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Maximum residue limits and agrifood exports of China: choosing the best estimation technique

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Abstract: The main aim of the article is to show the response of the Maximum Residue Limits adopted by importing countries on exports of the selected food commodities from China. The study estimates the gravity model using the Ordinary Least Squares, Poisson and the Negative Binomial Regression estimators. According to the results, the Maximum Residue Limits has a trade enhancing effect on exports of the selected food commodities from China. This trade enhancing impact may be due to the current government policies to put a cut on the food safety issues, to ensure safe food for all and adopting a protectionist policy in terms of the Maximum Residues Limits for the selected commodities.

Keywords: food safety, gravity, MRLs, OLS, Poisson family, trade

With the creation of World Trade Organization (WTO), the traditional barriers to trade continue to decline. Taking this opportunity, many of the developing countries participated in the world trading system and most of them have shown tremendous performances. However, the entry of products from the developing to developed countries is restricted by the non-tariff barriers (NTBs), like the Sanitary and Phyto-Sanitary (SPS) and Technical Barriers to Trade (TBT) (Jongwanich 2009; Neeliah et al. 2013). According to Li and Beghin (2012), these barriers affect agriculture and food industries more than other sectors.

In the past, several attempts have been made to address the trade losses due to the stringent regulations by importing countries. According to Bao and Qiu (2012), the effects of the TBT depend on their settings; they promotes trade if set properly and otherwise, if set at a higher level. Therefore, Disdier et al. (2008) term that the impacts of the SPS and TBT are ambiguous, such as to facilitate the trade if consumers find the product safe and to impede trade if these measures are used in a protectionist way. Disdier and his colleaques conclude a significant negative impact of these standards on exports from the developing countries to the OECD countries, while they find no effect on the trade among the OECD members. Jongwanich (2009) considers that the food safety standards help in smoothening trade and reducing transaction costs as the exporters may know the importers' expectations for a particular commodity. So far, many studies (Henson and Jaffee 2008; Drogue and DeMaria 2012; Li and Beghin 2012) agree upon the trade impeding effects of these standards for developing countries. However, Bao and Qiu (2010); Moenius (2006) have reported a trade impeding effect for agricultural products and a trade promoting effect for manufacturing goods. Moenius (2006) argues that though exporting costa are increased by meeting these standards but this facilitates lower search costs for both producers exporting their products to a specific market and consumers searching for a certain minimum quality. Jongwanich (2009) assesses the impact of the SPS standards on exports of the processed food in developing countries and concludes that the stringent SPS standards adopted by the developed countries impede the trade.

This study provides new evidence on the effect of the food safety standards measured in terms of the Maximum Residue Limits on food products export of China. It is important to analyse the MRL for Chinese exports because China is one of the major players in the international trading system and a leading exporter of food products to the United States, Canada, and Africa, South and South East Asia and some of the European countries. China has

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been facing food safety concerns in the recent past that brought a bad name to the "Made in China" food products. As a result, most of the countries either banned the entry of Chinese food products in their markets or adopted stringent food safety measures to check for the quality of the products. These importer specific food safety standards demand a thorough investigation of the possible impact of these standards on food exports from China. The study makes three major contributions:

(1) This study has considered all the major food products as compared to apples and pears considered by Drogué and DeMaria (2012),
(2) In contrast to the previous studies conducted in China, this research considers all the pesticides and major food exports.
(3) The study uses indices recently developed by Li and Beghin (2014) as a measure of protectionism (using the Maximum Residue Limits (MRLs)) to empirically show the impact of the SPS measures on food exports from China.

The study estimates the gravity equation using different estimators and selects the Negative Binomial model for its best results over others. The findings of the study are in contrast to the previous studies as no effect has been observed on the exports of the selected commodities. The main reason for this trade enhancing impact may be due to the current government policies to put a cut on the food safety issues. Secondly, the MRL index for all selected commodities (except apples which are almost at par with the codex value) is greater than that of the Codex ($L_{ij} > 1$) i.e., the country has adopted a protectionist policy. As the study is based on two years data covering the selected food products.

AGRICULTURAL TRADE OF CHINA

Since opening up its borders for the international trade, China has been transformed to a more market-oriented economy (Cerra and Saxena 2003). According to Ortega et al. (2009), the Chinese economy is in its transitional period from the developing to a developed one. The country has recorded an annual growth rate of above 8%, the highest in the World. Agricultural production of the country has increased many times (Chen et al. 2008; Gao and Thornsbury 2008), though its share in the economy is continuously declining relative to the industrial and service sectors (Yu and Frandsen 2005).

With the accession to the WTO, China is integrating and playing its increasing role in the global trading system. According to UN-Comtrade data on food and live animals[1], China ranks as the fourth largest exporter (Figure 1a) and seventh largest importer (Figure 1b) of the world. For many products like aquatic products, fresh and processed vegetable and fruits, animal products etc., China is still the leading exporter, while being a leading importer of a variety of agricultural products including cotton, hides and skins, soybeans, vegetable oils, and wool.

A comparative picture of Chinese agricultural exports and imports over a period of time is presented in Figure 2. It delineates that agricultural exports of the country jumped nearly two times from 32.603 US$ (billion) in 2009 to 55.726 US$ (billion) in 2013,

(a) (b)

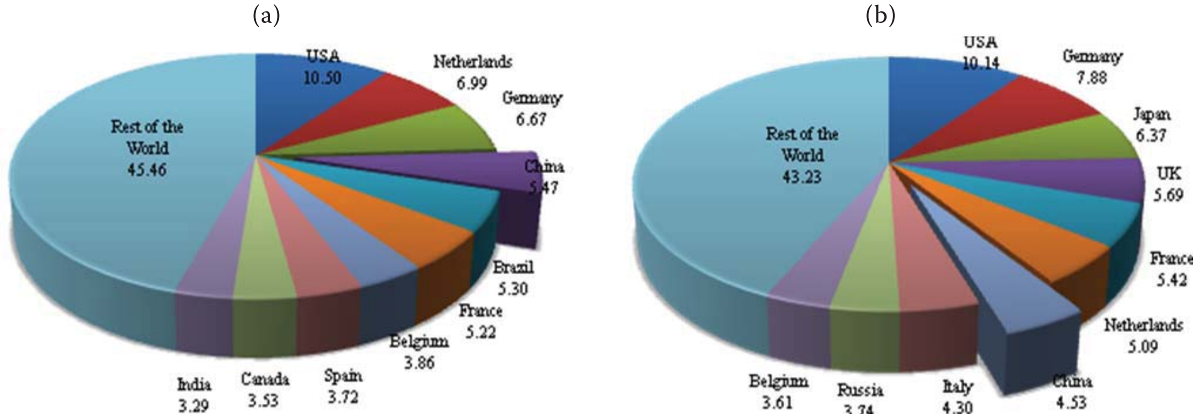

Figure 1. Exports (a) and imports (b) of food and live animals

[1]http://comtrade.un.org/data/ (accessed on August 3, 2014), SITC Revision 4

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Table 1. Major food export items of China (value in $ US billion)

