Journal of Integrative Agriculture
2012, 11(4): 684-693
Available online at www.sciencedirect.com
ScienceDirect
April 2012
RESEARCH ARTICLE

Honey Safety Standards and Its Impacts on China's Honey Export

WEI Guo-xue, HUANG Ji-kun and YANG Jun

Center for Chinese Agricultural Policy, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, P.R.China

Abstract

Food safety standard draws increasing concerns on agricultural trade throughout the world. This paper aims to assess the impact of maximum residual limit standard (MRL) of chloromycetin on honey exporting from China. To achieve this objective, the paper discusses the trends of China's honey production and export practices, analyzes changes on MRL of chloromycetin adopted by major importing countries, and use a gravity model to estimate the impact of MRL of chloromycetin on China's honey export. The results show that despite the rapid growth of China's honey production, honey export has declined significantly since 2000. The major reason of declining honey export was mainly due to the more stringent food safety standards indicated by MRL of chloromycetin imposed by importing countries on their honey imports.

Key words: food safety standards, MRL, chloromycetin, honey, export, China

INTRODUCTION

Increasingly stringent requirements on food safety standards are becoming major obstacles to agricultural export across the world. Exporting countries are facing challenges in meeting food safety requirements imposed by many importing countries, which initially aim to protect human health and environment but often act as pretext for trade protectionism (Hillman 1978; Henson and Loader 2001). Empirical studies have shown that agricultural exports have been significantly affected by changes on food safety standards in importing countries (Wilson *et al.* 2003; Wilson and Otsuki 2004), particularly agricultural products exporting from developing countries to developed countries (Disdier *et al.* 2008).

China, as one of major agricultural exporting countries in the world, has been also experiencing serious trade conflicts with its trading partners due to food safety standards. While China increased agricultural imports after its accession to World Trade Organization in 2001 when China significantly reduced its import tariffs (Anderson *et al.* 2004), the export of labor intensive commodities (e.g., vegetables, fruits, aquatic products and processed foods) from China have not experienced significant increase as anticipated (Shan and Jiang 2005; Huang and Gale 2006; You and Cui 2006). Policy makers and some scholars argued that more stringent food safety standards imposed by developed countries were the major obstacles to China's agricultural export in recent years (Chen *et al.* 2008; MOC 2009; Wei *et al.* 2011). In some cases, China's agricultural products were actually banned by some importers. For example, Japan banned importing of spinach from China in May 2003 due to its concerns of pesticides residues (Wu 2004), and EU prohibited importing of animal-based processed food from China for similar reason in early 2002 (Chen *et al.* 2008).

Understanding the impacts of food safety standards

Received 12 May, 2011 Accepted 26 July, 2011
Correspondence HUANG Ji-kun, Tel: +86-10-64889833, Fax: +86-10-64856533, E-mail: jkhuang.ccap@igsnrr.ac.cn

on China's agricultural export is an important issue for China to adapt to the changing global food trade environment. However, few empirical studies have been conducted so far. Chen *et al*. (2008) selected maximum residue limit (MRL) of pesticides (chlorpyrifos on vegetable and oxytetracycline on aquatic products) as critical proxies for food safety standards in importing countries, and applied gravity model to assess the impact of food safety standards on vegetable and aquatic products exporting from China. Their results showed that the impacts of food safety standards were significant and much larger than the impacts of tariffs on China's vegetable and aquatic products export. Wei *et al*. (2011) examined the impacts of tea safety standards on China's tea export, and their results from gravity model showed that new tea safety standards imposed by importing countries can largely explain the stagnated growth of China's tea export between 1996 and 2009.

In this study, we examine the impacts of food safety standards in other countries on China's honey export. Honey export from China is an interesting case due to China's important roles in global production and trade. China is the largest honey producer in the world. Its production accounted for more than 20% of the world's total honey production in recent years (FAO 2010). China is the second largest honey exporter in the world (FAO 2010). Meanwhile, more and more evidences show that honey safety standards have been changing in many major importing countries (Gu and Zhang 2003; Yang and Zhen 2007), but so far no empirical studies as we know have quantitatively analyzed the impacts of changing safety standards in other countries on China's honey export. Therefore, China's honey export is an ideal case to assess the impacts of food safety standards on agricultural trade.

The rest of this paper is structured as follows. Section of CHINA's HONEY PRODUCTION AND EXPORT presents an overview of China's honey production and export between 1996 and 2009. Section of FOOD SAFETY STANDARDS AND CHINA'S HONEY EXPORT discusses changes on honey safety standards which are indicated by Sanitary and Phytosanitary (SPS) measures as well as MRL of chloromycetin on honey. Section of EMPIRICAL MODEL uses a gravity model to assess the impact of food safety standards on China's honey export. Section of DATA briefly discusses sources of data used in empirical estimation. Section of ESTIMATION METHODS AND RESULTS discusses the results of econometric estimations. The final section concludes with policy implications.

