Do China's food safety standards affect agricultural trade? The case of dairy products

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Abstract

Purpose – The purpose of this paper is to empirically examine how China's food safety standards affect agricultural trade in the case of dairy products.

Design/methodology/approach – A gravity model is applied to quantitatively address the impacts of changing food safety standards in China in the case of its dairy imports. The paper considers the trade impacts of not only a specific hazard substance but also overall strictness of safety standards.

Findings – The paper shows that changes in food safety standards of dairy products have no effect on China's dairy imports. The finding is not particularly surprising considering special characteristics of China's food safety standards. Given the fact that China's safety standards are relatively lower than that in its major exporters, the trade-impeding effect may not be substantial.

Research limitations/implications – First, this study is unable to estimate the trade-enhancing and trade-impending effects separately. Second, the study does not account for a potential endogeneity issue associated with food safety standards.

Originality/value – This paper contributes to the debate on how food safety standards affect trade by demonstrating that safety standards in developing countries like China can affect international trade differently from that in developed countries. Although results are specific to China's dairy imports, the explanations are applicable to food safety standards in other developing countries.

Keywords Agricultural policy, Food policy, Agricultural trade

Paper type Research paper

1. Introduction

The proliferation and enhanced stringency of food safety standards become a growing concern among countries that are increasingly integrating into world agricultural trade. Many countries, including both developed and developing ones, have significantly improved their food safety standards in response to consumers' demand for high quality

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and safe food or have been pushed into action by major food safety incidents (Lin *et al.*, 2010; Ortega *et al.*, 2012). Reflecting changes in trade regime for food products, there is a wide-spread presumption that food safety standards, referred to sanitary and phytosanitary (SPS) measures within the World Trade Organization (WTO), were used as a trade obstacle, providing "scientific" justification for restricting certain imports (Roberts, 2004). In practice, do food safety standards significantly restrict agricultural trade?

The answer to that question, however, is unclear yet. On the one hand, several case studies showed that improving food safety standards can impede agricultural trade, especially agricultural exports from developing countries, through explicit bans on imports of particular products or high costs of compliance with stringent regulations (Wilson and Otsuki, 2004; Chen *et al.*, 2008; Wei *et al.*, 2012). On the other hand, some studies highlighted positive trade-enhancing effect of food safety standards as they can provide consumers information about quality of products and build trust for consumers on imported products (Thilmany and Barrett, 1997; Moenius, 2006; Xiong and Beghin, 2011). Moreover, there also exist studies arguing that food safety standards can have no impacts on trade as the trade-enhancing effect outweighs the trade-impeding effect (Disdier *et al.*, 2008). Given the different estimated effects of food safety standards on trade, the debate regarding how food safety standards affect international agricultural trade is far from over.

Concerns over the impact of food safety standards on agricultural trade are becoming increasingly important in international agricultural trade as more and more developing countries started improving their safety standards significantly. Previous studies, however, focused primarily on the impact of food safety standards in developed countries, such as the USA, the European Union, and Japan, on agricultural trade (Otsuki *et al.*, 2001; Henson and Lorder, 2001; Wilson and Otsuki, 2003, 2004; Chen *et al.*, 2008; Disdier *et al.*, 2008; Drogué and DeMaria, 2011; Wei *et al.*, 2012). Few studies have been carried out to explore characteristics and the effect of food safety standards in developing countries, especially emerging economies such as China.

The impact of food safety standards on agricultural trade in developing countries could be different from that in developed countries. The food safety standards in developing countries, in general, are lower than that imposed by developed countries. For instance, compared to most developed countries, developing countries often require fewer items to be inspected and impose higher level of the maximum residue limits (MRLs) on hazardous substances. Enhancing regulations in developing countries may lead to no additional complying cost over exporting firms in developed countries. As such, the trade effect of food safety standards, at least for exports from developed countries, could be negligible.

The overall goal of this paper is to understand how China's food safety standards affect its dairy imports, the knowledge of which may help China's policymakers and its trading partners better evaluate SPS related trade policies. To meet this goal, we have two specific objectives. First, we describe changes in China's dairy product safety standards and discuss unique characteristics of these safety standards. Second, we empirically measure the impact of China's food safety standards on its dairy imports.

To achieve these objectives, we choose dairy trade as a case study. First, rapid economic growth, along with accelerated urbanization, has resulted in an increase in dairy imports, especially since China's WTO accession. The dairy product has become the largest imported animal food of China in term of imports value in 2010 (NBSC, 2011). Second, food safety standards for dairy products were amended several times and became more stringent in recent years. More importantly, due to several food safety incidents happened in the past, China's demand for safety attributes in milk products significantly raised (Wang *et al.*, 2008). China's governments substantially promoted the supervision of safety standards to prevent reoccurrence of food safety scandals. Given the importance of dairy trade and the evolution of safety standards of dairy products, dairy trade provides a good case study for understanding the effects of China's food safety standards on trade.

Using a gravity model, we examine the impact of changing China's food safety standards for ten major exporters of dairy products during the 1992-2010 time period. We first focus on the level of MRLs for lead (Pb) in our analysis as it is one of the most important toxicological substances in dairy products. We then consider the number of safety measures imposed as an alternative proxy for food safety standards since a set of specific hazardous substances were settled down in the case for dairy products. This approach allows us to examine the impact of overall changes in safety standards, rather than a single hazardous substance, on trade. Anticipating our results, we find that there is no evidence that China's food safety standards significantly affect its dairy imports.

