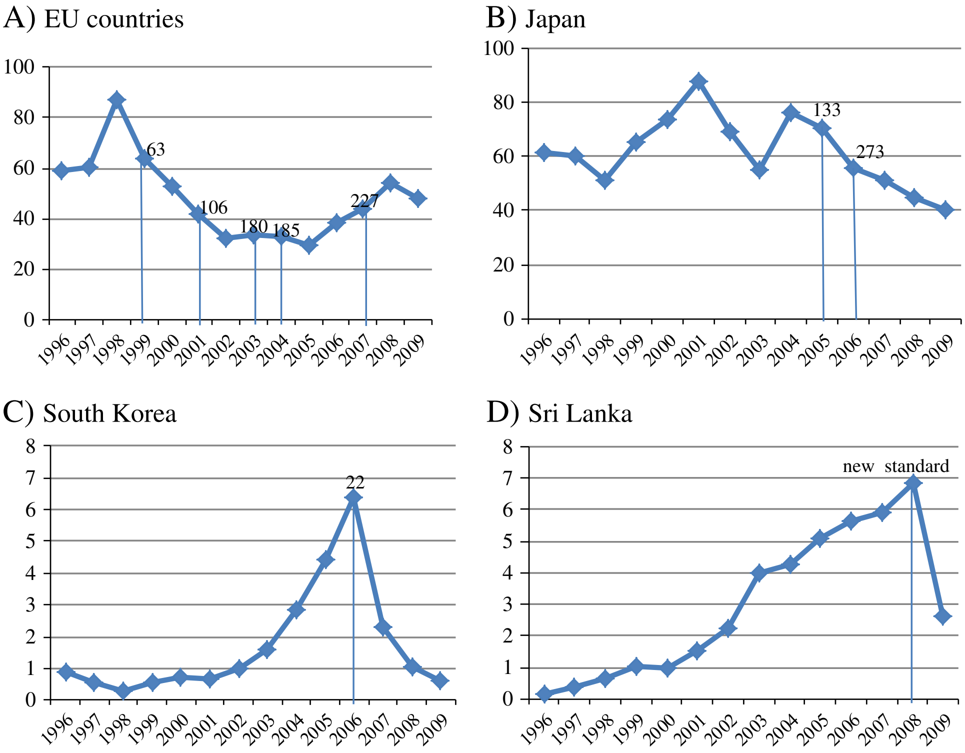
[a] All importers in Table 2 except for EU, Japan, Korea and Sri Lanka.

in 2009. Although it is not clear how many pesticides were regulated, the negative relationship between China's tea exports to Sri Lanka and the new safety standards is quite obvious (Panel D, Fig. 4).

A number of pesticides are strictly regulated in the importing countries because of their toxicity. Endosulfan, fenvalerate and flucythrinate were once widely used in tea production. All are toxic and hazardous to human health. The U.S. Environmental Protection Agency (EPA) has indicated that endosulfan is hazardous to both wildlife and humans, citing evidence of this among both fish and farmers (Lubick, 2010). Thus, the United States recently banned the use of endosulfan. Fenvalerate is known to be most toxic to bees and fish (WHO & FAO, 1996), and flucythrinate can cause extreme eye irritation and mild to severe skin irritation (ETN, 1993).

There has been a debate as to which safety standards should be applied to tea. The Codex Alimentarius Commission (Codex), which was established by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), is the major international organization for encouraging fair international trade in food and for protecting the health and economic interests of consumers. The Codex suggests limits on endosulfan (30 parts per million or ppm) and flucythrinate (20 ppm) in tea but does not suggest regulating fenvalerate (last row, Table 4). However, tea importers from some of the developed countries have set their own upper limits or MRLs for many pesticides, including endosulfan, fenvalerate and flucythrinate, whereas the developing countries have not established special standards for these three pesticides (Table 4).

In general, the safety standards imposed by the developed countries are higher than those suggested by the Codex, and there is also evidence that the safety standards have become increasingly strict over time. For example, the EU's MRL on endosulfan from 1996 to 2004 was the same as that of the Codex, but the EU raised its standards in 2005 and 2006. The MRL on endosulfan



Source: Chen (2004, 2007), UNCTAD (2010) and WTO(2010).