	2012	2013		2012	2013
Aquatic and Seawater Products	10.984	18.118	Frozen Chicken	0.268	0.222
Vegetables	9.350	7.559	Natural Honey	0.201	0.215
Tea	0.965	1.042	Edible Vegetable Oil	0.208	0.184
Apples	0.914	0.960	Pine Nut Kernels	0.154	0.175
Mandarins and Oranges	0.637	0.839	Canned Pork	0.126	0.150
Cereals and Cereals Flour	0.753	0.594	Dried Capsicum	0.180	0.137
Canned Mushroom	0.555	0.523	Fresh Eggs	0.121	0.112
Live Hogs	0.452	0.461	Frozen, Fresh Beef	0.120	0.081
Frozen, Fresh Pork	0.326	0.295	Sugar	0.051	0.043
Soybean	0.162	0.279	Live Poultry	0.029	0.031
Peanuts	0.260	0.272			

Source: China Statistical Year Book 2013 (http://www.stats.gov.cn/tjsj/ndsj/2013/indexeh.htm, accessed on August 4, 2014

while, during the same period, agricultural imports of the country increased by almost three times from 14.824 US$ (billion) in 2009 to 41.701 US$ (billion) in 2013. According to Xin and Liu (2008), irrespective of imports, the country has experienced an instable growth in agricultural exports of less than 10 percent in some years to above 15 percent in others. Chen et al. (2008) view that China has a comparative advantage in labour-intensive agricultural products and a comparative disadvantage in land-intensive agricultural products. Resultantly, the imports of land-intensive and exports of labour-intensive agricultural products have increased. Ishaq et al. (2014) view that the trust of consumer both at home and abroad was lost due to frequent occurrences of the negative food safety issues in China. This resulted in the increase in imports and the instable increase in exports.

The major food export items of China are presented in Table 1. The major markets for Chinese agricultural products include Japan, which accounted for 10.10 US$ (billion), followed by the United States (6.34 US$ billion), Hong Kong (5.92 US$ billion), the Republic of Korea (6.34 US$ billion), Malaysia (2.43 US$ billion) and others (Table 2). It is clear from the data that the Chinese exports are mainly concentrated to developing countries except Japan, the USA, Russia and Germany. However, the total share of the developing countries is far less than that of Japan and the USA.

The above discussion makes it clear that China is not only self-sufficient in the labour- intensive agricultural products (mainly food), but also a supplier to many of the economies. However, the importing countries have imposed stringent food safety standards to check the entry of food products into their markets. If these standards are trade impeding,

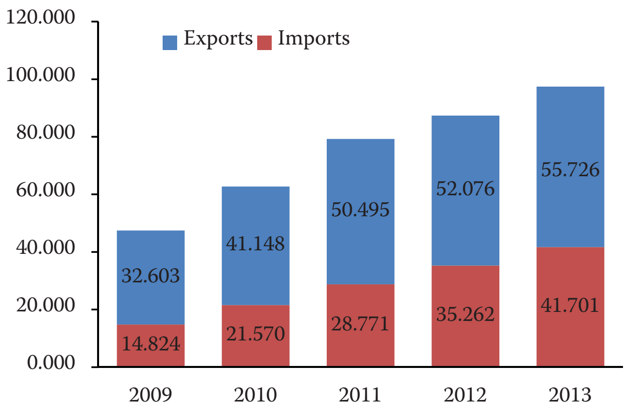

Figure 2. Exports and imports of agricultural products

Table 2. Top ten importers of Chinese food and live animals (value in $ US billion)

Importer	2009	2010	2011	2012	2013
Japan	6.88	8.25	9.88	10.77	10.10
USA	4.27	5.25	6.04	6.31	6.34
Hong Kong	2.64	3.22	4.38	4.94	5.92
R Korea	2.29	2.97	3.53	3.40	3.61
Malaysia	1.13	1.56	1.98	1.99	2.43
Thailand	0.73	1.02	1.55	1.80	2.33
Viet Nam	0.78	1.15	1.80	1.60	1.93
Russia	1.06	1.38	1.75	1.76	1.91
Germany	1.10	1.27	1.41	1.40	1.41
Indonesia	0.82	1.42	1.72	1.44	1.31

Source: UN-Comtrade SITC Rev.4, (http://comtrade.un.org/data/, accessed on August 4, 2014)

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then it will not only affect the domestic demand and supply situation but will also affect consumers in the importing countries. This study may be helpful to depict a clear picture of the actual happenings to Chinese food exports in the international market in the face of the implementation of stringent food safety standards.

REVIEW OF LITERATURE[2]

The reviview of literature starting from Moenius (2004) till the recent available study of Melo et al. (2014) shows a trade impeding effects of stringent regulations/standards on the trade of agricultural commodities,except, de Frahan and Vancauteren (2006); Disdier et al. (2008); Song and Chen (2010); Xiong and Beghin (2012), who noticed a trade enhancing effects of these regulations/standards on trade. To the contrary, Disdier and Marette (2010) found an increase in both the domestic and international welfare because of the imposition of the regulations/standards.