CHINA's HONEY PRODUCTION AND EXPORT

With rapid growth in honey production, China has been the largest honey producer since late 1990s. From 1996 to 2009, China increased honey production from 183 to 402 thousand tons (Table 1). Its average annual growth rate reached 7.7% during 1996-2000. Although the annual growth rate fell in early 2000s, it recovered to 6.5% in 2006-2009. Rapid growth of China's honey production had increased China's share in world production from 16.6% in 1996 to 26.6% in 2009 (Table 1).

Interestingly, despite China experienced rapid growth in honey production in 1990s and 2000s, honey export has decreased significantly since 2000 (column 2, Table 1). Honey export from China reached its peak in 2000 (103 thousand tons), accounted for 42% of China's production (246 thousand tons, Table 1). However, after 2000, although production continued to expand, export had

Table 1 Average annual growth rates of China's honey production and export and its shares in the world, 1996-2009[1)]

Year	Production (thousand tons)	Export (thousand tons)	China's share in the world (%)	
			Production	Export
1996	183	83	16.6	22.3
2000	246	103	19.6	19.9
2005	293	88	20.8	12.5
2009	402	72	26.6	10.5
Year	Annual growth rate in China (%)	Annual growth rate in China (%)		
1996-2000	7.7	5.4		
2001-2005	3.9	-4.6		
2006-2009	6.5	-4.0		

[1)] Numbers are estimated based on UNCTAD (2010), FAO (2010), and National Statistical Bureau of China (2010).

fallen to 88 thousand tons in 2005 and 73 thousand tons in 2009. Less than 18% of honey production was exported in 2009. In short, increase in honey production in recent years in China has been associated with the fall in honey export since early 2000s.

It is indicated from Table 2 that the significant fall of China's honey export since 2000 is not explained by changes in tariff rather than other reasons. Indeed, the tariff rates on China's honey imposed by its major importers have either fallen or remained unchanged except for India (columns 2 and 3, Table 2). Some studies argued that non-tariff measures (such as antidumping measures) and competitions from other major exporting countries (such as Argentina and Canada), have undermined competitiveness of China's honey based on low-price (Ying and Zhou 2005; Zhou and Qi 2010). Some scholars argue that Argentina has expanded its international market share and substituted some of China's traditional markets in the past decade due to its rising competitiveness in honey production (Li and Wu 2009). However, others believed that diminishing of China's honey export is in relation to food safety standards imposed by importing countries (Wang 2005; Zhu and Yang 2006). China's honey export dropped dramatically when major importing countries (EU, U.S., and Japan) raised requirements on honey safety standards. Wang and He (2008) claimed that change on MRL of chloromycetin in U.S., Japan, and Germany significantly reduced China's honey export between 2000 and 2005.

Despite more than 50 countries/regions have imported honey from China; most of China's honey goes into small number of countries. The top five importers of China's honey, including Japan, U.S., Belgium, United Kingdom, and Spain, accounted for nearly 77% of total honey exporting from China between 2005 and 2009 (Table 2). Between 2005 and 2009, Japan is a leading importer of China's honey. Its honey import from China accounted for 46% of China's total honey export. China's honey export to U.S. was approximately 14% of China's total honey export. Belgium, United Kingdom, and Spain together imported approximately 16% of China's total honey export. The top 16 importers of China's honey accounted for nearly 95% of China's total honey export between 2005 and 2009 (Table 3).

Table 2 Average tariff rate (%) on honey in China's major honey importers in 1996-2009[1)]

Country (area)	1996-2000	2001-2005	2006-2009
North America			
U.S.	1.62	1.34	1.18
Canada	0.00	0.00	0.00
Europe			
EU[2)]	20.25	17.30	17.30
Poland	80.40	89.00	89.00
Asia			
Japan	27.02	25.50	25.50
South Korea	264.60	249.48	243.00
India	35.00	31.00	60.00
Malaysia	5.00	4.40	2.00
Hongkong & Singapore	0.00	0.00	0.00

[1)] UNCTAD (2010).
[2)] EU countries included in this study are Belgium, United Kingdom, Spain, Portugal, Netherlands, Germany, and France. The same as below.

Over the past decade, there is an obvious diversified trend on honey importing from China. Japan, Belgium, Malaysia, South Korea, Singapore, Poland, and India have substantially increased honey imports from China between 1996 and 2009 (last column, Table 3). Other importers, such as U.S., United Kingdom, Spain, Netherlands, Germany, Hong Kong, Canada, and France have recorded negative average annual growth rates during the same period. Why major importers recorded different trends of honey imports from China? What is the primary factor influenced China's honey export? In next two sections, we will examine food safety standards and other factors that may affect China's honey export.