The rest of the paper is organized as follows. Section 2 presents an overview of China's dairy production, consumption and international trade from 1992 to 2010. In Section 3, we describe the evolution of food safety standards of dairy products and discuss characteristics of changes in these safety standards. Section 4 deals with econometric specifications and data. In Section 5, we report our estimation results. Section 6 summarizes our findings and draws policy implications.

2. China's dairy consumption, production, and trade

Due to rapid economic growth and urbanization, demand for dairy products in China has increased dramatically since 1990. As shown in Table I, per capita dairy consumption rose remarkably by 7.4 times, from 3.6 kg in 1990 to 26.7 kg in 2010, an average annual growth rate of 10.5 percent. As the income elasticity of dairy products in China is about 1 (Huang *et al.*, 2011), a growth of income will result in equally a rapid growth of dairy consumption. Moreover, urban residents consume more milk than rural residents, mainly due to the fact that the per capita income of urban residents is higher than that of rural residents (Fuller *et al.*, 2004, 2007). For example, while average per capita consumption in rural was only 7.2 kg in 2010, it was 50.5 kg in urban, six times of that for rural residents (Table I). Therefore, the income growth in rural and urbanization will further stimulate dairy demand in China.

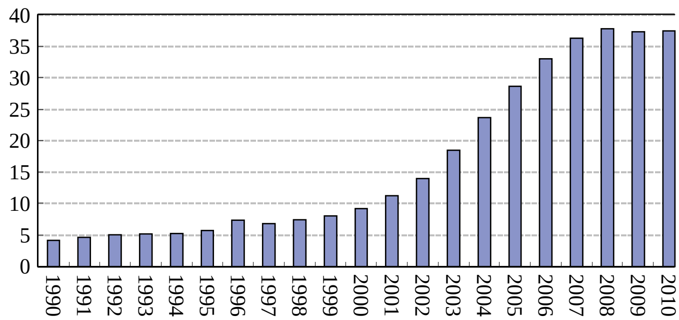
	1990	1995	2000	2005	2010
Production (mmt)	4.16	5.76	9.19	28.65	37.48
Consumption (mmt)	4.39	5.88	9.61	31.15	44.60
Per capita consumption (kg)					
National average	3.6	4.6	7.3	19.4	26.7
Rural residents	1.8	2.4	3.2	5.1	7.2
Urban residents	8.8	10.2	14.8	39	50.5

Note: The weight of milk is measured in milk equivalent
Source: Production from NSBC (2011), and consumption from database of China's Agricultural Policy Simulation Model (CAPSiM)

Table I. Production and consumption of milk in China from 1990 to 2010

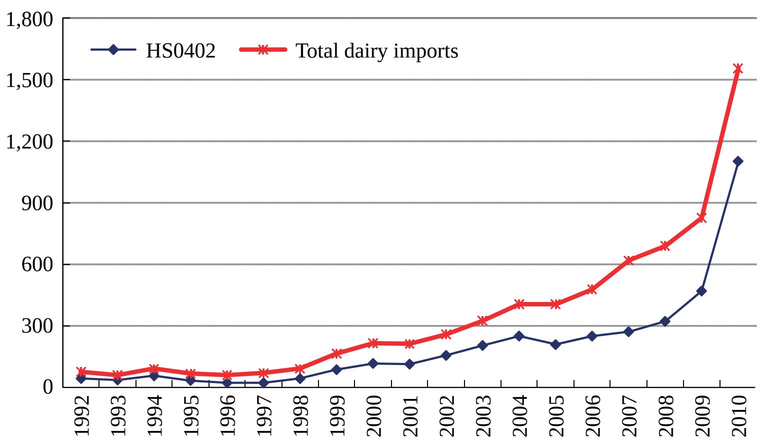
Accompanied with rapid growth of dairy consumption, milk production has also been expanding rapidly since 1990 (Table I and Figure 1). Milk production in China had increased about 8 times from 4.16 million metric tons (mmt) in 1990 to 37.48 mmt in 2010 (Table I). The most rapid growth was recorded in the early 2000s. However, expansion of milk production has also accompanied with rising concerns on food safety of dairy products. In the fall of 2008, China's biggest food crisis struck when it was discovered that milk suppliers were adding melamine to artificially boost the protein readings of their milk (Liu, 2009; Xiu and Klein, 2010). The crisis resulted in a fall of milk production in 2009 (Figure 1), which was major reason of decreased average annual growth rate of milk production in recent years.

Despite rapid expansion of milk production since early 1990s, imports of dairy products have been keeping rising. The first wave of increase in imports was probably driven by lowering China's import tariff, which was started in the late 1990s when China prepared itself to join the WTO and continued after China's WTO accession in 2001 (Figure 2). Dairy imports increased from US$89.5 million in 1998 to US$210.1 million in 2001 and US$689.2 million in 2008. The second wave of increase in imports occurred after 2008 (Figure 2). The milk crisis may be a major reason that led to an accelerated



Source: NSBC (2011)

Figure 1.
China's milk production from 1990 to 2010 (million metric tons)



Source: UNCOMTRADE database

Figure 2.
China's imports of dairy products (HS0401-HS0406) from 1992 to 2010 (million US$ in 2000 constant price)

growth of dairy imports since 2008. Within two years, China's dairy imports were more than doubled, imported 1.6 billion in 2010 (in 2000 constant price).