Moenius (2004) analyses the impact of environmental and technical standards on trade. He estimates a trade enhancing effect of the standards on manufactured goods and a trade impeding effects on agricultural commodities. Otsuki et al. (2001a,b) incorporate a direct measure of the aflatoxin standard in the gravity equation and found its negative effect on the exports of cereals, dried fruits and nuts (Otsuki et al. 2001a) and groundnut (Otsuki et al. 2001b) from Africa to the EU countries. Wilson and Otsuki (2004) found that a 1% increase in the regulatory stringency of the chlorpyrifos pesticide resulted in a decrease of 1.63% in banana imports, keeping other variables constant. Fontagne et al. (2005) acknowledge the data compilation efforts of Moenius (2004) since it is challenging to compile data on the environmental and technical standards and then harmonizing these standards with the trade data. Fontagne and colleagues estimate the gravity equation using the random effect Tobit technique to account for zeros in trade flow. They note trade impeding effects of these standards on the flow of fresh and processed food and an insignificant, and at times trade enhancing effect on the manufactured goods. de Frahan and Vancauteren (2006) estimate a structural gravity equation using Tobit estimator and noticed that the intra-EU trade has increased with the harmonization of food regulations. Disdier et al. (2008) anlysed the structure of the sanitary and phytosanitary (SPS) and TBT agreements of the World Trade Organization in agricultural trade and estimated the stringency of them for the trade using a gravity equation. Their results suggest that the stringent regulations adopted by the importing countries have a trade impeding efffect on the trade flows from the developing to the OECD countries, however, these do not affect the trade among the OECD member countries. Chevassus-Lozza et al. (2008) estimated a gravity equation using the Heckman's selection model to take care of the selection bias due to missing trade data. Their findings revealed a significantly persistent trade resistance in the EU market for the Central and Eastern European Countries (CEECs) agrifood products regardless of the EU integration and the trade liberalization processes. Similarly, Jayasinghe et al. (2010) also use the Heckman's selection model to cope with zeros in the trade data and concluded that, like other trade costs, the SPS regulations impede exports. Vigani et al. (2012) showed that the variation in the GMO standards impeded the trade flows. Chen et al. (2008) find a negative effect of the chlorpyrifos on the export of vegetables and oxytetracycline on the export of aquatic products using the gravity model. They concluded that the food safety regulations have higher trade impeding effects as compared to tariffs. Song and Chen (2010) estimated the short- and long-run effects of the food safety standards on trade flows. Their findings show a negative effect of the food safety standards on the export of agricultural products of China in the short-run and a positive effect in the long-run. Disdier and Marette (2010) working on the non- tarrif measures investigate the association between the gravity and welfare frameworks. They found a negative impact of the NTMs on imports in the gravity framework and an increase in both the domestic and international welfare in the welfare context. Xiong and Beghin (2012) did not find a negative evidence of the MRL on aflatoxins implemented by the EU on the imports of groundnut products from Africa. They summed up their findings that the trade volume is determined by the domestic supply in the exporting country rather than the restricted market access. Drogue and DeMaria (2012), unlike the previous studies, developed a similarity index measured as

[2]Detailed review is presented by Ferrantino (2006) and Korinek et al. (2008).

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$$S_{ij}^{c} = 1 - \left(\frac{1}{n} \sum_{\mathrm{k}=1}^{\mathrm{n}} \left(\frac{M_{ik}^{c} - \bar{M}_{i}^{c}}{\sigma_{i}^{c}} \right) \left(\frac{M_{jk}^{c} - \bar{M}_{j}^{c}}{\sigma_{j}^{c}} \right) \right)$$

while focussing on the entire list of substances defined by various regulations. There, S_{ij}^{c} is the Pearson's correlation coefficient for (dis)similarity, (n) represents the total number of pesticides, M_{ik}^{c} and M_{jk}^{c} are the MRL of the exporting (i) and importing (j) countries, respectively, for the pesticide (k) and the commodity (c). $\bar{M}_{i}^{c}$ and $\bar{M}_{j}^{c}$ are the sample means of the MRL for the commodity c in exporting (i) and importing (j) countries, respectively, σ_{i}^{c} and σ_{j}^{c} are the sample standard deviation of the MRL for commodity c in exporting (i) and importing (j) countries, respectively. The Pearson's correlation coefficient ranges between –1 and 1 and the corresponding distance falls between 0 and 2]. If $S_{ij}^{c} = 0$, then the two compared samples are similar and when $S_{ij}^{c} = 2$ then the two compared samples are dissimilar.They studied how the similarity (or dissimilarity) of the MRL regulations affects the trade of apples and pears and the related products using the gravity equation, and found that in some cases, these regulations impede trade. Melo et al. (2014) incorporate a stringency perception index into the gravity equation for six dimensions of the sanitary and phytosanitary quality related regulations and standards. The index is measured as

$$SPI_{it} = \frac{1}{6} \sum_{n=1}^{6} \gamma_{t}^{n} s_{i}^{n}$$

where γ_{t}^{n} is the progression of the severity of the standard n over time, as described by exporters, with $\gamma_{2009}^{n} = 1$ for all n, and s_{i}^{n} is the simple average of the stringency perceptions of a regulation or standard n of the destination country i. They found a substantially negative effects of stringent regulations and standards on the trade of Chilean fresh fruit exports.

Maximum residue limits

According to Li et al. (2014), the MRL is determined by the institutional, macroeconomic, and political factors of a country. They viewed that the cost of implementing the MRL is much higher than that of the traditional barriers to trade. Therefore, the probability of food safety standards is much higher in countries with a better regulatory quality. Secondly, the socio-demographic conditions, especially in the rural areas of a country, play an important role in the agricultural policy and make it more likely to pass through the creation of food safety standards. Li et al. (2014) used the regulatory quality index (from the World Bank) and the ratio of farm employment over farm land to represent the institutional factor. The competitiveness of agricultural products is determined by the macroeconomic policy of the country. Li et al. (2014) used the real exchange rate of the country as a proxy to replace the macroeconomic policy of it. They used the legislative index of the electoral competitiveness (LIEC) and political stability in the country (the number of years in a democratic or an autocratic status) to represent the political factors.

In the case of China, the regulatory quality was not good in the recent past. The frequent occurrence of crises, especially in the food sector, has compelled the government to take drastic steps in order to streamline the monitoring and implementation of regulations. Second, the economic condition of the country is now getting better year by year. Like other sectors of the economy, the agricultural sector has also shown a tremendous performance and the socio-demographic condition of farm families is far better than in the past. Due to its comparative advantage in labour- intensive commodities, China is among the leading exporters and a major player in the international trading system. The macroeconomic policy of the country also aims to boost the trade flows. The country is governed by the one party system and all the decisions are made and implemented by it. Therefore, in accordance with the determinants set by Li et al. (2014) MRL, China qualifies for the implementation of the MRL.