Fig. 4. Tea imported (millions of USD) from China and the number of regulated pesticides or changes in standards among the selected countries, 1996–2009. Source: Chen (2004, 2007), UNCTAD (2010) and WTO (2010).

dropped substantially, from 30 ppm between 1996 and 2004 to only 0.01 ppm in 2005 and 2006, far below the level suggested by the Codex (30 ppm). However, this stricter regulation was in place for only two years. In 2007, the EU reverted to its initial standard of 30 ppm. Regarding fenvalerate, the Codex has not imposed MRLs on tea; however, the EU and Japan have listed them as restricted pesticides. The EU's safety standard was set at extremely high levels in recent years. Its MRL on fenvalerate changed from 10 ppm between 1996 and 1998 to 0.05 ppm after 1999 (first row, Table 4). The EU's MRL for flucythrinate (0.1 ppm) is 200 times lower than the Codex's standard (20 ppm). In the U.S., the MRL on endosulfan is 24 ppm, which is also lower than the Codex's MRL (30 ppm). The U.S. does not have specific standards for either fenvalerate or flucythrinate, but the U.S. can apply general MRL guidelines (0.01 ppm to 0.1 ppm) to any pesticide that has not been included in its list of regulated pesticides.

In contrast to the increasingly stringent safety standards adopted by some tea importers, tariff rates on tea have declined significantly worldwide from 1996 to 2009 (Table 5). Table 5 also shows that, compared to developing countries, developed countries generally have lower tariff rates on tea imported from China. South Korea, however, is an exception. It has high tariff rates (276.8% between 2006 and 2009) on tea imported from China (Table 5).

4. The empirical model

As discussed earlier, with decreasing tariff rates on China's tea, tea safety standards reflected by the MRL of pesticides and the coverage of regulated pesticides may be the major obstacles to China's tea exports. Rising and frequent changes in safety standards can impose greater risks and additional costs to tea exported from China. The key question is as follows: to what extent have the changes in food safety standards affected China's tea exports? This section is intended to quantitatively analyze the standards' impact.

In the empirical econometric analysis, we include all tea importers listed in Table 2 except the EU. For the EU, among the 25 member countries, there are only 6 countries that have imported significant quantities of tea from China, which are Germany, Poland, Spain, France, the Netherlands and the United Kingdom (UK). In total, we analyze 31 countries/regions, of which 8 are in Europe (6 EU countries plus Russia and Ukraine), 2 are in North America (the U.S. and Canada), 9 are from Asia, and 12 are in Africa. These countries accounted for 90% of China's tea exports in 2009 and can significantly influence China's tea exports. Other countries only have imported a small fraction of China's tea or have not imported tea from China in recent years, and thus, these countries are not included in the empirical model because they have a limited impact on China's tea exports.

Gravity model applications have been widely used to model agricultural trade and to study the empirical impact of food safety standards on trade. Gravity modeling was first used by Tinbergen (1962) in a study of the levels of bilateral trade flows. The model is compatible with neoclassical models (Deardorff, 1998) and imperfect competition models (Anderson, 1979) but may suffer from omitted variable bias (Anderson & van Wincoop, 2003). Otsuki et al. (2001) estimated the effect of the EU's aflatoxin standards on food imports from Africa using a gravity model. They showed that, after controlling for the real per capita GNP in European and African countries, average rainfall in African countries, distance between the EU and African countries, time trends, and using a colonial tie dummy, a 10% tighter aflatoxin standard in European countries can reduce edible groundnut imports by 11%. Wilson and Otsuki (2004) used a similar gravity model to analyze the impact of MRLs on the pesticide chlorpyrifos for the banana trade. Their results suggest that a 1% increase in regulatory stringency leads to a decrease in banana trade of 1.63%. Similar methods have been used to study the impacts of non-tariff barriers by Moenius (2000), Wilson, Otsuki, and Majumdsar (2003), and Chen et al. (2008).

In this study, we also apply a gravity model to analyze the effects of food safety standards on China's tea exports. In this model, tea exports from China to different importing countries in real value are regressed on the GDP of the importers, on the tea production in China, on the geographical distance between China and importers, on the tariff rates on tea in each importing country, and on tea safety standards. Tea safety standards are indicated by the coverage of regulatory pesticides and the MRLs for endosulfan, fenvalerate, and flucythrinate of the importing countries.