FOOD SAFETY STANDARDS AND CHINA's HONEY EXPORT

Over last decade, food safety standards are getting increasingly important in honey trade. As one of the major measures for food safety standards in importing countries, Sanitary and Phytosanitary (SPS) measures on honey have been adopted by major importing countries frequently and the number of SPS notifications (under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures, the SPS Agreement, importing countries need to notify the information on SPS measures to the WTO when they take SPS measures to a imported commodity) has been rising (Fig. 1). While not shown in Fig. 1, the rising SPS notifications on honey occurred mainly from EU, Japan, U.S., Canada, South Korea, Poland, and India. The notifications by South Korea were issued at least one time each year between 2001 and 2009. EU, Japan, and India also issued SPS notifications frequently. The trend of SPS notifica-

Table 3 Annual average export of honey from China to major importers in 2005-2009 and average annual growth rate in 1996-2009[1)]

Rank	Importers	Annual average export from China in 2005-2009		Annual growth rate of export from China in 1996-2009[2)]
		Value (US$ million in 2000)	Cumulative percentage of the export value (%)	
1	Japan	43.2	46.1	3.55
2	United States	13.2	60.3	-15.09
3	Belgium	8.0	68.8	**23.26**
4	United Kingdom	4.4	73.5	-19.96
5	Spain	3.2	76.9	-2.56
6	Portugal	2.7	79.9	-38.10
7	Malaysia	2.0	82.0	18.12
8	South Korea	1.8	84.0	11.70
9	Singapore	1.8	85.9	12.24
10	Netherlands	1.8	87.8	-6.16
11	Germany	1.7	89.6	-22.83
12	Poland	1.1	90.9	**140.10**
13	India	1.1	92.0	**22.97**
14	Hong Kong	0.9	93.0	-4.71
15	Canada	0.9	94.0	-17.53
16	France	0.8	94.9	-9.50

[1)] UNCTAD (2010).
[2)] The calculation of growth rate is based on regression. **23.26**, calculated from 1999-2009; **140.10**, calculated from 1998-2009; **22.97**, calculated from 2000-2009.

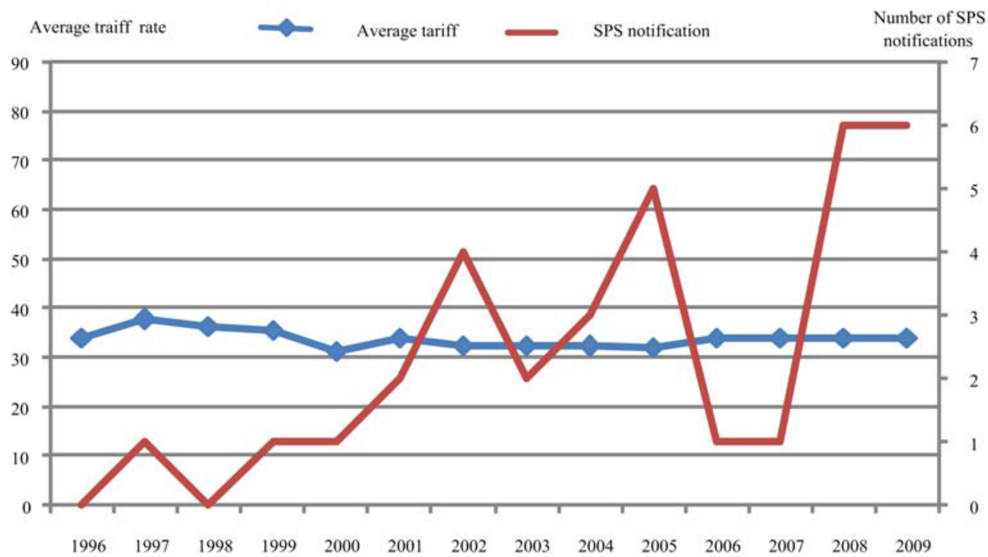

Fig. 1 Average tariff rate (%) and total number of SPS notifications on honey imported from China in 16 major importers, 1996 to 2009. Total number of SPS notifications comes from SPS-IMS database (WTO 2010), and average tariff rate sources from TRAINS database (UNCTAD 2010).

tions shows that honey safety standards are drawing increasing attentions from importing countries.

Maximum residual limit (MRL) of chloromycetin is another important honey safety standard concerned by importing countries. Chloromycetin is a bacteriostatic antimicrobial and effective against a wide variety of gram-positive and Gram-negative bacteria, including most anaerobic organisms (Falagas *et al.* 2008). Chloromycetin is widely used for the treatment and prevention of bee diseases (Katznelson 1950). But chloromycetin treatment is associated with bone marrow toxicity, which may occur in two distinct forms: bone marrow suppression, which is a direct toxic effect of the drug and is usually reversible, and aplastic anemia, which is idiosyncratic (rare, unpredictable, and unrelated to dose) and generally fatal (Rich *et al.* 1950). Thus most importing countries have set MRL of chloromycetin on honey in order to protect human health.