Currently, after a series of food safety issues, especially the melamine incident in the baby milk formula, China has revised its food safety regulations and adopted a stringent food safety measures. The government has reorganized and renamed the Chinese State Food and Drug Administration (SFDA) into a ministry-level agency known as the China Food and Drug Administration (CFDA). The Ministry of Health is responsible for risk assessment and standard setting. Exports and imports of food products are monitored by the Administration of Quality Supervision, Inspection and Quarantine (AQSIQ). While policing

[3]According to its definition, pesticide includes all substances used to control pests. The Food and Agricultural Organization of the United Nation defines pesticide as:*"any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals*

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Table 3. Maximum residue limits indicator by products and countries for the period 2012–2013

	Apple			Bean			Garlic			Pork		
	2012	2013	diff.	2012	2013	diff.	2012	2013	diff.	2012	2013	diff.
Australia	1.0790	1.1591	0.0801	0.9029	1.8015	0.8986	1.1962	1.9275	0.7313	1.4888	1.5815	0.0927
Canada	0.8710	0.9723	0.1013	0.9257	1.4407	0.5150	1.4000	1.9109	0.5109	1.3057	2.2635	0.9578
China	**0.9139**	**0.9321**	**0.0182**	**0.9257**	**1.4407**	**0.5150**	**1.4000**	**1.9109**	**0.5109**	**1.0163**	**2.7183**	**1.7020**
Codex	*1.0000*	*1.0000*	*0.0000*	*1.0000*	*1.0000*	*0.0000*	*1.0000*	*1.0000*	*0.0000*	*1.0000*	*1.0000*	*0.0000*
EU	1.2393	1.2489	0.0096	0.0000	1.5788	1.5788	0.8273	1.2088	0.3815	1.5155	1.4566	–0.0589
Hong Kong	1.0000	0.8465	–0.1535	1.0000	1.3313	0.3313	1.0000	1.5786	0.5786	1.0408	1.1925	0.1517
India	0.9762	0.9725	–0.0037	1.0041	1.0763	0.0722	1.0000	1.0000	0.0000	1.0412	1.0576	0.0164
Malaysia	0.0000	0.6408	0.6408	0.0000	2.5194	2.5194	0.0000	2.7183	2.7183	1.0498	1.0742	0.0244
Singapore	0.9407	0.9612	0.0205	0.9793	0.8927	–0.0866	0.8182	0.9375	0.1193	1.0737	1.0701	–0.0036
UK	1.2393	1.2489	0.0096	0.0000	1.5788	1.5788	0.8273	1.2088	0.3815	1.5860	1.4566	–0.1294
United States	0.8848	0.9005	0.0157	0.8713	0.8964	0.0251	1.0974	1.0735	–0.0239	1.3116	1.5110	0.1994

diff. = difference

the stakeholders is the responsibility of the Ministry of Public Security. Table 3 delineates that China has either adopted at par or a more stringent food safety regulations than its trading partners.

To estimate the effect of stringent standards using the gravity model, it is important to get the value of the food safety measure, the Maximum Residue Limits (MRLs). There exist science based international food standards, the "Codex Alimentarius" jointly developed by the FAO and the WHO. The Codex Alimentarius sets limits on the pesticide[3] and veterinary drugs residues, and other harmful substances in human food. However, every country has the right to set its own MRLs to protect the consumers' health and the environment rather than protecting producers. In addition, the MRLs vary from country to country and product to product (Drogue and DeMaria 2012). Drogue and DeMaria (2012), Li and Beghin (2014) have developed and used indices for calculating the MRLs. The beauty of using these indices is that they take care of all the pesticides rather than one or two substances.

In this research, we have used the index developed by Li and Beghin[4] (2014) due to its merits over others. Li et al. (2014) have identified three practical merits of Li and Beghin (2014) index. First, the index takes the Codex MRLs as a reference, this provides an information on the scientific grounds that some of the pesticides or veterinary drugs pose greater risks than others. Second, unlike the other indices, the measurement of the MRL stringency increases in the individual MRLs. Third, the MRLs are estimated in the exponential form which articulates the convexity of the complying costs associated with the stringency much beyond the Codex recommendations. This is in accordance with the SPS and TBT agreements to encourage the signatories for the harmonization of the MRLs towards the science-based Codex levels to circumvent the complying cost.

Li and Beghin (2014) use the Codex Alimentarius MRL standards as a reference and consider it a non-protectionist science-based level. Their index is based on the deviation of the country MRLs standards from that of the Codex Alimentarius standards. Therefore, if the MRLs exceed the reference level, they are said to be protectionist or "excessively stringent".

$$LB_j^p = \frac{1}{N_{(p)}}\left(\sum_{n_{(p)}=1}^{N_{(p)}} exp\left(\frac{Cod_{pn_{(p)}} - MRL_{jpn_{(p)}}}{Cod_{pn_{(p)}}}\right)\right)$$

where LB_j^p is the deviation of MRL levels imposed by country j for product p from that of the Codex

causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport."

[4]Detail is provided in Li and Beghin (2014).

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Alimentarius MRL standards. $N_{(p)}$ is the total number of chemicals applied to product p, $Cod_{pn_{(p)}}$ represents the standard MRL level (Codex Alimentarius MRL standards) and $MRL_{jpn_{(p)}}$ is the MRL level imposed by importer j for product p. Therefore, if $LB_j^p = 1$ policy is said to be non-protectionist i.e., on average respective country MRLs stringency is equal to that of Codex, $LB_j^p > 1$ represents protectionist policy as on average respective country MRLs are more stringent than that of Codex while $LB_j^p < 1$ represents anti-protectionism policy i.e., as on average respective country MRLs are less stringent than that of Codex.

This index is robust, i.e., an unintentional protectionist MRL is taken care of by other non-protectionist MRLs. By design, the index is unit-free as long as the respective MRLs are in the same units. The index has the properties of convexity in protectionism, monotonicity in the MRL stringency for the same product, same substance and different countries, *ceteris paribus.* The index is made invariant to the scale, as the difference between the MRLs' of importing country and the Codex is scaled by the codex MRL. The lower the value of the index, the harder it is for the exporting country to meet the requirements. The index is made invariant to the regulation intensity of a country by averaging it with the total number of harmful substances.

The estimated values of Li and Begin indicators by product and country[5] for the year 2013 are provided in Table 3. The highest MRL value for apples is 1.2489 adopted by the EU, beans 2.7183 adopted by China, garlic 2.2262 adopted by China, and pork 2.7183 adopted by China. The MRL indicators make it clear that China has adopted the trade protectionist policy in the case of garlic, bean, and pork, while a non-protectionist policy for the apple trade. The estimated values 2012 show that the highest MRL value for apples is 1.2393 adopted by the EU, beans 1.0041 adopted by India, garlic 1.400 adopted by Canada, and pork 1.5860 adopted by China. The data for both years show that during the two periods, most of the indicators have increased. It means that the countries have adopted a protectionist policy compared to the previous year. The Codex values are used when a particular substance is not regulated between the partners.