Table 4

The MRLs of endosulfan, fenvalerate and flucythrinate in tea, 1996–2009.

Source: United Kingdom Health and Safety Executive Database, Codex Database on Pesticides of the Food and Agricultural Organization of United Nation (FAO), Japan Food Chemical Research Foundation Database, and Chen (2004 and 2007).

Importers	The MRLs of 3 major pesticides		
	Endosulfan	Fenvalerate	Flucythrinate
EU	30 ppm−>0.01 ppm−>30ppm[a]	10 ppm−>0.05ppm[b]	0.1 ppm
Japan	30 ppm	1 ppm	20 ppm
USA	24 ppm	0.01 ppm–0.1ppm[c]	0.01 ppm–0.1ppm[c]
Russian	–	–	–
South Korea	–	–	–
Africa	–	–	–
ASEAN	–	–	–
Codex	30 ppm	–	20 ppm

[a] The MRLs of endosulfan were 30 ppm, 0.01 ppm and 20 ppm in 1996–2004, 2005–2006, and 2007–2009, respectively, in the EU.

[b] The MRLs of fenvalerate were 10 ppm and 0.05 ppm in 1996–1998 and 1999–2009, respectively, in the EU.

[c] The U.S. does not set specific standards for these 2 pesticides. The numbers in this table reflect the U.S.' general safety standards for pesticides.

Table 5
Average tariff rate (percent) on tea among major importers of China's tea in 1996–2009.
Source: UNCTAD (2010).

	1996–2000	2001–2005	2006–2009
North America			
USA	1.90	1.60	1.60
Canada	0.00	0.00	0.00
Europe			
EU	13.73	4.15	3.15
Russia	6.00	5.00	1.25
Ukraine	8.33	8.33	7.71
Asia			
Japan	12.64	11.67	11.67
Uzbekistan	17.50	17.50	17.50
Pakistan	50.00	20.33	10.00
Malaysia	25.00	21.60	8.00
Sri Lanka	33.00	26.10	28.00
Afghanistan	2.50	2.50	3.23
South Korea	299.65	283.65	276.80
Hong Kong and Singapore	0.00	0.00	0.00
Africa			
Morocco	36.25	35.15	34.72
Algeria	45.00	32.00	30.00
Mauritania	10.00	10.00	8.25
Libya	50.00	20.00	0.00
Tunisia	15.00	15.00	15.00
The Gambia and Ghana	20.00	20.00	20.00
Others[a]	10.00	10.00	10.00

[a] Others include Senegal, Mali, Togo, Benin, and Niger.

The gravity model used in this study is specified as follows:

$$\begin{aligned}\mathrm{Ln}(Export_{it}) = {} & \beta_0 + \beta_1\mathrm{Ln}(GDP_{it}) + \beta_2\mathrm{Ln}(Production_{t-1}) + \beta_3\mathrm{Ln}(Distance_i) + \beta_4\mathrm{Ln}(Tariff_{it} + 100) \\ & + \beta_5\mathrm{Ln}(END_{it}) + \beta_6\mathrm{Ln}(FEN_{it}) + \beta_7\mathrm{Ln}(FLU_{it}) + \beta_8 D_{ij} + \varepsilon_{it}\end{aligned} \qquad (1)$$

where *i* denotes the importer of China's tea and *t* stands for the import year. The β terms are coefficients to be estimated, and ε_{it} is the error term, which is assumed to be normally distributed with a mean of zero. The data used here cover the time period between 1996 and 2009.

