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The Economic Impact of SPS Measures on Agricultural Exports to China: An Empirical Analysis Using the PPML Method

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Abstract: Since China first joined the World Trade Organization (WTO) in 2001, many countries around the world have sought to capitalize on lower tariff rates and China's increasing demand for high quality agricultural products. However, as competitive pressures in its agricultural sector have intensified, the Chinese government has implemented other forms of protectionist measures. Known as non-tariff measures (NTMs), these policy initiatives have added another dimension to international trade activities that needs to be better understood. Using a set of variables clearly identified in academic literature, our paper analyzes the effect that sanitary and phytosanitary measures (SPS) have on New Zealand, U.S., Korean, and Japanese agricultural exports to China. To measure the effect that NTMs have on exports, we use an adapted version of the gravity model and the Poisson pseudo maximum likelihood method. The key findings from the empirical projection show that Chinese SPS measures have a negative, albeit insignificant effect on the sample as a whole. However, when looking at the individual countries, the SPS measures were seen to have a negative effect on Japan and the U.S., while from a Korean perspective, their impact was positive and significant. As part of a secondary analysis, it was interesting to note that the SPS measures had a positive effect on New Zealand's exports before its free trade agreements (FTA) with China came into force. However, in the years since then, they were seen to have a negative impact.

Keywords: non-tariff barriers; sanitary and phytosanitary measures; China; agricultural exports; international trade

1. Introduction

Since joining the World Trade Organization (WTO) in 2001, China has grown to be a true global leader in the field of international trade. With a rapidly growing economy and a burgeoning middle class, international business has embraced the unbounded economic potential that China represents. In the field of agriculture, countries such as New Zealand, South Korea, Japan and the U.S. have been very active in utilizing the competitive advantages they may have to capture better market share opportunities. In a period of trade liberalization and lower tariff levels due to cyclical rounds of bilateral and multilateral trade negotiations, these countries have been able to successfully increase their trading activities with the Asian powerhouse. However, in response to these developments, the

Chinese government, whilst supporting a more open trade liberalization agenda,[1] has implemented an increasing number of alternative protectionist measures.[2] Known as non-tariff measures (NTMs) or non-tariff barriers (NTBs) as they are otherwise known, these policy initiatives have sought to protect Chinese domestic agricultural producers from the competitive pressures associated with increased import competition (see Appendix A Table A1).[3]

In the agricultural sector, the primary form of NTB used by China and other governments around the world are sanitary and phytosanitary measures (SPS). These policy initiatives set out the basic rules and requirements for food safety and animal and plant health standards and many other diverse conditions such as import licenses, inspection requirements, testing and certification requirements, labeling and packaging requirements and quarantines.[4] Driven by an increase in consumer demand for safe and high quality agricultural products, these SPS measures play a critical role in determining one's ability to access export markets (see Table 1). According to WTO rules, WTO members are authorized by the WTO Technical Barriers to Trade and Sanitary and Phytosanitary Measures (TBT/SPS).

Agreement to implement a range of protective measures that endeavor to protect human, animal and plant health, as well as a myriad of environment, wildlife and human safety factors. However, from a trade perspective, one of the most important aspects of SPS measures is their potential distortionary effect, as these requirements are generally applied in a nondiscriminatory manner as they usually target products regardless of their origin.

The distortionary and trade-restrictive effects of SPS measures are among the most important reasons why SPS measures are increasingly addressed in trade agreements. At the multilateral level, these policy initiatives are governed by the broad guidelines set in the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement). The fundamental tenet of the SPS Agreement is the principle of non-discrimination, of which SPS measures should only be applied so as to limit any unnecessary international trade distortions. In addition to this, the restrictive effects of SPS measures are also increasingly addressed in regional and bilateral trade agreements. However, the actual ability for these agreements to remove the distortionary effects of the SPS requirements is debatable. Our study hopes to shed light on the problem by examining countries that have varying types of economic and political relationships with China. In this instance, New Zealand was selected as it was the first country with which China completed an FTA. Korea and Japan are China's two most significant East Asian trading partners, both of which have experienced complex and at times difficult relationships. While the U.S. as the leading global hegemonic power represents not only China's strongest political and economic adversary, but also its largest overall trading partner with bilateral trade equaling an estimated $659.4 billion in 2015.[5]