The model

Since long[6], the gravity model is estimated linking bilateral trade volume to the economic masses (GDP per capita income) of the trade partners and the geographical distance (transportation cost) between them. Researchers have also used the gravity model to assess the effect of the stringency of the SPS standards on trade flows. Moenius (2006) estimated the gravity model to show the impact of the stringency standards on the bilateral trade flows. Following Otsuki et al. (2001a), Wilson and Otsuki (2003), Moenius (2006), Sun et al. (2014) also estimated the gravity equation to show the effect of food safety standards on trade between the trading partners. Currently, the issue has received much attention of the researchers. Among others, the work of Otsuki et al. (2001a), Yu and Frandsen (2005), Chen et al. (2008), Disdier et al. (2008), Disdier and Marette (2010), Drogue and DeMaria (2012), Xiong and Beghin (2012), Melo et al. (2014), Sun et al. (2014) are the recent attempts estimating gravity model to address the issue of food safety standards and its possible impact on trade.

The gravity model in its generalized form is:

$$X_j^p = f(E, I_j, Re_{ij})$$

where X_j^p represents the export value of product p from China to country j while E, I_j and Re_j, respectively represent exporting country (China), importing country and resistance variables.

The log-linear version of gravity model is:

[5]Detailed list is available upon request.

[6]Isard W. (1954), Ravenstein E.G. (1885). Are among the pioneers who nearly developed the gravity model but a different reflection from Newton's Law of Gravity. However, it is believed that Tinbergen (1962) pioneer to publish empirical application of gravity model followed by Linnemann (1966). Despite its application, till Anderson (1979) the model was operative without solid economic theory. Anderson (1979) assumed a (weakly) separable social utility function with respect to traded and non-traded goods. Deardorff (1995) proves its compatibility with the neoclassical models. Bergstrand (1985, 1989) presented gravity equation in a new dimension by incorporating the price term in it. While, Anderson and van Wincoop (2003) suggested modus operandi to deal with the price term and now their contribution work as a reference.

[7]Like other variables in the gravity equation, the MRLs (LB_{jt}^p in our case) is considered to represent the NTMs affecting the trade flows especially of agricultural products and therefore enters in the gravity equation.

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$$\ln(X_{jt}^{p}) = \beta_0 + \beta_1 \ln(Pr_t^p) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(LB_{jt}^p) + \\ + \beta_4 \ln(Dis_{ij}) + \beta_5(Cont_{ij}) + \beta_6(Lng_{ij}) + \\ + \beta_7(LL_{ij}) + \beta_8(Col_{ij}) + \beta_7(FTA_{ijt}) + \gamma_j + \\ + \gamma_t + \gamma_p + \varepsilon$$

where X_{jt}^{p} is the export value (1000 US \$) of product p from China to country j at time t, Pr_t^p is production quantity (1000 tonnes) of product p in China at time t, GDP_{jt} is per capita GDP (US \$) of country j at time t, LB_{jt}^p is the Li and Beghin indicator of Maximum Residue Limits[7] for product p imposed by country j on exports from China at time t, Dis_{ij} is the geographical distance between the capitals of China i and country j, and $Cont_{ij}$, Lng_{ij}, LL_{ij}, Col_{ij}, and FTA_{itj}, are the dummy variables representing common border, common language, landlocked country, common colony and signatory of free trade agreement, respectively China i and country j. β_i are the coefficients of parameters to be estimated, γ_j country j fixed effect, γ_t year t fixed effect, γ_p product p fixed effect and ε is the error term.

The study uses FTA and importing, year and product fixed effects to account for tariffs. The use of fixed effects (FE) in the gravity equation has been adopted in many studies because of its consistency with economic theory and ease to implement (Head and Mayer 2014) Feenstra (2002) compared the techniques of Anderson and van Wincoop (2003) and incorporated FE for multilateral trade resistance term using trade data between and within Canada and the US. He obtained a more consistent results of the border effects using the FE technique. Haq and Meilke (2009) included the FE to report for the unobserved variables, like the commodity-specific characteristics, domestic and trade related policies, industry-specific border-related hindrances (tariff etc.), prices, technical and nontechnical barriers to trade, and the non-measurable product quality characteristics. The economists have used the FE as a solution to the unobserved heterogeneity. In our case, the FE are also incorporated to account for the unobserved factors specified by Haq and Meilke (2009).

Data

This study aims to show the effects of the stringency of the MRLs adopted by importing countries (Appendix-A) on the China's food exports. Table 1 lists the major food exports of China, but the data are limited only to those products for which the MRLs information are available. These include apples, frozen and fresh pork, garlic, kidney bean, live swine, mandarins and oranges, and tea. The exports data on apples (0808), garlic (0703), kidney bean (0713), live swine (0103), mandarins and orange (0805), pork meat (0203), tea (0902), are compiled at the HS-4 from the United Nations Commodity Trade Statistics Database[8] (UN-Comtrade). The time period covered for the estimation includes only two years i.e., 2012 and 2013. The MRLs data for the year 2013 are estimated by using the equation 1, while the data for the year 2012 are provided by Li and Beghin (2014) upon request. The MRLs data for the year 2013 are extracted from the United States Department of Agriculture – Foreign Agricultural Service[9] (USDA-EPA MRL Database). Production data of various commodities are obtained from the FAOSTAT[10]. The data on per capita GDP are compiled from the World Bank's World Development Indicators[11]. The data required for other gravity variables, like distance, common border, common language, landlocked, and common colony are acquired from the French Research Centre in International Economics (CEPII)[12]. The total sample for this study has 1203 observations, of these 288 are zeros. Some of these zeros may be due to rounding errors or the incompleteness of the trade data, while the others represent zero trade among countries.