In model (1), $Export_{it}$ is the export of tea from China to *ith* country in year *t*. GDP_{it} denotes the real Gross Domestic Product (GDP) of the importing country *i* in year *t* and captures the market size as would a typical gravity model. Export was measured in thousands of U.S. dollars, and GDP was measured in billions of U.S. dollars; both are expressed as the year 2000 constant price using the U.S. Consumer Price Index as a deflator. $Production_{t-1}$ denotes tea production in China lagged by one year and is measured in thousands of tons. It captures the supply-side effects in China. The production lags by one year to avoid potential endogeneity. $Distance_i$ is the bilateral distance between the capital cities of China and the importing country *i*. $Tariff_{it}$ denotes simple average import tariff rates imposed by importing countries on tea from China. END_{it}, FEN_{it} and FLU_{it} denote the MRL of endosulfan, fenvalerate and flucythrinate, respectively, on tea imposed by the importing countries. Although only the EU, Japan, and the U.S. have established the MRLs of these pesticides explicitly, this does not imply that other countries did not address the presence of these pesticides in imported tea. Following a similar approach used in the literature[6] (Chen et al., 2008), we also assume that the MRLs of endosulfan, fenvalerate and flucythrinate in these countries are the maximum MRL values among all importers in a particular year because China needs to meet the least-stringent requirement for the MRLs of these pesticides set by its trade partners.

Based on the discussion in the previous section, we created four D_j terms for EU countries: EU1999, EU2001, EU2003 and EU2007. These dummy variables have a value of 1 for the year indicated and afterwards and zero otherwise. They reflect the changes in coverage of regulated pesticides initiated in the year indicated. We also create one dummy variable for Japan (JA2005), one for South Korea (KO2006) and one for Sri Lanka (SL2008). JA2005 is 1 in the years when Japan applied the "Positive List System" and is zero otherwise (years before 2005). KO2006 has a value of 1 for years 2006 through 2009, when South Korea included 22 pesticides into its regulations and zero for years 1996 through 2005. SL2008 captures the likely impact of Sri Lanka's new tea safety standards that were implemented in 2008 and 2009.

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[6] Chen et al. (2008) used the following two methods to assign numbers for the missing MRL data: 1) when the MRL data are available in the CAC database, they used these data; 2) otherwise, they used the maximum value of MRL among the data collected for other countries.

5. Data

This study collected data from several sources. Tea export data are from the United Nations Commodity Trade Statistics Database (COMTRADE) of the United Nations Conference on Trade and Development (UNCTAD). Tea (HS 1992 code of 0902) is included in this analysis. GDP data are from the World Development Indicators (WDI) database of the World Bank. Tea production statistics for China are from the National Bureau of Statistics of China (NSBC, 2010). The bilateral distance between the capital cities of China and the importing countries is from the Institute for Research on the International Economy (CEPII). Data on tariffs are taken from the Trade Analysis Information System (TRAINS) of the UNCTAD. The data on the MRLs of pesticides and the coverage of regulated pesticides are based on various literature and policy document reviews, particularly on information obtained from the UK Health and Safety Executive database, the Codex database on pesticides from the Food and Agricultural Organization of the United Nations (FAO), the Japan Food Chemical Research Foundation database, and other studies in Chinese (Chen, 2004, 2007). Basic statistics of all the variables used in the regression are summarized in Appendix Table 1.

6. Estimation methods and estimated results

First, model (1) is estimated by the following two methods: ordinary least squares (OLS) and country fixed-effect models. Because OLS estimation is consistent only under restrictive assumptions that rarely hold, OLS estimation is used as a basic method of comparison with other consistent estimations. Country fixed-effect estimation controls for all unobserved non-time varying effects, including distance and other factors (e.g., consumption preferences) that are not considered in our model. A gravity model with fixed effects is more likely to avoid problems of inconsistency (Anderson & van Wincoop, 2003). To avoid likely collinearity between two sets of tea safety standards, in each estimation method, we first introduce the MRL for endosulfan, fenvalerate and flucythrinate (or *END*, *FEN* and *FLU*) and a set of dummy variables for the changes in the coverage of regulated pesticides (columns 1, 2, 4, and 5, Table 6). We then run a model with two sets of variables together (or all variables, columns 3 and 6, Table 6). For *tariff*, because there are zero tariffs in a number of countries, we follow Wilson and Otsuki (2004) by adding 100 to the original tariff value.

Table 6
Regression results of China's tea export value in double-log specification without time dummies in 1996–2009.