By incorporating a gravity model and the Poisson pseudo maximum likelihood (PPML) methodology within the confines of our analysis, this study empirically assesses the potential impact that SPS measures have on agricultural exports (Harmonized System (HS) Codes 01–24) from Japan, South Korea, New Zealand and the United States to China. In contrast to previous empirical studies that have tended to use GDP as an explanatory variable for trade flows, this study embraces the

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1 As of 18 July 2016, China has signed 11 free trade agreements (FTA). In regards to the countries included in this study, two FTAs have been signed and enforced. The China-New Zealand FTA was signed on 7 April 2008 and came into force on 1 October 2008; while the China-South South Korea FTA was signed on 1 June 2015 and came into effect on 20 December 2015 (WTO).

2 China's weighted mean applied tariff has fallen from 14.1 percent in 2002 to 3.21 percent in 2014 (World Bank). The change trend of Non-tariff measures (NTMs) imposed by China is floating up and down. With 338 notifications in 2009, 344 in 2010, 276 in 2011, 285 in 2015, these mark the years with the most notifications.

3 According to the data obtained from the WTO I-TIP (World Trade Organization Integrated-Trade Intelligence Portal) in 2015, China is the fourth most active country in terms of its implementation of NTB measure notifications.

4 For example, in the area of food safety, China currently bans imports of pork containing any residue of ractopamine, an animal drug approved for use in feed that promotes feed efficiency in pigs and certain other livestock. The use of such a measure has created difficulties for many agricultural exporters, in particular the U.S., which is currently looking at ways to overcome the issue (USTR 2014).

5 Trade statistics were obtained from the United States Trade Representative website (USTR 2017).

mechanism of supply and demand by using the disaggregated data that are associated with China's imports and its targeted countries' exports at the HS 2-digit level. In addition, our analysis also calculates the SPS coverage ratios and frequency indexes from the HS 4-digit level, so that we are able to clearly identify the impacts that China's NTB policy framework has on agricultural exports. Given the significance of the Chinese market to each of the countries included and the range of findings gathered from previous empirical analyses, this study marks an important step forward in our understanding of how SPS measures impact agricultural exports.

The rest of the study is organized as follows. Related key studies and associated literature are reviewed in Section 2. This is followed by a detailed examination of the empirical framework and data used in the study in Section 3. In Section 4, we present the data and estimation results of our gravity model using the PPML method; some important policy implications are also discussed. While an overview of the key issues and some concluding remarks are offered in Section 5.

2. Literature Review

In recent times, the gradual and continuous collapsing of global tariff levels due to multilateral, regional and bilateral trade negotiations and agreements has brought to prominence the importance and relevance of the use of NTB measures in regulating international trade (Fugazza 2013; Moise and Le Bris 2013; Kareem 2014). In conjunction with this, changes in tastes and preferences in importing countries, as well as the need to keep the environment safe, especially in developed markets, have contributed to a rising trend in the demand for SPS measures for quality agricultural products. As such, between 1996 and 2015, the global average tariff rate (simple average rates) for agricultural products fell from 14.6% to 8.8%,[6] while the total number of SPS notifications (all types of notifications) across the world for agricultural products (HS Codes 01–24) increased considerably, from 136 in 1996 to 1199 in 2014.[7] Increases in SPS measure usage also reflect the fact that when markets fail to provide adequate health and safety mechanisms, governments have turned to alternative trade policy initiatives as a means of appeasing the concerns of highly educated consumers (Roberts et al. 1999). As a result of these developments, many scholars have switched their focus to address the impact of NTBs on international trade, particularly SPS measures. In this instance, studies by Beghin and Bureau (2001), Ganslandt and Markusen (2001), Ferrantino (2006), Korinek et al. (2008), Ardakani et al. (2009), and Fugazza (2013) provide a comprehensive overview of the key economic issues that relate to the modelling and measurement of NTBs.