The smaller the MRL of chloromycetin is, the more stringent the honey safety standards are. Table 4 shows that the MRL of chloromycetin had been changing in four major honey importing countries (EU, Japan, U.S., Canada and South Korea) between 1996 and 2009, and honey safety standards have become more stringent in these countries. Between 1996 and 2001 when MRL of chloromycetin was 10 parts per billion (ppb) in EU, annual export of China's honey reached US$ 32.3 million (Table 4). However, the export of honey from China to EU fell substantially to only US$ 6.8 million in 2002 and only 1.6 million in 2003-2004 when EU reduced the MRL of chloromycetin from 10 ppb in 2001 to 0.1 ppb in 2002-2004. As expected, the less stringent in the honey safety standards (0.3 ppb) during 2005-2009 was associated with increase of China's honey export. In 2005-2009, average annual export of China's honey to EU recovered to US$ 22 million, still much less than that during 1996-2001.

Similar correlations between MRL of chloromycetin and China's honey export to Japan and U.S. are also evidenced and reflected in Table 4. For example, in 2003 when Japan changed the MRL of chloromycetin on honey from 5 ppb in 2002 to 0.3 ppb in 2003, annual honey export from China to Japan also fell from US$ 48.3 in 2002 to US$ 38.2 million in 2003-2004 (Table 4). Although there was slight rise of honey imports thereafter, average annual import (US$ 43.2 million) was still less than that in 2002. U.S. set the MRL of chloromycetin at 5 ppb between 1996 and 2001, average annual export of honey from China to U.S. was US$ 19.6 million (Table 4). However, U.S. changed the MRL of chloromycetin to 0.3 ppb in 2002, export of honey from China to U.S. declined immediately to only US$ 7.8 million in the same year. The recovery of China's honey export to U.S. in 2003-2004 was unexpected, but this recovery stopped and export of honey from China continued to fall during 2005-2009. Indeed, China's honey export to U.S. fell to nearly zero in 2009 (not showing in Table 4).

Table 4 The MRL of chloromycetin in honey and honey import (million US$ in 2000 constant price) from China, 1996-2009[1)]

Item	1996-2001	2002	2003-2004	2005-2009
The MRL of chloromycetin (ppb)				
EU	10	0.1	0.1	0.3
Japan	5	5	0.3	0.3
U.S.	5	0.3	0.3	0.3
Canada	-	-	-	0.3
South Korea	-	-	-	0.3
Others[2)]	-	-	-	-
Annual honey import from China (US$ million)				
EU	32.3	6.8	1.6	22.0
Japan	31.3	48.3	38.2	43.2
U.S.	19.6	7.8	30.7	13.2
Canada	2.4	1.0	2.9	0.7
South Korea	0.1	1.3	0.6	1.5
Others[2)]	3.2	9.6	15.0	12.0

[1)] WTO (2010), Hangzhou Entry-Exit Inspection Institute (2007), and Huo *et al*. (2003).

[2)] Other includes Malaysia, Singapore, and Hong Kong.

EMPIRICAL MODEL

Many major honey importers have enhanced honey safety standards mainly through changes on the MRL of chloromycetin. More stringent safety standards on honey would impose additional costs and greater risks to honey exporters. The key question here is to what extent the changes on the MRL of chloromycetin have affected China's honey export. This section intends to develop a gravity model that can quantitatively analyze the impacts of food safety standards indicated by the MRL of chloromycetin on China's honey export.

16 honey importers presented in Table 2 are selected for empirical analysis. These honey importers include eight from Europe, two from North America (U.S. and Canada), and six from Asia. These importers accounted for 93% of China's honey export in 2009, and can largely influence China's honey export. Other countries only have imported tiny fraction of China's honey or have never imported honey from China in recent years, so these countries aren't included in the empirical model because they could only have very limited impacts on China's honey export.

Gravity model applications have been widely used to model agricultural trade, and implemented in empirical study on the impacts of food safety standards on trade. Gravity model was first used by Tinbergen (1962) in 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 variables bias (Anderson and van Wincoop 2003). Zahniser *et al*. (2002) used gravity models to analyze effects of the various free trade agreements in detail on U.S. agricultural exports. Ghazalian *et al*. (2007) and Tamini *et al*. (2010) specified a gravity framework that allows vertical linkages between agricultural sectors. This framework facilitates analysis of the impact on the intermediate sector by trade barriers at the upstream level. Otsuki *et al*. (2001) estimated the effect of the EU's aflatoxin standards on food imports from Africa by a gravity model. They showed that, after controlling the real per capita gross national product in European and African countries, average rainfall in African countries, distance between the EU and African countries, time trends, and using 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 MRL of the chlorpyrifos on 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 *et al*. (2003), and Chen *et al*. (2008).