	OLS			Fixed-effect model		
	(1)	(2)	(3)	(4)	(5)	(6)
GDP	0.17***	0.16***	0.11**	0.79**	0.69**	0.68**
	0.04	0.03	0.05	0.30	0.31	0.32
Production	1.15***	1.45***	1.53***	0.69	1.13**	1.14**
	0.28	0.30	0.32	0.42	0.53	0.54
Distance	−0.01	−0.00	−0.12			
	0.17	0.14	0.18			
Tariff	−1.31***	−1.01***	−1.02***	−0.12	0.02	0.03
	0.30	0.33	0.34	1.47	1.49	1.49
Endosulfan	0.06**		0.03	0.04***		0.02
	0.03		0.04	0.01		0.02
Fenvalerate	0.16***		−0.09	0.18***		0.08*
	0.04		0.06	0.04		0.04
Flucythrinate	0.03		−0.09			
	0.05		0.06			
EU1999		−0.28	−0.86***		−0.43*	
		0.27	0.33		0.22	
EU2001		−0.49	−0.49		−0.46***	−0.46***
		0.34	0.35		0.17	0.17
EU2003		−0.14	−0.14		−0.20**	−0.20**
		0.39	0.39		0.08	0.08
EU2004		−0.22	−0.06		−0.26	−0.13
		0.34	0.41		0.16	0.09
EU2007		−0.23	−0.40		−0.21	−0.35
		0.27	0.37		0.22	0.32
JA2005		0.93***	0.96***		−0.67***	−0.67***
		0.27	0.28		0.24	0.24
KO2006		−1.54***	−1.60***		−0.77***	−0.78***
		0.52	0.53		0.19	0.20
SL2008		−0.90**	−0.93**		−0.23	−0.24
		0.41	0.41		0.22	0.22
Constant	6.34*	3.27	4.25	1.17	−1.64	−1.93
	3.30	3.40	3.68	8.44	8.97	9.03
Observations	395	395	395	395	395	395
R-squared	0.17	0.21	0.22	0.25	0.30	0.30

Note: *, **, *** indicate statistically significant at the 10 percent, 5 percent, and 1 percent level, respectively.

Table 7
Regression results of China's tea export value in double-log specification with time dummies in 1996–2009.

	OLS			Fixed effect model		
	(1)	(2)	(3)	(4)	(5)	(6)
GDP	0.17***	0.16**	0.11**	0.81**	0.60	0.59
	0.05	0.03	0.05	0.35	0.37	0.37
Production						
Distance	−0.01	0.00	−0.12			
	0.17	0.14	0.18			
Tariff	−1.29***	−1.00***	−1.01***	0.32	0.47	0.48
	0.30	0.33	0.34	1.61	1.62	1.63
Endosulfan	0.09**		0.02	0.07***		0.02
	0.03		0.05	0.02		0.02
Fenvalerate	0.16***		−0.09	0.21***		0.08
	0.06		0.08	0.06		0.05
Flucythrinate	0.02		−0.09			
	0.05		0.06			
EU1999		−0.17	−0.77**		−0.41	
		0.33	0.37		0.26	
EU2001		−0.46	−0.45		−0.52**	−0.52**
		0.44	0.45		0.22	0.22
EU2003		−0.42	−0.41		−0.38***	−0.38***
		0.49	0.49		0.13	0.13
EU2004		−0.22	−0.12		−0.29	−0.18*
		0.42	0.51		0.18	0.10
EU2007		−0.04	−0.15		0.04	−0.07
		0.31	0.43		0.20	0.28
JA2005		0.93***	0.96***		−0.75***	−0.77***
		0.25	0.26		0.26	0.26
KO2006		−1.49***	−1.55***		−0.68***	−0.68***
		0.50	0.51		0.15	0.15
SL2008		−0.83**	−0.85**		−0.09	−0.09
		0.38	0.38		0.17	0.17
Constant	13.54***	12.55***	14.02***	3.73	4.52	4.37
	2.78	2.62	3.06	8.39	8.25	8.26
Observations	395	395	395	395	395	395
R-squared	0.17	0.22	0.23	0.28	0.32	0.32

Note: 13-year dummies are included but not reported due to space constraints.