China's dairy imports consist primarily of concentrated milk and cream (Harmonized System Code of Heading 0402). As shown in Figure 2, imports value of HS 0402 increased dramatically with an annual growth rate of 11.6 percent from 1992 to 2001, and accelerated to annual growth rate of 28.9 percent from 2001 to 2010. The share of HS 0402 in total dairy imports was about 70.9 percent in 2010.

China's dairy imports highly concentrated on several major exporting countries. As shown in Table II, New Zealand, Australia and the USA are the top three exporters to China of HS 0402. Their exports accounted for 70.8, 11.3 and 5.3 percent of China's total dairy imports from 1992 to 2010, respectively. Moreover, the growth of importing HS 0402 from New Zealand is astonishing. The annual growth rate from 1992 to 2010 was 37.7 percent, the highest among all exporting countries. The top ten dairy exporters of HS 0402 are listed in Table II, and their joint exports from 1992 to 2010 accounted for 95 percent of China's total HS 0402 imports.

3. China's safety standards and dairy imports

China has developed comprehensive food safety standards since the late 1980s. As imported dairy products by China is dominated by concentrated milk and cream (i.e. HS 0402), we focus on safety standards for concentrated milk only in our analysis. The first safety standards for concentrated milk (GB 13102-1991) issued in 1991 were fairly simple. These standards were amended in 2005 (GB 13102-2005), expanding the MRLs regulation to cover more hazardous substances and lowering the level of MRLs for lead. In 2010, the safety standards for concentrated milk were further amended (GB 13102-2010), placing more hazardous substances under the MRLs regulation. A detailed discussion on China's food safety standards for dairy products is provided in the Appendix.

One feature with respect to the evolution of safety standards of dairy products is particularly noteworthy. Changes in China's food safety standards for dairy products

		Annual average imports of HS 0402 from 1992 to 2010		
Rank	Exporters	Imports value (million US$ in 2000)	Cumulative percentage of imports value	Annual growth rates of China's imports from 1992 to 2010
1	New Zealand	141.0	70.8	37.7
2	Australia	22.6	82.1	20.0
3	USA	10.4	87.4	14.9
4	France	3.8	89.3	25.1
5	The Netherlands	3.3	91.0	0.9
6	Ireland	2.5	92.2	3.7
7	Denmark	2.0	93.2	17.1
8	Germany	1.8	94.2	2.8
9	Belgium	1.2	94.8	24.8
10	Great Britain	1.2	95.4	−2.1

Source: UNCOMTRADE database

Table II. Annual average imports of concentrated milk and cream (HS 0402) from major exporters and average annual growth rates from 1992 to 2010 in general, and for concentrated milk in particular, typically imposed the MRLs measure on more hazardous substances, rather than simply lowering the level of MRLs for a certain substance. Comparing the latest version with previous ones, we found that only a few measures, such as the level of MRLs for lead, became more stringent, but more and more hazardous substances were placed under the MRLs requirement.

Table III presents the level of MRLs for lead, the most important hazardous substance in dairy products, and the total number of regulations between 1991 and 2010. As shown in Table III, the safety standards on lead became stricter and the level of MRLs for lead decreased from 0.5 parts per million (ppm) in 1991 to 0.3 ppm in 2005. The level of MRLs of lead for infant formula milk was not imposed specifically until 2010. Before 2010, the sanitary standards of lead for infant formula milk were the same as that for regular milk. Since 2010, this standard for infant formula milk powder has become more stringent, dropping from 0.3 to 0.02 ppm. Besides changes in the MRLs for lead, the number of hazardous substances that were placed under regulations increased from six in 1991 to 23 in 2010. More hazardous substances are regulated, more stringent the food safety standards are.