Based on previous studies on impacts of food safety on trade (Otsuki *et al*. 2001; Wilson *et al*. 2003; Wilson and Otsuki 2004; Chen *et al*. 2008; Disdier *et al*. 2008), a gravity model for a specific commodity export normally includes the following five sets of variables. They are income in importing countries, production in exporting countries, distance between exporting and importing countries, tariff, and variables related to food safety standards (Wilson and Otsuki 2004; Chen *et al*. 2008). We follow a similar approach to examine the impact of the MRL of chloromycetin on China's honey export with the following 2 alternative specifications:

$$Export_{it}=a_0+a_1 GDP_{it}+a_2 Production_{t-1}+a_3 Distance_i +a_4 Tariff_{it}+a_5 Chloromycetin_{it}+e_{it} \quad (1)$$

$$\text{Ln}(Export_{it})=b_0+b_1 \text{Ln}(GDP_{it})+b_2 \text{Ln}(Production_{t-1}) +b_3 \text{Ln}(Distance_i)+b_4 Tariff_{it}+b_5 (Chloromycetin_{it})+\varepsilon_{it} \quad (2)$$

In models (1) and (2), $Export_{it}$ is the export of honey from China to *i*th country in year *t*. GDP_{it} denotes real gross domestic product (*GDP*) of importing country *i* in year *t* and captures the market size as typical gravity model does. Export was measured in thousands of US dollars and GDP was measured in billions of US dollars, both are in year 2000 constant price using US Consumer Price Index as deflator. $Production_{t-1}$ is honey production in China lagged one year and measured in thousand tons. In this study we use production instead of GDP because we deal with only one commodity (honey) in the whole economy. More discussions about using output variable instead of GDP in the regression can be found in Evans (2001), Hillberry (2002) and Chen *et al*. (2008). This production variable captures the supply side effects in China. The production is lagged one year to avoid potential endogeneity. $Distance_i$ is the bilateral distance between capital cities of China and the importing country *i*. $Tariff_{it}$ denotes simple average import tariff rates imposed by importing countries on honey from China. $Chloromycetin_{it}$ is the MRL of Chloromycetin on honey imposed by importing countries. Although only EU, Japan, U.S., Canada, and South Korea have established the MRL of chloromycetin explicitly, this does not mean that other countries did not care of chloromycetin in importing honey. Following similar approach used in literature (Chen *et al.* 2008), we also assume that MRL of chloromycetin in these countries are the maximum value among all importers in particular year because China at least needs to meet the loosest requirement for MRL of chloromycetin set by its trade partners.

DATA

The data used in this study are collected from several sources. Honey export data are from the United Nations Commodity Trade Statistics Database (COMTRADE) of the United Nations Conference on Trade and Development (UNCTAD). Honey (HS 1992 code of 0409) is included here for the analysis. GDP data are from the World Development Indicators (WDI) database of the World Bank. Data of China's honey production are from the National Bureau of Statistics of China (NBSC 2010). The bilateral distance between the capital cities of China and importing countries is from the Institute for Research on the International Economy (CEPII). Data on tariff are taken from the Trade Analysis Information System (TRAINS) of the UNCTAD. The MRL of chloromycetin on honey imposed by importing countries comes from Hangzhou Entry-Exit Inspection and Quarantine Bureau (2007) and Huo *et al*. (2003). Basic statistics of all variables used in the regression are summarized in Appendix.

ESTIMATION METHODS AND RESULTS

In estimating model (1), we use three estimation methods. They are ordinary least square (OLS), country fixed effect estimations, and Poisson pseudo-maximum likelihood (PPML), and the estimation results are presented in columns 1-3 in Table 5. Because OLS estimation is consistent only under restrictive assumptions that rarely hold, OLS estimation is just used as a basic method to compare 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 have not considered in our model. Anderson and van Wincoop (2004) demonstrated the complexity of various trade costs in the bilateral trade, and emphasized the importance to include the relative trade barriers (i.e., multilateral resistance) in gravity model. Because the multilateral resistances are quite difficult to measure in empirical study, gravity model with fixed effect can be more likely to avoid inconsistent problems of omission of multilateral resistance effects (Anderson and van Wincoop 2003). Such a method has been commonly used in many empirical studies (Zahniser *et al*. 2002; Cheng and Wall 2005). Because there are some zero observations in dependent variable in model (1), we also estimate the model using PPML estimator as suggested by Silva and Tenreyro (2006). It treats all zeros equally, but some zeros represent countries that are just below the threshold for exporting, while others represent situations with a low probability of export occurring (Martin and Pham 2008; Jayasinghe *et al*. 2010).

Model (2) is first estimated with OLS to check whether the estimated parameters of control variables are consistent with our estimation. However, as the dependent variable in model (2) is the natural log of honey export from China to importing countries and there are 33 observations (about 15% of total samples) that have zero import from China, the natural log of zero is undefined and dropping zeros will result in sample selections bias and biased estimates. In fact, zero value is a common problem in gravity applications. Haveman and Hummels (2004) found that nearly 1/3 of the bilateral trade matrix is empty. Helpman *et al*. (2008) showed that about half of the country pairs in their 158-country sample do not trade with each other at all.