Second, in order to avoid inconsistent problems caused by omitted variables, including competition from other tea-exporting countries that can affect China's tea export and the state of the global tea market in different years, time dummies are introduced into the gravity model, and the estimation results are shown in Table 7. Although we have addressed endogeneity caused by omitted variables through introducing fixed-effect and time dummies into the gravity model, this two-way fixed-effect strategy may not be sufficient to address a likely causality of SPS measures if changes in the importing countries' SPS measures are endogenous with exports from China. However, this type of endogeneity might not be serious because China is only one of many tea-exporting countries that have been exporting tea to the importing countries in this study. Under the WTO's SPS agreement, tea safety standards in any importing country must be applied to all exporting countries, including China.[7]

In all models, many of the estimated coefficients of the control variables have signs that are intuitive. The signs, and often the levels of statistical significance, for the estimated coefficients of GDP and production are robust when using alternative econometric approaches (OLS or fixed-effect model in both linear or log specifications, the 1st and 2nd rows in Tables 6 and 7). For example, the estimated coefficient for an importing country's GDP is positive and highly significant (at 1% level of statistical significance) in all columns. Rising incomes in importing countries increase the countries' demand for tea from China. Similarly, five of six coefficients for tea production variables are also positive and statistically significant, at least at the 1% level. On the margin, a 1% increase in tea production in China can raise its tea exports by approximately 1.1% (1.13 and 1.14, columns 5 and 6, Table 6). The coefficients for distance variables were also expected to have negative signs but were not statistically significant in the linear model (columns 1–3, Table 6). Although they become insignificant in terms of log specification, they are negative.

The coefficient of the tariff variable is also consistent across the different specifications of models using the OLS estimation (row 4, Tables 6 and 7), although its impact on tea imports disappears under the fixed-effect estimation. The negative sign of the estimated coefficient of tariffs under the OLS estimation shows that higher rates of tea import tariffs are associated with lower imports of tea from China. Insignificant results from the fixed-effect estimation are not surprising, given the minor changes

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[7] China's market shares accounted for 19.9% of the total tea imports, or 10% of the total domestic tea markets (domestic production plus import), of all countries studied in 1996–2009. There were only five countries where China's market shares in their total imports exceeded 50% in 2009: Algeria, the Gambia, Niger, Morocco and Senegal. However, none of them applied SPS measures in response to increasing tea imports from any countries in 1996–2009.

in import tariffs within a country during the period studied (Table 5). Thus, the result of a significant negative impact of tariffs on tea imports from China under the OLS estimation should arise from the large variations in tariffs among the countries.

The most important results, given the overall goal of the paper, can be seen from the coefficients of the variables measuring food safety standards (lower parts of Tables 6 and 7). We will first discuss the impact of the MRL of endosulfan, fenvalerate and flucythrinate (columns 1, Tables 6 and 7) and the coverage of regulated pesticides (column 2) separately. We will then examine the estimated results from the models in terms of both the MRL and the coverage variables under the OLS regression (column 3). Finally, we will present the results from the fixed-effect regression (columns 4–6, Tables 6 and 7).

The positive sign and statistical significance of endosulfan and fenvalerate (columns 1, Tables 6 and 7) support the hypothesis that tea safety standards are important factors that have affected China's tea exports. For example, the estimated coefficient of endosulfan suggests that a 1% decrease in the MRL on endosulfan can result in a 0.06% decrease in China's tea exports (column 1, Table 6). The impact of the MRL of fenvalerate is even larger, as the estimated coefficient (0.16) is more than two times higher than that of endosulfan (0.06, column 1, Table 6). The coefficient of flucythrinate has a positive sign but is not statistically significant in the OLS linear regression (Table 6). This could be due to minimal variations of flucythrinate in our samples (Table 4).

Estimated coefficients of the coverage of regulated pesticides confirm our descriptive analysis presented in the previous section. That is, increasing the coverage of regulated pesticides often has a significant negative impact on China's tea exports (column 2, Tables 6 and 7). Under the OLS linear regression (column 2, Table 6), seven of eight estimated coefficients for time period dummies have negative signs, and two of them are statistically significant. An unexpected sign was observed for Japan, but as we see later, the expected negative impact is found in the fixed-effect model. When we include two sets of variables (the MRL and coverage of regulated pesticides), significant levels of all the coefficients decrease (column 3, Tables 6 and 7). This is explained by the high multicollinearity of these two sets of variables.

The results from the fixed-effect model show robust findings. Flucythrinate is dropped from the regression because there is no variation detected within any country studied. For the coverage of regulated pesticides, all eight estimated variables have negative and significant impacts on China's tea exports under linear specification, and five of them maintain statistical significance (column 5, Tables 6 and 7). Interestingly, even when we included all variables in the model (column 6, Tables 6 and 7), the two sets of food safety standards have the signs that we expected them to have, and many of them are statistically significant.