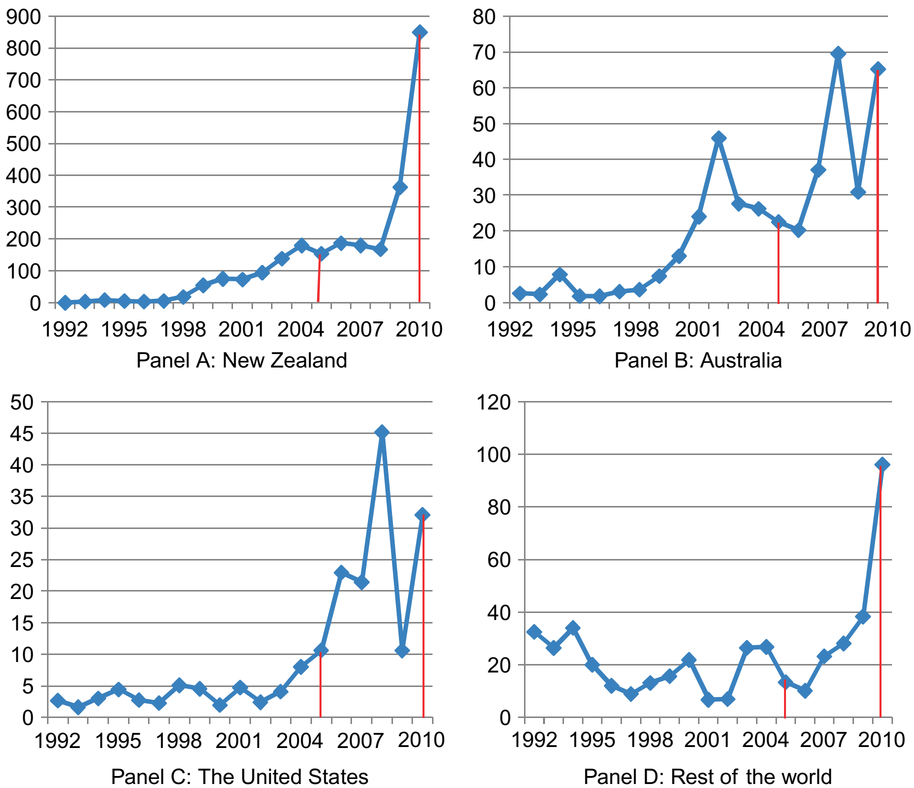
The improved food safety standards can affect dairy imports through two different channels. First, it is expected that safety standards would reduce dairy imports if the new standards imposed additional costs for exporting countries. However, in the case where enhanced safety standards in China are still lower than those in exporting countries, the new safety standards would have no direct impacts on dairy imports as exporting firms have already complied with stricter safety standards. Second, food safety standards can affect domestic production and consumption of dairy products, and consequently influence dairy imports. The improved safety standards could decrease domestic production and increase prices in the short run as rising production costs to meet the new standards. On the other hand, rising price could reduce consumption if consumers do not react to changes of food safety standards, which is quite likely in the short run. In the end, the impact of safety standards on trade through changes in domestic production and consumptions may be small. Hence, given the different effects of safety standards on imports through different channels, the net impact of safety standards on dairy imports may require an empirical investigation.

Figure 3 shows changing trends of China's dairy imports from top exporting countries. China experienced an increase in imports from New Zealand, the largest exporter of dairy products to China, when safety standards were amended in 2005. When safety standards became more stringent, lowering the level of MRLs for lead and putting more hazardous substances under the MRLs regulation, dairy imports from New Zealand further increased in 2010 (Panel A in Figure 3). It seems that improving

Table III. The level of MRLs for lead and the number of regulations from 1992 to 2010

	1991-2004	2005-2009	2010
The level of MRLs of lead (ppm)	0.5	0.3	0.3
The level of MRLs of lead for infant formula milk (ppm)			0.02
Number of regulations over hazardous substances	6	15	23

Notes: The level of MRLs of lead for infant formula milk was not imposed specifically until 2010; before 2010, the sanitary standards for infant formula milk were the same as that for regular milk
Source: Chinese National Standards GB 13102-1991, GB 13102-2005, GB 13102-2010



Source: UNCOMTRADE database

Figure 3.
China's dairy imports (HS 0402) and changes in safety standards (million US$ in 2000 constant price)

safety standards might probably not restrict imports from New Zealand. The lack of clear relationship between changing safety standards and China's dairy imports from Australia and the USA is also evidenced and reflected in Panels B and C of Figure 3. These figures imply that improvements in safety standards for dairy products did not accompany with declines in China's dairy imports.

4. Model specification and data

4.1 Empirical specification

A gravity model has been widely used for understanding the determinants of international trade flows since the early 1960s. Drawing upon an analogy to Newton's law of gravitation, the observed bilateral trade flows between two countries could be explained by the products of the economic sizes of the two countries divided by the distance between them. In the international trade literature, Nobel laureate Jan Tinbergen is credited as the first to specify econometrically what has become a benchmark gravity model for studying international trade flows (Tinbergen, 1962). Since 1979, theoretical foundations for a gravity model have been developed that provide a rigorous rationale for econometric use (Anderson, 1979). Over 50 years, the gravity model has been used to evaluate the impact of various trade policies, including food safety standards, on international agricultural trade (Zahniser *et al.*, 2002; Wilson and Otsuki, 2004; Tamini *et al.*, 2010; Wei *et al.*, 2012)[1].

As in Wilson and Otsuki (2004) and Wei *et al.* (2012), a gravity model is built to examine the impact of changing food safety standards on China's dairy imports. We develop our specification as follows:

$$\begin{aligned} Ln(Import_{it}) = \beta_0 + \beta_1 Ln(GDP_t) + \beta_2 Ln(Output_{it-1}) + \beta_3 Ln(Tariff_{it}) \\ + \beta_4 Melamine_t + \beta_5 SS_t + \eta_i + \varepsilon_{it} \end{aligned} \quad (1)$$

where $Import_{it}$ denotes the value of dairy imports from country i to China in year t. β_s are coefficients to be estimated. η_i is a country-specific effect for country i, and ε_{it} is an idiosyncratic error term, which is assumed to be independent and identically distributed.

SS_t represents changes in China's food safety standards. Two different measurements are developed to capture the stringency of safety standards. First, a direct measure of standards, the level of MRLs for lead ($Lead_t$), is introduced in the gravity equation (1) because lead is one of the most common hazardous materials found in dairy products. It is also a major potential threat to human, particular to children. Lead poisoning in dairy products can cause a number of adverse human health effects. The level of MRLs for lend is one of the most important factors that determine the safety of dairy products. Moreover, among all the hazard substance, the level of MRLs for lead in dairy products is the only one that received several improvements. For example, first specified in 1991, the level of MRLs for lead in dairy products was amended in 2005, significantly improved from 0.5 to 0.3 ppm. In 2010, the level of MRLs for lead was further amended from 0.3 to 0.02 ppm for infant dairy products. Hence, lead has become one of the most important hazardous substances that could affect trade of dairy products.