Estimation technique

The use of the Ordinary Least Squares (OLSs) is the simplest technique to estimate the gravity equation. However, the OLS estimates suffer from a number of econometric issues like biasness due to the heteroskedasticity, the presence of zeros and the potential sample selection bias because of the non-randomized

[8]http://comtrade.un.org/data/ (accessed on August 4, 2014)
[9]http://www.mrldatabase.com/default.cfm?selectvetdrug=0 (accessed on August 4, 2014)
[10]http://faostat3.fao.org/download/Q/*/E (accessed on August 4, 2014)
[11]http://databank.worldbank.org/data/views/reports/tableview.aspx?isshared=true (accessed on August 4, 2014)
[12]http://www.cepii.fr/CEPII/en/bdd_modele/bdd.asp (accessed on August 6, 2014)

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Table 4. Descriptive statistics

Variable	Mean	Std. Err.	[95% Conf. Interval]	
$\ln(X_{jt}^{p})$	6.096	0.099	5.902	6.291
$\ln(Pr_{t}^{p})$	8.671	0.061	8.552	8.790
$\ln(GDP_{jt})$	13.540	0.053	13.436	13.643
$\ln(LB_{jt}^{p})$	0.088	0.006	0.076	0.100
$\ln(Dis_{ij})$	1.946	0.018	1.911	1.981
$Cont_{ij}$	0.127	0.010	0.107	0.146
Lng_{ij}	0.046	0.006	0.034	0.058
LL_{ij}	0.118	0.010	0.099	0.137
Col_{ij}	0.011	0.003	0.005	0.017
FTA_{ijt}	0.146	0.010	0.126	0.167

Number of observations: 1136

elimination of zeros (Silva and Tenreyro 2006; Burger et al. 2009). Above all, the economic interpretations of the OLS estimates are limited Xiong and Beghin (2012).

To address the inherent issue of heteroskedasticity of the gravity equation, Silva and Tenreyro (2006) use the Poisson Pseudo Maximum Likelihood (PPML) method. The PPML can deal with heteroskedasticity given the equi-dispersion (when the mean of the dependent variable is equal to or less than the variance of occurrences) and fails in the presence of over-dispersion. A Negative Binomial (NB) model is used to correct the over-dispersion of the count data (Burger et al. 2009). It can be considered as a generalization of the Poisson regression, since it has the same mean structure as the Poisson regression and it has an extra parameter to model the over-dispersion. If the conditional distribution of the outcome variable is over-dispersed, the confidence intervals for the Negative Binomial Regression are likely to be narrower as compared to those from the Poisson regression. A likelihood ratio test of Alpha can be used to test whether the NB is preferred over the PPML.

RESULTS AND DISCUSSION

Descriptive statistics and the matrix correlation of the variables in the model are presented, respectively, in Table 4 and 5. Table 5 confirms that there is no significant correlation between the dependent and independent variables column (1), which combined with the sample characteristics of the dataset validates absence of multicolinearity to bias the results.

The dispersion parameter (Likelihood-ratio test of alpha) and the RESET test are used (Table 6) as the selection criteria to choose an estimation method among the OLS, PPML, and NBR, models. The likelihood-ratio chi-square test describes the dispersion of the response variable. The larger value suggests that the response variable is over-dispersed and is not sufficiently described by the simpler PPML distribution, while the RESET test is used to detect the specification of the model. On the basis of these tests, the NBR estimator of the Poisson family is chosen for a further analysis.

Both the random and fixed effects models estimator are analysed to highlight the impact of the MRLs stringency on the selected Chinese food exports. The NBR results for both the random effect and fixed effect are presented in Table 7. Generally, the fixed-effects (FE) models are estimated to study the impact of variables that vary over time. Variables like the business cycles, the business practices of a company, the political system of a country, etc. are exogenous in nature and are fixed within a country

Table 5. Correlation matrix

Variables	$\ln(X_{jt}^{p})$		$\ln(GDP_{jt})$		$\ln(Dis_{ij})$	$Cont_{ij}$	Lng_{ij}	LL_{ij}	Col_{ij}	FTA_{ijt}
$\ln(X_{jt}^{p})$	1.000									
$\ln(Pr_{t}^{p})$	0.024	1.000								
$\ln(GDP_{jt})$	−0.330	−0.019	1.000							
$\ln(LB_{jt}^{p})$	0.046	−0.011	−0.036	1.000						
$\ln(Dis_{ij})$	−0.237	−0.012	0.099	0.013	1.000					
$Cont_{ij}$	0.217	−0.010	−0.115	−0.084	−0.635	1.000				
Lng_{ij}	0.214	−0.071	0.111	−0.062	−0.323	0.271	1.000			
LL_{ij}	−0.103	−0.061	0.031	−0.091	−0.177	0.304	−0.080	1.000		
Col_{ij}	0.017	−0.006	0.082	−0.044	−0.305	0.271	−0.023	0.283	1.000	
FTA_{ijt}	0.254	−0.034	−0.060	−0.089	−0.364	0.322	0.529	−0.105	−0.043	1.000

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Table 6. RESET and Dispersion Tests

	OLS	OLS $(1+X^p_{ijt})$	PPML	NBR
Observations	1001	1136	1136	1136
RESET Test	0.0048	0.000	0.048	0.057
Dispersion				−2.034***(0.19)

and vary across countries. Therefore, the FE models remove the effect of those time-invariant characteristics, so that the net effect of the predictors on trade could be assessed. However, the FE models have high standard errors and assume the correlation between the error term and predictor variables. These will not work well with the data for which the within-cluster variation is low or when the variables change slowly over time. The Random Effects (RE) model assumes that the unobserved variables are uncorrelated with the observed variables. While this assumption may often be wrong but having lower standard errors as compared to the FE and the possibility to estimate the effects for time-invariant variables, the RE model may still be desirable.

Table 7 depicts the estimates of the gravity equation resulting from the NBR with the random effects and fixed effect models. The coefficients of the models are direct elasticity estimates. Globally, the coefficients have the expected signs in accordance with the economic theory. The results of per capita GDP of the importing country, the MRLs, distance, contiguity, common language, and FTA are more interesting.

Table 7. Random- and fixed-effect NBR model

Independent variables	Random-effect model	Fixed-effect model
$\ln(Pr^p_t)$	0.00553 (0.0070)	0.548 (1.21)
$\ln(GDP_{jt})$	−0.105*** (0.0100)	−0.107*** (0.010)
$\ln(LB^p_{jt})$	0.129 (0.067)	0.170* (0.072)
$\ln(Dis_{ij})$	−0.0664* (0.033)	−0.0801* (0.032)
$Cont_{ij}$	0.137** (0.051)	0.139** (0.052)
Lng_{ij}	0.339*** (0.051)	0.348*** (0.055)
LL_{ij}	−0.199** (0.067)	−0.204** (0.067)
Col_{ij}	0.250** (0.088)	0.258** (0.091)
FTA_{ijt}	0.115** (0.043)	0.121** (0.043)
Constant	3.245*** (0.16)	−4.004 (15.8)
Dispersion	−1.974*** (0.19)	−2.034*** (0.19)
Observations	1136	1136
Wald χ^2	424.74***	397.78***

Figures in parentheses are robust standard errors; $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$

The results indicate that the production of the major exporting commodities at home insignificantly affect exports of the selected food products of China. The per capita GDP in the importing country significantly affects the exports suggesting a significant role of the income level in the importing countries for the exports from China.