7. Conclusions

As the world's largest tea producer and exporter, China has experienced declining trends in tea export growth rate since the mid-1990s. The SPS notifications on China's exports and China's trade disputes with its major trade partners, particularly with developed countries such as Japan, South Korea, the EU and the United States, have been emerging. The objective of this paper is to assess the impact of tea safety standards on China's exports. To achieve this objective, we first examined the trends and nature of China's tea production and exports, the MRLs of major pesticides and coverage requirements of regulated pesticides imposed on tea by major importers. We then applied a gravity model to examine the impact of tea safety standards adopted by 31 of China's major tea importers between 1996 and 2009.

The results indicate that the Maximum Residual Limit of pesticides (e.g., endosulfan, fenvalerate and flucythrinate) imposed by importing countries has significantly affected China's tea exports. A 1% increase in the regulatory stringency (ppm) on endosulfan and fenvalerate (tighter restrictions on the pesticide) can lead to a 22% decrease of tea exports from China (column 4, 0.04 + 0.18, Table 6). Although tariffs on tea remain important factors that affect China's tea exports, the MRLs of certain pesticides can significantly limit China's tea exports.

The results also show that China's tea exports have been significantly restricted when importing countries increase tea safety standards and coverage requirements of regulatory pesticides. In particular, Japan and the EU have increasing categories and numbers of pesticides regulated over time, and Korea and Sri Lanka began setting MRLs on tea in recent years. These policy changes have largely contributed to the decrease in the growth rates of China's tea exports since the beginning of the century. On the contrary, African countries and other Asian countries do not have specific safety regulations on tea, and they have become major importers of Chinese tea.

These findings have two policy implications. First, large variations among countries and increasing tighter restrictions from developed countries on food safety standards, as well as increasing coverage of regulated pesticides, suggest that developing countries will face great challenges in exporting food products. Although it is difficult to harmonize safety standards and although it is not possible to impose the Codex on every country, there is room to coordinate standards through better international cooperation. Food safety standards specified by SPS measures should be one of the main agenda items upon the completion of Doha's negotiations. Second, China and other developing countries can learn an important lesson from past trade disputes. Measures and investments in both food production and processing to improve food safety should be explored by food-exporting countries.

Acknowledgments

The authors acknowledge the financial support of the Chinese Academy of Sciences (KSCX1-YW-09-04, KACX1-YW-0906), National Natural Sciences Foundation of China (70873116) and the European Community (227202, NTM-IMPACT; 044255, SSPE).

Appendix Table 1. Basic statistics of major variables used in regression for 1996–2009.

Variable	Unit	Mean	Std. Dev.	Min	Max
Export	1000 U.S. $	11,912	16,832	0	114,260
GDP	Billion U.S. $	808.2	1969.9	0.3	11,629
Production	1000 tones	859	242	593	1359
Distance	Kilometer	7871	3369	956	12,366
Tariff	percent	21.7	49.9	0	299.7
END (Endosulfan)	ppm	29	5	0.01	30
FEN (Fenvalerate)	ppm	1.94	1.84	0.05	10
FLU (Flucythrinate)	ppm	15.5	8.3	0.1	20

Note: the number of samples is 434.

References

Anderson, J. E. (1979). A theoretical foundation for the gravity equation. *The American Economic Review*, *69*, 106–116.

Anderson, K., Huang, J., & Ianchovichina, E. (2004). Will China's WTO accession worsen farm household incomes? *China Economic Review*, *15*, 443–456.

Anderson, J. E., & van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, *93*, 170–192.

Chen, Z. (2004). EU and Japan appllied new standard on pesticides in tea. *Zhongguo Chaye [China Tea]*, *6*, 12–13.

Chen, Z. (2007). Explaination of worldwide MRL standards for tea together with China's response. *Zhongguo Zhibao Tekan [China Plant Protection]*, *27*, 30–33.

Chen, C., Yang, J., & Findlay, C. (2008). Measuring the effect of food safety standards on China's agricultrual exports. *Review of World Economics*, *144*, 83–106.