Second, we use the number of regulations imposed on hazardous substances and bacteria in dairy products ($Regulation_t$) to proxy overall stringency of safety standards. As discussed in Section 3, new safety standards often tend to impose the MRLs regulation on more hazardous substances, not simply enhance the level of MRLs for hazardous substances that have been placed under regulations. In general, when more safety regulations were imposed, the safety standards would become more stringent. One potential criticism of using a direct measure of one or two substances is that it does not capture changes in other measures that might affect China's dairy imports. Even though lead is one of the most important hazard substances, the list of substances settled down in the regulations are often impressive in the case for dairy products. Thus, selecting only one measure, such as the MRLs of lead, as explanatory variables may not fully estimate the impact of changing food safety standards on China's dairy imports. Therefore, we alternatively consider the number of regulations imposed on hazardous substances and bacteria as the second proxy for changes in safety standards to assess how overall strictness of food safety standards affects dairy imports.

The two proxy variables (the level of MRLs of lead and the number of regulations imposed on hazardous substances) represent food safety standards from different angles. They could probably have different impacts on China's dairy imports. In a situation where lead is one of the most important factors that restrict dairy imports, the level of MRLs of lead can well measure the impact of safety standards on imports. On the other hand, if sanitary regulations regarding other hazardous substances are likely to influence dairy imports, the number of regulation would provide a good measurement for China's food safety standards of dairy products.

It is particularly noteworthy that the number of regulations imposed on hazardous substances and bacteria may not be a perfect proxy for the overall stringency of food safety standards on dairy imports. As some regulations were removed due to modern technologies, changes in the number of regulations may not fully reflect changes in stringency of food safety standards.

A set of additional control variables are included in the equation (1). GDP_t denotes real gross domestic product of China in year t and captures the market size as a typical gravity model does. We include the total output of dairy products in exporting country i ($Output_{it-1}$) to capture exporting country's supply capacity. This variable was lagged one year in order to avoid possible spurious correlation with dependent variable. A tariff barrier ($Tariff_{it}$) faced by exporting country i is also introduced into the gravity equation to estimate the impact of a tariff reduction on trade flows. A dummy variable, $Melamine_t$, is used to assess the effect of the milk crisis in 2008 on imports due to changes of consumers' preference for domestic and imported dairy products.

4.2 Variables construction and data

Annual data on China's imports of HS 0402 were obtained from the UNCOMTRADE database. Ten major exporting countries are covered in this study. These exporting countries are chosen on the basis of their shares in China's imports of HS 0402 and the availability of data. Table II reports the Cumulative shares of imports value during the period 1992-2010. These exporting countries are major exporters of dairy products to China, accounting for over 95 percent of the total value of China's dairy imports from 1992 to 2010.

The levels of MRLs for lead in dairy products were obtained from Chinese National Standards of GB 13102-1991, GB 13102-2005, and GB 13102-2010. It is worth to note that the level of MRLs for lead in concentrated milk was specified based on its usages in 2010. The sanitary standard of lead for infant formula milk powder dropped from 0.3 to 0.02 ppm while this standard for regular milk remained 0.3 ppm. As China's imports of infant formula milk accounted for a large share in its total milk imports in 2010, we consider the standard for infant formula milk powder as measurement for the MRLs for lead in regression analysis. If the regular level of 0.3 ppm in 2010 was used in the regression, this measurement cannot fully capture changes in sanitary standards of lead for dairy products because the sanitary standards for infant formula milk have been significantly improved. A lower value of the standard reflects stricter regulation of lead residue limit. The coefficient on the level of MRLs for lead implies the percentage changes in imports value of dairy products with response to a change in residue standards on lead. This coefficient is expected to be positive if food safety standards restrict imports.

The number of regulations imposed on hazardous substances and bacteria is counted based on information drawn from Chinese National Standards of GB 13102-1991, GB 13102-2005, and GB 13102-2010. When the MRLs regulation was imposed on different types of dairy products, we consider them as different regulations. For example, levels of MRLs for lead on infant milk and regular milk were different in 2010. We treat them as two regulations, rather than only one measure for lead. The coefficient on the number of regulations is expected to be negative if food safety standards significantly impede imports.

Data on Chinese GDP were obtained from the National Bureau of Statistics of China (NBSC, 2011). The variable GDP is used as a proxy for an import-demand shifter for the importing country. It is expected to have a positive impact on China's dairy imports. Data on dairy production in exporting countries are from the World Development Indicators (WDI) database. The dairy production includes all dairy products, measured in one thousand metric tons. The expected effect of dairy production in exporting countries on China's imports is positive.

Data on import tariffs were extracted from the Trains database developed by United Nations Conference on Trade and Development (UNCTAD). Tariffs in this dataset are computed initially at the HS-6 level, but our study is conducted at the HS-4 level. Thus, we averaged tariff data. Although the dataset contains both simple average and import-weighted average tariffs, we choose the simple average in order to avoid the problem of endogeneity between trade flows and tariffs caused by import-weighted averaging. The expected effect of the import tariff is negative on China's imports of dairy.