There are two common approaches that have been used to deal with the "zero problems" in gravity applications. The first common one is an ad hoc approach. This approach adds a very small positive number to all trade flows (Thursby and Thursby 1987; Bröcker 1989; Linders and Groot 2006). Three methods, including OLS, fixed effect model, and random effect model, are used to estimate model (2) in ad hoc approach, and the results of three estimation methods are presented in columns 4-6 of Table 5. The second common one is so called sample-selection method (SSM). This approach estimates a Probit (trade

Table 5 Regression results of China's honey export in 1996-2009

Variable	Export			Ln (0.001+Export)		
	OLS	Fixed effect[1), 2)]	PPML	OLS	Fixed effect[1)]	Random effect[1), 3)]
	(1)	(2)	(3)	(4)	(5)	(6)
GDP	0.003***	-0.004***	0.078	1.10***	2.66***	1.20***
	(0.000)	(0.001)	0.222	(0.11)	(1.03)	(0.27)
Production	-0.006	0.021**	0.835***	5.01***	4.40***	4.99***
	(0.016)	(0.007)	0.210	(1.34)	(1.14)	(1.06)
Distance	-0.001***			-1.84***		-1.66***
	(0.000)			(0.24)		(0.65)
Tariff	-0.037***	0.022	0.018	-0.02***	0.03	-0.02***
	(0.007)	(0.043)	0.012	(0.00)	(0.02)	(0.01)
Chloromycetin	-0.003	0.189*	0.146***	0.72***	0.75***	0.71***
	(0.179)	(0.100)	0.032	(0.17)	(0.14)	(0.14)
Constant	13.345**	4.552		-19.54**	-43.39***	-21.34**
	(5.575)	(2.812)		(8.01)	(7.11)	(8.33)
Observations	224	224	224	224	224	224
R-squared	0.48	0.84	-	0.36	0.47	0.47

1) Country dummies variables are included but not reported.

2) The result of Hausman test (Chi^2=50.04, Prob>Chi^2=0.00) shows that fixed effect model, compared with random effect model, generates consistent estimators.

3) The result of Hausman test (Chi^2=7.69, Prob>Chi^2=0.10) shows that random effect model is preferred to use at the significant level of 5%.

-, no R-squared value reported in PPML and Heckman methods.

propensity) model in which the dependent variable is a 1/0 indicator of whether or not a given observation is in the sample, then estimates the main model by OLS, including a measure of the probability of being in the sample, derived from the Probit estimates (Helpman *et al*. 2008) and Heckman's (1979) sample selection model. The regression results of Heckman's sample selection model are quite similar to those of ad hoc method. Its results are not reported in Table 5.

Estimation results presented in Table 5 demonstrate that the model is capable of producing results that are consistent with our expectations. R-squares for OLS versions of the honey export from China show that the goodness of fit is adequate (ranging from 0.46 to 0.48), about normal for these types of analyses using cross-sectional and time-series data. Fixed effect models have much higher R-squares because they control for all unobserved non-time varying effects within all countries.

Many of the estimated coefficients of the control variables have signs that are intuitive and expected. Except for fixed effect estimation for model (1) (column 2, Table 5), the coefficients of *GDP* are positive and statistically significant (columns 1, 3-6). Five of six estimated coefficients for *Production* are also positive and statistically significant (row 3). The negative sign of coefficient of *Distance* is consistent with what a gravity model should produce (row 4). The significant coefficients of *Tariff* in OLS estimation indicate that, after controlling for other effects, higher tariff results in lower import of honey from China. Insignificant coefficients of *Tariff* under fixed effect estimations (column 3, 4 and 6) are explained by the fact that there was nearly no change in tariff overtime within each country (Table 2).

Of course, the most important finding of this study is the estimated coefficients of *Chloromycetin*, which are positive and statistically significant in all estimations (column 2-6) except for the coefficient in OLS estimation under model (1). The estimates presented in Table 5 also indicated that model (2) generates more statistically significant and consistent results than those in model (1). In the following discussions, we focus on the estimated result using double-log fixed effect model (column 6).

Estimated coefficient (0.75) of *Chloromycetin* using fixed effect model indicates that the impact of the MRL of chloromycetin on China's honey export was substantial. For 1% increased (or decrease) in the MRL of chloromycetin China's honey export can raise (or reduce) by 0.75%. In 2000, the average value of MRL of chloromycetin on honey imposed by China's honey importers was 9.38, but it fell by 97% to 0.30 only in 2009 (see note under Appendix), which implies that much more stringent requirements on honey safety standards had reduced China's honey export by more than 70% between 2000 and 2009. Despite the MRL of chloromycetin has become one of the major obstacles to China's honey export, it is difficult to get honey producers in China use relatively small amount of chloromycetin to meet importers' food safety requirements in short-term, because of the widely usage of chloromycetin (Huo *et al*. 2003; Wang and He 2008). Therefore, it is important for Chinese government to let honey producers to recognize the risk and adverse effects caused by abuse of chloromycetin.