Deardorff, A. (1998). *Determinants of bilateral trade: does gravity work in a neoclassical world? NBER working paper 5377.* Cambridge, Mass: National Bureau of Economic Research.

Disdier, A. -C., Fontagné, L., & Mimouni, M. (2008). The impact of regulations on agricultural trade: Evidence from the SPS and TBT agreements. *American Journal of Agricultural Economics*, *90*, 336–350.

Dong, F., & Jensen, H. (2004). The challenge of conforming to sanitary and phytosanitary measures for China's agricultural exports. *MATRIC working paper 04-MWP8.* Iowa State University: Midwest Agribusiness Trade Research and Information Center.

ETN (1993). Extension toxicology network,flucythrinate. http://pmep.cce.cornell.edu/profiles/extoxnet/dienochlor-glyphosate/flucythrinate-ext.html

FAO (2010). *Food and Agriculture Organization FAOSTAT online statistical service.* Rome: FAOhttp://faostat.fao.org/

Gu, G., & Niu, X. (2007). Empirical study on the impacts of technical barrier to trade on international trade—Taking tea trade between China and Japan as an example. *Guoji Maoyi Wenti [Journal of Internationl Trade]*, *6*, 74–80.

Huang, S., & Gale, F. (2006). *China's rising fruit and vegetable exports challenge U.S. industries.* Electronic outlook report from the economic research service FTS-320-01, ERS, USDA.

Lubick, N. (2010). Endosulfan's exit: U.S. EPA pesticide review leads to a ban. *Science*, *328*, 1466.

Moenius, J. (2000). *Three essays on trade barriers and trade volumes.* San Diego: University of California.

MOFCOM (2009). *Reports of Chinese agricultural exports.* Beijing: Ministry of Commerce of People's Republic of China.

NSBC (2010). *National Bureau of Statistics of China, China Statistical Yearbook.* China Statistical Yearbook: China Statistical Press, Beijing.

Otsuki, T., Wilson, J., & Sewadeh, M. (2001). What price precaution? European harmonisation of aflatoxin regulations and African groundnut exports. *European Review of Agricultural Economics*, *28*, 263–284.

Shan, S., & Jiang, A. (2005). Analysis on the comparative advantage and export competity of China's aquatic products. *Guoji Maoyi Wenti (Journal of International Trade)*, *5*, 20–24.

Sun, D., Sun, W., & Zhou, J. (2007). The impacts of EU's MRL standard on China's tea exports. *Nongye Jishu Jingji [Journal of Agricultural Technical Economics]*, *1*, 63–71.

Sun, D., Zhou, J., & Yang, X. (2005). Study on the effect of Japan's technical barriers on China's agricultural exports. *Nongye Jishu Jingji [Journal of Agricultural Technical Economics]*, *5*, 6–12.

Tinbergen, J. (1962). *Shaping the world economy; Suggestions for an international economic policy.* New York: Twentieth Century Fund.

UNCTAD (United Nations Conference on Trade and Development) (2010). Tariff data included in database of World Integrated Trade Solution (WITS). http://wits.worldbank.org/wits/.

WHO, & FAO (1996). World Health Organization and Food and Agriculture Organization data sheets on pesticides no. 90. http://www.inchem.org/documents/pds/pds/pest90_e.htm

Wilson, J., & Otsuki, T. (2004). To spray or not to spray: Pesticides, banana exports, and food safety. *Food Policy*, *29*, 131–146.

Wilson, J., Otsuki, T., & Majumdsar, B. (2003). Balancing food safety and risk: do drug residue limits affect international trade in beef? *The Journal of International Trade & Economic Development*, *12*, 377–402.

WTO (2010). World Trade Organization SPS Information Management System (SPSIMS). http://spsims.wto.org/.

Wu (2004). *Reflections after Japan forbided China's spinach from exporting, Nomgmin Ribao.* Peasants Daily. http://www.sxny.net/html/main/nyplView/2006031330588.html

Xu, Y. (2006). Comparative analysis of international competitiveness of China's tea exports Shijie Nongye. *World Agriculture*, *1*, 26–28.

You, J., & Cui, Y. (2006). Considerations on the import and export trade of Chinese fruit. *Guoji Maoyi Wenti (Journal of International Trade)*, *6*, 26–31.