Results of the fixed effect model (Table 7) show that the exports of the selected commodities are significantly affected by the per capita income of the importing country (–),the maximum residue limits indicator (+), the geographical distance between China and the importing country (–),the common border (+),the common language (+), the fact whether the trading partner is a landlocked country (–), the colonial relationship (+), and the trade agreement between the trading partners (+).

The coefficient of geographical distance between China and importing countries depicts a significant role of the transportation costs in the determination of exports from China under the fixed effect model. These results are re-affirmed by the contiguity (common border) coefficient. The coefficient suggests that sharing a border boost the trade; the exports of the selected commodities are higher to countries sharing a common border with China. Similar results are observed for the common language. Generally, it is believed that the access to seawater appears to be an important determinant for the trade flows as the ocean transportation is cheaper. In this case, the coefficient of the landlocked dummy is negative and significant. It means that the access to seawater plays an important role in determining the exports of the selected commodities. In other words, the trade flows are significantly reduced if the importer is landlocked. Generally, it is believed that the trade is higher between the trading partners who are signatories of a common trade agreement. This is also true in this case, as the coefficient of the free trade agreement has a significant role in determining the volume of exports of the selected food products from China.

The main aim of the article is to show the response of the MRLs adopted by importing countries on exports of the selected food commodities from China. According to the results obtained by estimating the fixed effect model, the Maximum Residue Limits imposed by importing countries significantly increase the exports of the selected commodities (+0.170). The coefficient explains that keeping all the other variables

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constant, imposing the regulatory level at 100 percent by the importing countries enhance export volume of the selected agrifood exports from China by almost 17 percent. This shows a trade enhancing effect of the MRL stringency on exports of the selected commodities from China. Our findings are in contrast to the findings of Chen et al. (2008), Jongwanich (2009), Bao and Qiu (2012), Drogue and DeMaria (2012), Li and Beghin (2012), Melo et al. (2014). All these studies conclude that the food safety standards imposed by importing countries (especially the developed ones) have a trade impeding effect on agricultural exports from developing countries. This trade enhancing impact may be due to the current government policies to put a cut on the food safety issues and to ensure safe food for all. The MRL indicators support the statement, Table 3 shows that the MRL indicators for all the selected products (except apples which is almost at par with the Codex value) is greater than that of the Codex ($L_{ij} > 1$) i.e., the country has adopted a protectionist policy. According to Disdier and Marette (2010), the stringent regulations lead to an increase in the domestic as well as international welfare. This is also applicable in our case as the consumers (both domestic and international) have access to safe and healthy food. Beside this, adopting stringent regulations at home may also have a significant effect on the environment as China is the leading producer and exporter of many agrifood products to a number of countries (Table 1 and Table 2).

Robustness checks

To check the robustness of results presented as Appendix C, the gravity equation is estimated using the Heckman selection model and replacing the Li and Beghin indicator (with the MRL of importing countries and with the Euclidian distance between China and the importing country MRL, using the NBR technique with fixed effects.

The Heckman sample selection model is considered theoretically sound and econometrically reliable to estimate the gravity equation in the presence of zero observations. However, the performance of the Heckman maximum likelihood model depends on the exclusion of true variable (Martin and Pham 2008; Burger et al. 2009). In addition, despite its wide application in estimating the gravity equation, the Heckman model does not control the heteroscedasticity, which is common with the trade data (Silva and Tenreyro 2006; Flam and Nordström 2011). The Heckman model is estimated by dropping colony in the outcome equation. In the second case, the equation is estimated by replacing the Li and Beghin indicator with the MRL imposed by the importing countries to check exports of the selected Chinese products, while the Li and Beghin indicator is replaced with the Euclidian distance between the MRL regulations implemented by China and its trading partners in third case. In all the three cases, all the variables carry the same signs and level of significance except the Heckman selection model, wherein only the Li and Beghin indicator and the distance are insignificant.

CONCLUSION

This study estimates the trade effect of the MRLs as a NTM imposed by the importing countries on major food exports of China. The gravity equation is estimated using different estimators and the Negative Binomial model is selected for its superiority over others in this case. The Li and Beghin index shows that China has adopted a protectionist policy as the values of the index for all the selected products (except apples, for which is almost at par with the Codex value) are greater than that of the Codex. According to Disdier and Marette (2010), stringent regulations lead to an increase in the domestic as well as international welfare. This is also applicable in this case as results of the trade effects of the MRL regulations show that the MRLs imposed by the importing countries have a trade enhancing effect on the exports of the selected food commodities from China. Similarly, adopting stringent regulations may also help in smoothening the exports from China as the consumers will find the product safe and save the search cost of the importers for a certain minimum expectations for a particular commodity. This study is based on the two years data covering the selected food products because of the inability of the researchers to access the MRL values for more years. Therefore, a further research along this line covering a wider range of products over a longer period of time is highly suggested for a better understanding of the trade effects of the NTMs and to generalize the findings. In addition, a study based on a homogenous group of products across the level of the development of economies is also suggested to explore the trade effects of the NTMs on the basis of commodity groups and the level of development of the trading partners.