The dummy variable melamine equals to 1 in 2009-2010 and 0 otherwise as this melamine scandal was publically reported in September 2008 and is expected to have impacts on trade in 2009 and 2010. Table IV provides descriptions and summary statistics for all variables used in this study.

5. Estimation results

Gravity models have been estimated using regression techniques for nearly 50 years. In order to check robustness of our estimates, we applied three different methods of estimation: ordinary least squares (OLS) estimate, random effect model, and country fixed effect model. The gravity model is often estimated using OLS in previous literature, assuming that there is no country-specific effect (η_i). As a benchmark, we first estimate the gravity model using OLS technique. In addition, in order to check the robustness of our estimates, we also applied a random effect model which assumes that the country-specific effect (η_i) is uncorrelated with other explanatory variables. However, as recommended by Anderson and Van Wincoop (2003) and Feenstra (2004), a country-specific fixed effect model is more likely to provide a theoretically consistent estimator for a gravity model. A country fixed effect model is finally estimated in order to avoid unobserved heterogeneity for each exporting country. The country fixed effect model would ensure that the coefficients are not biased by the omitted the resistance term between China and exporting countries.

Variable	Description	Mean	SD
Import_{it}	Annual imports of dairy from country i in year t (US$1,000)	19,874.9	78,930.8
GDP_t	Chinese GDP in year t (US$1,000)	1,824,624,330	1,183,387,043
Output_{it-1}	Dairy production of country i in year $t-1$	19,121,938	20,914,722
Tariff_{it}	MFN tariff against country i in year t	23.4	12.35
Melamine_t	Dummy for the occurrence of melamine scandal scandal in year t	0.11	0.32
Lead_t	The level of MRLs for lead in year t	0.42	0.13
Regulation_t	The total number of regulations on hazardous substances in year t	9.44	5.18

Source: Authors' calculation

Table IV.
Variable description and summary statistics

Estimation results of our gravity model using the level of MRLs for lead as a direct measure for safety standards are first reported in Table V. Results from OLS are presented in column 1, random effect model in column 2, country-specific fixed effect model in column 3. Our discussion below is based on estimation results of the country-specific fixed effect model.

The effects of the level of MRLs for lead in all three models are not statistically significant, indicating that enhancing safety standards for hazardous substances in particular the level of MRLs for lead has no empirical impacts on the value of exports from an exporting country to China's market.

The finding above is not particularly surprising considering the special characteristics of China's food safety standards. On one hand, the trade-impeding effect of food safety standards in the case of China's dairy products might be small as food sanitation standards for dairy products in China are relatively lower than that in its major developed exporting countries such as New Zealand, Australia and the USA. China, as a developing country, often tried to match leading food safety standards established in developed countries when it considered amending its food safety standards. For instance, the level of MRLs for lead in infant formula milk recently imposed in 2010 is 0.02 ppm, while New Zealand and Australia, two top exporters of dairy products to China, adopted this measures much earlier than China did (GEEIQB, 2009). Exporting firms in developed countries have passed through stricter sanitation regulations in their domestic markets. Therefore, it would not generate severe obstacles for them to entry China's market. On the other hand, the new standards, compared with old versions, put more emphasis on implementation rules and provided detailed regulations on sampling and detection methods. The clear definition of sampling and

	Dependent variable: Ln (import values of HS 0402)		
	OLS	Random effect	Fixed effect
Variables	(1)	(2)	(3)
Ln(GDP)	−0.12	−0.85	−0.93
	(0.82)	(0.59)	(0.58)
Ln(Output)	0.70***	1.43**	4.28***
	(0.15)	(0.60)	(1.32)
Ln(Tariff)	−1.47	−5.55*	−4.86*
	(4.09)	(2.92)	(2.90)
Melamine	1.67*	2.03***	2.04***
	(0.89)	(0.56)	(0.56)
Lead	−1.03	−0.88	−1.36
	(2.39)	(1.74)	(1.73)
Constant	5.90	28.82	−19.16
	(34.88)	(27.06)	(33.61)
R^2	0.14		0.23
Observations	180	180	180
Test for autocorrelation in panel data (H0*: no first-order autocorrelation)*			
Wooldridge test (F-statistic)			3.90
Durbin-Watson test		1.21	1.27
Baltagi-Wu LBI test		1.35	1.35

Notes: Variables statistically significant at: *10, **5 and ***1 percent levels; robust standard errors in parentheses

Table V. Estimates of effects of the level of MRLs for lead on China's dairy imports from 1992 to 2010 detection approaches under new safety standards would possibly facilitate the dairy trade with lower cost of conformity for exporting firms. If this trade-enhancing effect of food safety standards on dairy imports is sizeable, stricter regulations would more likely to benefit exporting firms and cause an increase in imported products.