An analysis of the NTB literature shows that quantification techniques can be broadly grouped as being either ex-post approaches, which predominantly use gravity-based econometric models to estimate the observed impact of NTBs on trade levels, or ex-ante methods that provide simulations of tariff equivalents that predict unobserved welfare impacts. From an ex-post perspective, empirical studies have shown NTBs to have a range of impacts on exports. Furthermore, the standards and technical regulations are often portrayed as protectionist, with empirical evidence to suggest that SPS measures act as a barrier to trade by restricting competition in the local economy and increasing costs to foreign suppliers. However, the literature identifies a range of conclusions that highlight both the beneficial and trade repressing effects of the policy requirements.

At the center of recent research has been the impact that NTB measures have on developing countries. In this regard, developing country exports have been found to be more susceptible to influence by SPS measures than countries with more developed economies (Chemnitz et al. 2007; Otsuki et al. 2001). Maskus et al. (2005), while using firm-level data generated from 16 developing countries, showed that exporters encounter significant additional costs when trying to adapt their production processes to comply with foreign regulatory measures. Maskus et al. (2005) argue

[6] Estimations based on World Bank data (World Bank 2017a).
[7] Estimations based on WTO I-TIP database (WTO I-TIP 2017).

that these costs stem from developing countries' lack of administrative, technical and scientific capacities to comply with foreign standards; while Disdier et al. (2008), in analyzing the distortionary effects that result from SPS measures applied by the Organization for Economic Co-Operation and Development (OECD) members on their agricultural exports, found that SPS measures significantly reduce developing countries' exports to OECD countries, while not affecting trade between OECD members. More recently, Hoda et al. (2016) showed that from a firm perspective, the SPS measures imposed on Egyptian exports have a negative impact on the probability of exporting new products to a new destination. These results have implications for developing countries' export earnings and incomes. They also affect their quest to achieve more sustainable means of development through reducing poverty, unemployment and reliance on smallholder producers (Kareem 2014).

As the findings suggest, developing countries are constrained in their ability to export agricultural and food products to developed countries by SPS requirements. This helps to demonstrate the fact that developed countries normally apply tougher SPS measures than developing countries and that the SPS control mechanisms established in most developing countries are ineffective and overly fragmented. Furthermore, in certain situations, the stipulated SPS requirements are incompatible with the prevailing systems of production that exist in developing countries. As a consequence, wholesale governmental and organizational change may be necessary in order to comply with the relevant measures. However, a particularly acute problem that must be overcome is access to appropriate scientific and technical expertise. Indeed, in many developing countries, knowledge of SPS issues is poor, both within government and the food supply chain, which may mean that the skills needed to accurately assess the measures are also are lacking.

Despite much research stating otherwise, it is also important to note that SPS measures may provide benefits, not just to domestic consumers, but also for foreign suppliers (Ganslandt and Markusen 2001; Van der Meer 2014). For example, if a standard certifies a product as being safe, healthy, of a certain quality standard, etc., it can help to raise consumer demand for the import, which could possibly result in increased profits for foreign firms, in spite of the higher costs they may initially face. Studies by Jaffee (2003), Maertens and Swinnen (2009) and Henson and Humphrey (2010) have concluded that because demand for quality products has increased, SPS regulations have forced producers/exporters to invest in product upgrading, which has ultimately enhanced their ability to gain greater market access for their agricultural products. These findings suggest that although they may initially face some compliance costs, in the long run, exporters are able to stabilize these costs and thereby improve their export levels to overseas markets. However, in reality, there are many standard requirements that an exporter must meet before a product can access any given market. In most instances where the SPS measures were found to increase trade levels, a single standard requirement was often used as part of their analysis. In this instance, Liu and Yue (2012) use the Hazard Analysis Critical Control Point (HACCP) to investigate the EU orange trade; Otsuki et al. (2001) quantify the impact of EU aflatoxins on African exports of cereals, dried fruits and nuts; Chen et al. (2008) investigate the effects of the maximum residue limit (MRL) standards on China's exports of vegetables (chlorpyrifos MRL) and aquatic products (oxytetracycline MRL); while Xiong and Beghin (2012) study the tightening of the EU maximum residue limit on aflatoxins on Africa's exports of groundnuts in 2002.