The results are consistent with the significant falling of China's honey export in the same period discussed in the previous section (Table 1). In sum, the results presented in Table 5 show that China's honey export could decline more than the actual drop in 2000-2009 due to changes on the MRL of chloromycetin if there would have no positive impacts of growing GDP in importing countries and rising domestic production in China.

CONCLUSION

As the world's largest honey producer and second largest honey exporter, China has experienced declining trends in honey export over the past decade. China's major honey trade partners, particularly developed countries such as Japan, South Korea, EU, Canada, and the United States, have been paying rising attentions to honey safety standards, and have taken much stringent MRL of chloromycetin.

Based on a standard gravity model and data on 16 major honey importers, this study examined impacts of the MRL of chloromycetin on China's honey export between 1996 and 2009. The results showed that the maximum residual limit of chloromycetin imposed by importing countries had significantly affected China's honey export. China shifted from the largest to the second largest honey exporter in early 2000s and substantial decline in its export since 2000 were largely explained by the more stringent requirements of honey safety standards. Although tariffs on honey remain high in some countries, the MRL of chloromycetin have been playing even much more important role in limiting China's honey export.

Therefore, certain new regulations are necessarily legislated and implemented in China to restrict the abuse of chloromycetin. Meanwhile, government should provide the educations to make honey producers to fully understand the adverse effects on export and huge losses caused. However, the best strategy to solve the problem is through technology innovation to substitute chloromycetin completely.

The finding of this study may provide valuable lessons that China and other developing countries can learn from, particular the efforts that are needed to meet increasing demand from importing countries on food safety standards. Appropriate measures in both food production and processing to improve food safety are essential to maintain China's past position in its honey (and other food) export markets.

Last but not least, increasing tighter restrictions by developed countries on food safety standards suggests that food export from developing countries will face greater challenges. Although it is almost impossible to harmonize food safety standards among countries, there is room for better international cooperation under the framework of World Trade Organization.

Acknowledgements

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

Appendix associated with this paper can be available on http://www.ChinaAgriSci.com/V2/En/appendix.htm

References

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

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

Anderson J E, van Wincoop E. 2004. Trade costs. *Journal of Economic Literature*, **42**, 691-751.

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

Bröcker J. 1989. Partial equilibrium theory of interregional trade and the gravity model. *Papers in Regional Science*, **66**, 7-18.

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.

Cheng I H, Wall H. 2005. Controlling for heterogeneity in gravity models of trade and integration. *Federal Reserve Bank of St. Louis Review*, **87**, 49-63.

Deardorff A. 1998. Determinants of bilateral trade: does gravity work in a neoclassical world? In: *NBER Working Paper 5377*. National Bureau of Economic Research, Cambridge, Mass.

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.

Evans C L. 2001. Big border effects, small border costs? Federal Reserve Bank of New York. mimeo.

Falagas M E, Grammatikos A P, Michalopoulos A. 2008. Potential of old-generation antibiotics to address current need for new antibiotics. *Expert Review of AntiInfective Therapy*, **6**, 593-600.

FAO. 2010. Food and agriculture organization FAOSTAT online statistical service. Rome, FAO. http://faostat.fao.org/

Ghazalian P, Tamini L, Larue B, Gervais J P. 2007. A gravity approach to evaluate the significance of trade liberalization in vertically-related goods in the presence of non-tariff barriers. [2010-11-21]. http://mpra.ub.uni-muenchen.de/2744/

Gu G, Zhang C. 2003. Export competitiveness of Chinese honey. *Chinese Rural Economy*, **7**, 60-64. (in Chinese)

Haveman J, Hummels D. 2004. Alternative hypotheses and the volume of trade: the gravity equation and the extent of specialization. *The Canadian Journal of Economics* **37**, 199-218.

Heckman J J. 1979. Sample selection bias as a specification error. *Econometrica*, **47**, 153-161.

Helpman E, Melitz M, Rubinstein Y. 2008. Estimating trade flows: trading partners and trading volumes. *Quarterly Journal of Economics*, **123**, 441-487.

Henson S, Loader R. 2001. Barriers to agricultural exports from developing countries: the role of sanitary and phytosanitary requirements. *World Development*, **29**, 85-102.

Hillberry R H. 2002. Aggregation bias, compositional change, and the border effect. *Canadian Journal of Economics*, **35**, 517-530.

Hillman J S. 1978. Nontariff barriers: major problem in agricultural trade. *American Journal of Agricultural Economics*, **60**, 491-501.

Huang S, Gale F. 2006. *China's Rising Fruit and Vegetable Exports Challenge US Industries*. Electronic Outlook Report from the Economic Research Service FTS-320-01, ERS, USDA.