Coefficients on many control variables are of the expected sign and statistically significant. We find that a reduction in tariffs against dairy imports significantly affect China's imports value of dairy product (column 3 in Table V). The tariff reduction has been one of the major driving forces that boosted dairy imports of China. The coefficient of dairy production of an exporting country (lagged one year) is positive and statistically significant. This result is consistent with our expectation, because an increase in production in an exporting country can encourage exporting firms to export more to China's market. Also, it is found that the occurrence of melamine incident in September 2008 affected imports of dairy products remarkably. As shown in column 3 in Table V, the coefficient of melamine incident is positive and statistically significant. The crisis made Chinese consumers worry deeply about safety of domestic dairy products and prefer over imported milk (Pei *et al.*, 2011). Such results are consistent with the fact that imports of HS 0402 shot up by increasing 46 percent in 2009 and 85 percent in 2010, respectively.

Table VI reports estimation results using the number of regulations as a proxy for changes in safety standards. Similar results are found on the effects of China's food safety standards on dairy imports. The coefficients on the number of regulations are not statistically distinguishable from 0, implying that food safety standards have no empirical effects on dairy imports even when we consider a measure for overall stringency of safety standards. The finding further confirms that there is no significant evidence thus far that China's dairy safety standards have restricted its dairy imports.

Table VI.
Estimates of effects of the number of regulations on China's dairy imports from 1992 to 2010

	Dependent variable: Ln (import values of HS 0402)		
	OLS	Random effect	Fixed effect
Variables	(1)	(2)	(3)
Ln(GDP)	−0.06	−0.77	−0.86
	(0.83)	(0.59)	(0.59)
Ln(Output)	0.70***	1.42**	4.23***
	(0.15)	(0.60)	(1.32)
Ln(Tariff)	−1.54	−5.66*	−4.93*
	(4.09)	(2.93)	(2.93)
Melamine	1.76**	2.13***	2.14***
	(0.87)	(0.55)	(0.55)
Regulation	0.01	0.02	0.02
	(0.06)	(0.04)	(0.04)
Constant	4.32	27.58	−20.06
	(34.59)	(26.97)	(33.70)
R^2	0.14		0.23
Observations	180	180	180
*Test for autocorrelation in panel data (*H0*: no first-order autocorrelation)*			
Wooldridge test (*F*-statistic)			3.96
Durbin-Watson test		1.28	1.28
Baltagi-Wu LBI test		1.36	1.36

Notes: Variables statistically significant at: *10, **5 and ***1 percent levels; robust standard errors in parentheses

To check on efficiency of our estimates, we further conducted several diagnostic tests. As our panel data set covers different country over a relative long time period, autocorrelation in the idiosyncratic error term may be a problem that affects the efficiency of our estimates. We first applied Wooldridge's test for serial correlation in panel data (Wooldridge, 2002). Results in the second panel of Tables V and VI show that we cannot reject the no autocorrelation hypothesis at 5 percent significance level, implying that autocorrelation is not a serious problem in our sample. We also estimated the panel data with AR (1) disturbance and then tested autocorrelation using Durbin-Watson and Baltagi-Wu LBI statistics. As the rough role thumb, a statistic value below 1 means that we should definitely correct for serial correlation. The value of both statistics in our estimations is larger than 1 and less than 2, indicating that autocorrelation is not serious.

6. Concluding remarks

In this paper, we examine the effect of China's dairy safety standards on its dairy imports. We focus on dairy trade because China's dairy product has been one of the most important imported agricultural products and China's safety regulations for dairy products have been dramatically amended. We are interested in the impact of not only a specific hazardous substance (e.g. the MRLs for lead) but also overall stringency of safety standards (proxied by total number of regulations) on dairy imports. Our results suggest that changes in China's dairy safety standards have had no significant impacts on its dairy imports.

Our findings have implications for the debate over the use of food safety regulations. The focus of previous studies was often put on agricultural trade from developing countries affected by more strict food safety regulations in developed countries such as the USA and the European Union. We show that food safety standards in developing country like China could have different effects on international agricultural trade. This finding implies that improving food safety standards of importable products in developing countries may have no implications for international trade if these products are mainly imported from developed countries where higher food safety standards were implemented. In this case, food safety policy would mainly benefit domestic consumers, causing no additional pain to producers in exporting countries. It should not be considered as a form of protectionism or a trade barrier by developing countries.

Although our results are specific to China's dairy imports, our explanations are applicable to food safety standards in other developing countries. If a developing country imports mainly from developed countries that have already established high safety standards, changes in its food safety standards would have no significant impact on trade. However, we cannot make implications for other products that imported mainly from less developed countries. Indeed, as shown in this study, what may be crucial is not the absolute stringency of safety regulations in an importing country, but the differences in the tolerance level between exporting and importing countries. As such, food safety standards could have different impacts on different importing sources. Hence, the impact of food safety standards on international agricultural trade should be assessed on a case by case basis.

It is worth noting that our study is subject to certain limitations. First, this study is unable to estimate the trade-enhancing and trade-impending effects separately. Fully explaining the impact of China's food safety standards on dairy imports requires information about safety standards in both China and exporting countries. Due to data limitation, however, we only have such information for a few top exporters.

Second, our study does not account for a potential endogeneity issue associated with food safety standards. For example, some omitted variables, such as the awareness of food safety, can drive both changes in food safety standards and increases in demand for dairy imports. In future work, the possible endogeneity may be fully explored.

Note

1. Although gravity models enjoyed continued popularity in empirical trade studies, shortcomings of this approach are worth noting. A major limitation of gravity models is their narrow focus on trade values and inability to generate predictions, such as distributional impacts of safety standards. In addition, in contrast to computable general equilibrium (CGE) models, a gravity model cannot provide explicit links between changes in trade and safety standards. Finally, it is argued that a gravity study is unable to take into account dynamic trade adjustments which can have significant effect on changes in trade and welfare.