The conflicting empirical viewpoints identified in the literature make it imperative that more analysis is conducted so as to provide a more conclusive documentation of the impact of SPS measures on trade levels. There predominantly developing country focus also facilitates the need for further analysis. As such, we have sought to examine the impact that SPS measures have on Japanese, Korean, New Zealand and U.S. agricultural exports to China. Given China's global economic prowess and enthusiastic use of such measures, an analysis of this kind provides much appeal. It also helps to establish a benchmark and reference point from which we can compare the before and after effects of the New Zealand-China FTA, as well as providing a means of also assessing the South Korea-China FTA in the future.

3. Empirical Framework and Data

In this section, we detail our use of an adapted gravity model (instead of GDP, we use disaggregated export data) to examine the trade effects of SPS measures on New Zealand, U.S., South Korean and Japanese agricultural exports to China.

3.1. Basic Empirical Model

Changes in the nature of standards and regulations across countries and time means that quantifying the effects of NTBs on trade performance can be a difficult task (Devadason and Chennayah 2014). In order to provide the most effective means of estimation, a number of studies have used the frequency index and coverage ratio to measure the restrictiveness of trade or the severity of NTBs (Bao and Qiu 2010; Choi et al. 2015; Devadason and Chennayah 2014; Disdier et al. 2008; Fontagne et al. 2005; Hoda et al. 2016) instead of a particular standard or regulation. Given their respective advantages and disadvantages, for robustness, we adopt both the frequency index and coverage ratio measures as part of our empirical analysis. For the purpose of this study, the adapted version of the Gravity estimation model is as follows:

$$\text{lnEXPC}_{it}^{j} = \alpha + \beta_1 lnEXS_{it}^{j} + \beta_2 lnIMDC_{it}^{j} + \beta_3 lnTNTM_{it}^{j} + \beta_4 lnZ_{it} + \beta_5 Year_t + \beta_6 Exporter_i + \varepsilon_{it}^{j} \quad (1)$$

j = product category j of HS 2-digit level, from HS 01–24,
so $j = 1, 2, \ldots, 24$;
t is year from 2002–2014;
i represents the countries (Japan, South Korea, New Zealand, United States) used in the study;
$EXPC$ represents New Zealand, U.S., South Korean and Japanese agricultural exports to China;
EXS is defined as the export supply from the target country;
$IMDC$ refers to Chinese demand;
$TNTM$ represents the Tariff and Non-Tariff Measures Imposed by China;
Z represents other related variables;
Year is a year dummy to capture year fixed effects, while $Exporter$ represents the dummy variable for an exporter country so as to capture the fixed effects of the exporter.
Finally ε_{it}^{j} is the error term.

However, if i country's export value for product category j is in fact zero, the use of a logarithm effectively drops such observations from the sample. As there are 58 zero observations in our sample, by dropping an export value of zero may mean that potentially useful information is removed. Such an instance may reflect the fact that the target country does not export products to China because of the strict SPS measures or its distance from China. Given the extent to which the probability of selection is correlated with SPS measures or distance, there is also the potential for bias to exist within the Ordinary Least Squares (OLS) estimations. In an effort to overcome these potential influences, our empirical study utilizes the pseudo Poisson maximum likelihood (PPML) estimation methodology. As documented in Santos Silva and Tenreyro (2006; 2011), the PPML method allows us to deal with any serious heteroscedasticity problems that may arise, as well as providing an econometric solution to the zero value of dependent variables present in data. The mixture of variables in levels and log levels are due to the PPML methodology.[8]

3.2. Independent Variables

In this sub-section, we define and explain the independent variables used in our empirical analysis.