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Appendix A. List of importing countries

Afghanistan	Cuba	Indonesia	Mongolia	Slovakia
Albania	Cura Cao	Iran	Montenegro	Slovenia
Algeria	Cyprus	Iraq	Morocco	Solomon Isds
Angola	Czech Rep.	Ireland	Mozambique	Somalia
Antigua and Barbuda	Denmark	Israel	Myanmar	South Africa
Argentina	Djibouti	Italy	Namibia	South Sudan
Armenia	Dominica	Jamaica	Nepal	Spain
Australia	Dominican Rep.	Japan	Netherlands	Sri Lanka
Austria	Ecuador	Jordan	New Caledonia	Sudan
Azerbaijan	Egypt	Kazakhstan	New Zealand	Suriname
Bahamas	El Salvador	Kenya	Nicaragua	Swaziland
Bahrain	Equatorial Guinea	Kiribati	Niger	Sweden
Bangladesh	Eritrea	Korea, DPR	Nigeria	Switzerland
Barbados	Estonia	Korea, Rep.	Norway	Syria
Belarus	Ethiopia	Kuwait	Oceania, nes	Taiwan
Belgium	Fiji	Kyrgyzstan	Oman	Tajikistan
Belize	Finland	Lao P	Pakistan	Tanzania, UR
Benin	Fmr Sudan	Latvia	Palau	Thailand
Bolivia	Fr. Polynesia	Lebanon	Palestine	Timor-Leste
Bosnia Herzegovina	France	Liberia	Panama	Togo
Botswana	Gabon	Libya	Papua New Guinea	Tonga
Brazil	Gambia	Lithuania	Paraguay	Trinidad and Tobago
Brunei Darussalam	Georgia	Luxembourg	Peru	Tunisia
Bulgaria	Germany	Macao	Philippines	Turkey
Burkina Faso	Ghana	Macedonia, TFYR	Poland	Turkmenistan
Cabo Verde	Gibraltar	Madagascar	Portugal	UAE
Cambodia	Greece	Malawi	Qatar	Uganda
Cameroon	Grenada	Malaysia	Romania	UK
Canada	Guatemala	Maldives	Russian Federation	Ukraine
Chad	Guinea	Mali	Saint Lucia	Uruguay
Chile	Guinea Bissau	Malta	Samoa	USA
Colombia	Guyana	Marshall Isds	Sao Tome and Principe	Uzbekistan
Comoros	Haiti	Mauritania	Saudi Arabia	Vanuatu
Congo	Honduras	Mauritius	Senegal	Venezuela
Congo, DR	Hong Kong	Mayotte	Serbia	Viet Nam
Costa Rica	Hungary	Mexico	Seychelles	Yemen
Cote d'Ivoire	Iceland	Micronesia, FS	Sierra Leone	Zambia
Croatia	India	Moldova, Rep.	Singapore	Zimbabwe

Appendix B-I. Random-effect estimates

Variables	OLS	OLS	PPML
$\ln(Pr_t^p)$	–0.000802 (0.035)	0.0418 (0.043)	0.00643 (0.0068)
$\ln(GDP_{jt})$	–0.556*** (0.051)	–0.601*** (0.055)	–0.100*** (0.0093)
$\ln(LB_{jt}^p)$	0.568 (0.33)	0.822* (0.42)	0.140* (0.065)
$\ln(Dis_{ij})$	–0.200 (0.19)	–0.408 (0.22)	–0.0690* (0.032)

Appendix B-II. Fixed-effect estimates

Variables	OLS	OLS	PPML
$\ln(Pr_t^p)$	1.439 (5.52)	3.044 (6.85)	0.516 (1.17)
$\ln(GDP_{jt})$	–0.568*** (0.053)	–0.605*** (0.056)	–0.100*** (0.0096)
$\ln(LB_{jt}^p)$	0.659 (0.36)	1.054* (0.44)	0.174** (0.068)
$\ln(Dis_{ij})$	–0.275 (0.19)	–0.511* (0.22)	–0.0831** (0.031)

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Continued table Appendix B-I.

Variables	OLS	OLS	PPML
$Cont_{ij}$	0.728* (0.32)	0.925* (0.37)	0.111* (0.049)
Lng_{ij}	1.940*** (0.35)	2.341*** (0.39)	0.335*** (0.049)
LL_{ij}	–0.659* (0.29)	–1.210*** (0.33)	–0.187** (0.065)
Col_{ij}	0.430 (0.49)	1.250* (0.56)	0.250** (0.091)
FTA_{ijt}	0.764** (0.25)	0.900** (0.30)	0.126** (0.042)
Constant	14.49*** (0.87)	14.37*** (0.96)	3.172*** (0.15)
Observations	1001	1136	1136
F test	37.71***	49.45***	
Wald χ^2			457.99***

Figures in parentheses are robust standard errors; $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$

Continued table Appendix B-II.

Variables	OLS	OLS	PPML
$Cont_{ij}$	0.718* (0.32)	0.923* (0.37)	0.113* (0.049)
Lng_{ij}	1.948*** (0.37)	2.385*** (0.41)	0.337*** (0.052)
LL_{ij}	–0.616* (0.30)	–1.248*** (0.33)	–0.193** (0.065)
Col_{ij}	0.418 (0.53)	1.347* (0.57)	0.256** (0.090)
FTA_{ijt}	0.796** (0.25)	0.919** (0.30)	0.129** (0.042)
Constant	–4.231 (71.9)	–26.09 (89.5)	–3.640 (15.3)
Observations	1001	1136	1136
F test	21.40***	27.80***	
Wald χ^2			440.03***

Figures in parentheses are robust standard errors; $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$

Appendix C. Robustness check using Heckman selection model, importing country's MRL, and Euclidian distance

Variables	Heckman selection model		Importing country MRL	Euclidian distance
	selection equation	outcome equation		
$\ln(Pr_t^p)$	0.00227 (0.024)	1.543 (4.91)	0.484 (1.21)	0.239 (1.25)
$\ln(GDP_{jt})$	–0.142*** (0.028)	–0.507*** (0.056)	–0.108*** (0.010)	–0.108*** (0.010)
$\ln(LB_{jt}^p)$	–0.0952 (0.21)	0.310 (0.39)		
$\ln(MRL_{jt}^p)$			0.0921* (0.046)	
$\ln(ED_{jt}^p)$				0.0280** (0.0071)
$\ln(Dis_{ij})$	–0.128 (0.11)	–0.106 (0.19)	–0.0801* (0.032)	–0.0820* (0.032)
$Cont_{ij}$	0.408 (0.25)	0.599 (0.33)	0.138** (0.052)	0.135** (0.052)
Lng_{ij}	2.883*** (0.64)	1.668*** (0.37)	0.349*** (0.055)	0.344*** (0.055)
LL_{ij}	–0.345 (0.19)	–0.276 (0.33)	–0.206** (0.067)	–0.215** (0.068)
Col_{ij}	2.414*** (0.70)		0.257** (0.091)	0.251** (0.091)
FTA_{ijt}	–0.0184 (0.16)	0.658* (0.27)	0.118** (0.043)	0.111** (0.043)
Constant	3.355*** (0.48)	–6.199 (64.0)	–3.255 (15.8)	0.0639 (16.3)
Observations		1016	1016	1016
Wald χ^2		209.07***	399.42***	400.36***
LR test		49.95***		

Figures in parentheses are robust standard errors; $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$

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