Huo C, Yao C, Yan Z. 2003. Requirements on honey veterinary residuals and contracts from major honey imporing countries. *Journal of Bee*, **3**, 7-8. (in Chinese)

Jayasinghe S, Beghin J, Moschini G. 2010. Determinants of world demand for US corn seeds: the role of trade costs. *American Journal of Agricultural Economics*, **92**, 999-1010.

Katznelson H. 1950. The influence of antibiotics and sulfa drugs on *Bacillus larvae*, cause of American foulbrood of the honeybee, *in vitro* and in *vivo*. *Journal of Bacteriology*, **59**, 471-479.

Li H, Wu J. 2009. Comparative analysis on the international competitiveness of China honey trade. *Journal of International Trade*, **6**, 29-31. (in Chinese)

Linders G J, de Groot H L. 2006. Estimation of the gravity equation in the presence of zero flows. [2010-10-11] http://ssrn.com/abstract=924160

Martin W, Pham C S. 2008. Estimating the gravity model when zero trade flows are frequent. [2010-12-10]. http://www.deakin.edu.au/buslaw/aef/workingpapers/papers/2008_03eco.pdf

MOC (Ministry of Commerce of China). 2009. *Reports of Chinese Agricultural Exports*. [2010-11-26]. http://wms.mofcom.gov.cn/accessory/201005/1272939548240.pdf

Moenius J. 2000. *Three Essays on Trade Barriers and Trade Volumes*. University of California, San Diego.

NBSC (National Bureau of Statistics of China). 2010. *China Statistical Yearbook*. China Statistical Press, Beijing. (in Chinese)

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.

Hangzhou Entry-Exit Inspection and Quarantine Bureau. 2007. Bee products detection monitoring project schedule. [2008-07-21]. http://www.ha.ziq.gov.cn/www/jyjy/wssp/2008/07/21/641.htm

Rich M L, Ritterhoff R J, Hoffmann R J. 1950. A fatal case of aplastic anemia following chloramphenicol (chloromyctin) therapy. *Annals of Internal Medicine*, **33**, 1459-1467.

Shan S, Jiang A. 2005. Analysis on the comparative advantage and export competity of china's aquatic products. *Journal of International Trade*, **5**, 20-24.

Silva J, Tenreyro S. 2006. The log of gravity. *The Review of Economics and Statistics*, **88**, 641-658.

Tamini L D, Gervais J P, Larue B. 2010. Trade liberalisation effects on agricultural goods at different processing stages. *European Review of Agricultural Economics*, **37**, 453-477.

Thursby J G, Thursby M C. 1987. Bilateral trade flows, the Linder hypothesis, and exchange risk. *The Review of Economics and Statistics*, **69**, 488-495.

Tinbergen J. 1962. *Shaping the World Economy: Suggestions for an International Economic Policy*. Twentieth Century Fund, New York. xviii. p. 330.

UNCTAD. 2010. The World Integrated Trade Solution (WITS) established by the united nations conference on trade and development. [2010-12-10]. http://wits.worldbank.org/wits/

Wang B. 2005. International honey mraket and quality requirements for chinese honey. *Shanghai Standardization*, **9**, 22-24. (in Chinese)

Wang Y, He C. 2008. An empirical analysis of the influence of standard gap over our agricultural trade. *Journal of International Trade*, **24**, 26-29. (in Chinese)

Wei G X, Huang J K, Yang J. 2011. The impacts of sanitary and phytosanitary measures on China's tea exports. Center for Chinese Agricultural Policy Working Paper.

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 and Economic Development*, **12**, 377-402.

WTO. 2010. World Trade Organization SPS Information Management System (SPSIMS). [2010-11-15]. http://spsims.wto.org/

Wu 2004. Reflections after Japan forbided China's spinach from exporting. [2006-03-13]. http://www.sxny.net/html/main/nyplView/2006031330588.html

Yang X, Zhen X. 2007. The impacts of TBT on China's honey trade. *Xinjiang State Farms Economy*, **10**, 13-17. (in Chinese)

Ying R, Zhou L. 2005. Analys is on regional revealed symmetric comparative advantage of Chinese honey export. *Journal of International Trade*, **8**, 41-46. (in Chinese)

You J, Cui Y. 2006. Considerations on the import and export trade of Chinese fruit. *Journal of International Trade*, **6**, 26-31. (in Chinese)

Zahniser S S, Pick D, Pompelli G, Gehlhar M J. 2002. Regionalism in the western hemisphere and its impact on US agricultural exports: a gravity-model analysis. *American Journal of Agricultural Economics*, **84**, 791-797.

Zhou H, Qi C. 2010. Research on the effect of US anti-dumping against China in honey case. *Ecological Economics*, **7**, 119-124. (in Chinese)

Zhu J, Yang H. 2006. The impact of TBT on China's honey exports. *Journal of Bee*, **6**, 32-34. (in Chinese)

(Managing editor WENG Ling-yun)