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[8] The PPML estimation procedure converts (1) into the following form:

$$\text{E}(\text{EXPC}_{i,\,t}^{j}|\text{X}_{it}) = \exp\left(\alpha + \beta_1 lnEXS_{it}^{j} + \beta_2 lnIMDC_{it}^{j} + \beta_3 lnTNTM_{it}^{j} + \beta_4 lnZ_{it} + \beta_5 Year_t + \beta_6 Exporter_i\right),$$

here X represents the explanatory variables.

3.2.1. Export Supply (EXS_{it}^{j})

Export supply is defined as the total value of exports from the target country[9] (New Zealand, the U.S., South Korea or Japan) of product j to the world in year t excluding China. In this instance, we calculate the variable using data (country-specific total exports, as well as country-specific exports to China) obtained from the South Korea International Trade Association (KITA 2017). The information obtained represents each individual country's supply of exports (HS codes 01–24) to the world. It is expected that if the targeted country's exports have a comparative advantage, then there will be an increase in both their total global exports and their exports to China.

3.2.2. Chinese Demand ($IMDC_{it}^{j}$)

Chinese demand refers to the value of China's total global imports of product j in year t excluding those from the target country i. The variable is calculated using data (China's total imports and China's imports from the respective trading partners included in the study) obtained from KITA. This variable represents China's total global demand (HS codes 01–24) for imports. With improvements in the living standards of its residents, their demand for imports is rising, and as a consequence, its target trading partners will also export more in order to meet these higher levels of consumer demand.

3.2.3. Tariff and Non-Tariff Measures Imposed by China ($TNTM_{it}^{j}$)

$TNTM_{it}^{j}$ denotes the tariff and non-tariff measures imposed by China on product j at year t using data obtained from the World Bank and WTO Integrated Database. This field of enquiry represents three variables that measure the effect that tariffs and non-tariff measure (SPS) may have on a target country's specific exports to China. In order to assess this, we use the applied average weighted primary products tariff to measure any potential effect the tariffs may have, and as such, we expect that an increase in tariff levels should lead to a reduction in exports from the target country. In this instance, SPS requirements are measured by way of a coverage ratio and a frequency index and are defined as *SPSC* (calculated using a coverage ratio) and *SPSF* (calculated using a frequency index). Since most of China's notifications are interpreted at the HS 4-digit level, the SPS coverage ratios and frequency indexes are calculated at the HS 4-digit level (203 products × 4 countries) for the period from 2002–2014. Once this is done, they are then aggregated according to the HS 2-digit level format.

First, the coverage ratio measures the percentage of trade value subjected to SPS measures for the target country's agricultural products (HS codes 01–24). In formal terms, the coverage ratio of product category j at the year of t is given by:

$$CR_{jt} = \left[\frac{\sum D_{xt} V_{xt}}{\sum V_{xt}}\right] \times 100 \tag{2}$$

x = product item x of HS 4-digit level; $i = 1, 2, \ldots, 203$)
j = product category j of HS 2-digit level; $j = 1, 2, \ldots, 24$;
t = 2002–2014.

Here, x represents a particular product item at the HS 4-digit level, which is contained in product category j at the HS 2-digit level. If an SPS measure is applied to product x for year t, the dummy variable D_{xt} takes the value of one or zero; while V_{xt} is the value of a target country's exports in product i; of course, the sum of V_{xt} ($\sum V_{xt}$) is also the export value of product category j at year t.