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(The Appendix follows overleaf.)

Appendix

China has developed comprehensive food standards since the late 1980s. The first standards for desalted whey powder (GB 11674-1989) were established in 1989. Since then standards for industrial sweeten condensed milk (GB 13102-1991), margarine (GB 15196-1994 and GB 15196-2003), fresh milk (GB 19301-2003) and yogurt (GB 19302-2003) have been established sequentially. The first comprehensive improvement of safety standards on dairy products was made in 2005. Not only standards on whey powder (GB 11674-2005) and condensed milk (GB 13102-2005) were amended, but also new standards on milk powder (GB 19644-2005), butter and dehydrated butter (GB 19646-2005), and pasteurized milk and sterilized milk (GB 19645-2005) were legislated. In 2010, new standards on butter and dehydrated butter (GB 19646-2010), whey powder (GB 11674-2010), condensed milk (GB 13102-2010), fresh milk (GB 19301-2010), fermented milk (GB 19302-2010), milk powder (GB 19644-2010) and pasteurized milk (GB 19645-2010) were further amended.

It is worthy to note that categories of dairy products in China are not exactly the same as those used in coding of international trade of dairy products. Safety standards were often issued for specific dairy products, while international trade of dairy products is grouped into six categories at four-digital level based on harmonized commodity description and coding system. It is hard to match aggregated trade data of dairy products exactly with safety standards of the same products. However, as China's dairy imports is dominated by concentrated milk and cream (i.e. HS 0402), we therefore focus on safety standards for concentrated milk only in our analysis.

As shown in Table AI, the first standards for concentrated milk (GB 13102-1991) in 1991 were fairly simple. It only contains the MRLs standards on three hazardous chemical substances (i.e. lead, copper, and antimony) and three measures on bacteria (i.e. bacteria amount, coliform group, and pathogenic bacteria).

These standards were amended in 2005. Two new measures, the MRLs for inorganic arsenic and aflatoxin M1 were imposed, and one measure, the MRLs for copper, was abolished. Only the standard on lead became stricter and the level of MRLs for lead decreased from 0.5 to 0.3 ppm (Table AI). With respect to standards for bacteria, the initial uniform standards on bacteria amount and coliform group were separated into three distinguished measures. Standards for unsweetened evaporated milk and sweetened condensed milk became more stringent, while standards for sweetened condensed milk for industrial usage remained the same. Standards for pathogenic bacteria, however, were amended with more concert and clearer definition on specific bacteria (i.e. *Salmonella*, *Staphylococcus aureus* and *Shigella*).

In 2010, safety standards for concentrated milk were further amended (Table AI). The MRLs standards for four additional hazardous chemical substances (i.e. chromium, selenium, $NaNO_2$ and aflatoxin B1) and two kinds of new bacteria (*Staphylococcus aureus*, *Salmonella*) were specified and the measure for antimony was abolished. Except for standards on lead, measures for bacteria amount, coliform group pathogenic bacteria, and other hazard substances remain the same as before. The level of MRLs for lead in concentrated milk was further amended based on its usages. Specifically, the MRLs of lead for infant formula milk powder became more stringent, dropping from 0.3 to 0.02 ppm. As to standards on bacteria amount and coliform group, standards on three varieties (i.e. unsweetened evaporated milk, sweetened condensed milk and sweetened condensed milk used in food industries) were unified. Standards for pathogenic bacteria changed as *Shigella* was eliminated from the listed bacteria which were not allowed initially.

Table AI. Sanitary standards on concentrated milk in China from 1991 to 2010

Indicators/year	*1991*	*2005*			*2010*			
		Unsweetened evaporated milk	Sweetened concentrated milk	Sweetened concentrated milk for industrial usage				
Lead (ppm)	0.5		0.3		0.02 (infant formula milk powder), 0.3 for others			
Copper (ppm)	4							
Antimony (ppm)	10		10					
Inorganic arsenic (mg/kg)			0.25		0.25			
Chromium (mg/kg)					2.0			
Selenium (mg/kg)					0.15			
$NaNO_2$ (mg/kg)					2			
Aflatoxin B1 (μg/kg)					5			
Aflatoxin M1 (μg/kg)			0.5		0.5			
					Modify the representation of "microbiological values" sampling program and limits (CFU/g, if not specified)			
					*n**	*c*	*m*	*M*
Bacteria amount (pieces/g)	100,000	10	30,000	100,000	5	2	30,000	100,000
Coliform group (pieces/100 g)	150	3	90	150	5	1	10	100
Staphylococcus aureus					5	0	0/25 g (ml)	–
Salmonella					5	0	0/25 g (ml)	–
Pathogenic bacteria	Cannot be detected	*Salmonella*, *Staphylococcus aureus*, *Shigella* cannot be detected			*Shigella* was deleted			

Notes: "n" denotes the number of tests; "m" and "M" represent an acceptable and maximum value of microorganism for each test, respectively; "c" is maximum numbers of tests in which bacteria amount exceeds the acceptable value

Source: Chinese National Standards GB 13102-1991, GB 13102-2005, GB 13102-2010