Despite its advantages, there are however some problems associated with the coverage ratio that require discussion. The confusing nature of the ratio is an issue, as a higher coverage ratio may mean the relative value of the affected products is higher, which can be interpreted as the SPS becoming more

[9] For the purposes of this research, target country refers to either New Zealand, the U.S., South Korea or Japan.

restrictive and having a greater effect on the trade; however, it can also be interpreted as SPS having a weaker impact on trade flows since the relative value of the affected products is higher. However, if the coverage ratio is lower, the relative value of the affected products is also smaller, which can be caused by an SPS measure that is either more or less restrictive. At the extreme, if the SPS has a very restrictive effect on product x, then the consequent trade flows on product x would be zero. Thus, the size of the coverage ratio does not accurately reflect the restrictiveness of a SPS requirement very well. In addition to this, the coverage ratio can also expose the dependent variable to endogeneity problems, which can be overcome by using frequency index.

The frequency index only accounts for the presence or absence of an SPS measure for a particular product. It shows the percentage of import transactions affected by an SPS requirement. The frequency index of product category j at the year of t is computed as:

$$FI_{jt} = \left[\frac{\sum D_{xt} M_{xt}}{\sum M_{it}}\right] \times 100 \quad (3)$$

i = product item i of HS 4-digit level; i = 1, 2, . . . , 203;
j = product category j of HS 2-digit level; j = 1, 2, . . . , 24;
t = 2002–2014.

Here, x is a product item defined at the HS 4-digit level which is contained in product category j at the HS 2-digit level; D_{xt} is defined in the same manner as Equation (2); and M_{xt} is also a dummy variable, which is equal to one if there is an import of product x or zero if no import value exists.

The coverage ratio and frequency index is used to measure the restrictiveness of trade measures. Their respective values both range from between zero and 100; however, as they interpret the restrictiveness of trade measures from different perspectives, the ways in which the coverage ratio (in terms of depth) and the frequency index (in terms of range) are calculated is different. For example, in regards to HS01 (i.e., live animals), there are six product categories at the four-digit HS code level (i.e., HS0101 (live horses, asses, mules and hinnies.), HS0102 (live bovine animals), HS0103 (live swine), HS0104 (live sheep and goats), HS0105 (live poultry, that is to say, fowls of the species *Gallus domesticus*, ducks, geese, turkeys and guinea fowls), and HS0106 (other live animals)). Of these, only four product items (HS0101, HS0103, HS0105, HS0106) have export value data, and one of them (i.e., HS0105) is covered by an SPS measure. Hence, the corresponding SPS frequency index for HS01 is equal to 25% (i.e., one of the four product categories contains an SPS measure), while HS01's SPS coverage ratio is equal to 15.5% (because the export value for HS0105 is $428,000 USD, while the value of HS01 is $2,761,000, so the coverage ratio is 428,000/2,761,000 = 15.5%).

To show the depth and range of restrictiveness in a simplistic manner, we calculated the coverage ratios and frequency indexes of the products affected by SPS measures at the HS 2-digit level (24 products) for the 2002–2014 period (see Table 1).

In this instance, the method of calculation used is the same as that of the HS 4-digit level calculation. In Equation (4) CR_t represents the depth of restrictiveness at the year of t, while in Equation (5), FI_t represents the range of restrictiveness at year t. If an SPS requirement is applied to product category j at year t, the dummy variable D_{jt} takes the value of one or zero if there is no measure present; V_{jt} is the value of a target country's exports in product category j, while the sum of V_{jt} ($\sum V_{jt}$) refers to the total target country's export value to China for the year t. Finally, M_{jt} is also a dummy variable, which is equal to one if there are imports for product category j or zero if there are none.

$$CR_t = \left[\frac{\sum D_{jt} V_{jt}}{\sum V_{jt}}\right] \times 100 \quad (4)$$

$$FI_t = \left[\frac{\sum D_{jt} M_{jt}}{\sum M_{jt}}\right] \times 100 \quad (5)$$

j = 1, 2, . . . , 24; t = 2002–2014.

Table 1. The impact of Chinese Sanitary and Phytosanitary Measures (SPS) measures on agricultural exports.

Year	Frequency Index	Coverage Ratio			
		Japan	South Korea	New Zealand	United States
2002	50.00%	50.65%	47.52%	75.39%	28.51%
2003	37.50%	56.36%	41.61%	85.71%	15.68%
2004	62.50%	95.42%	87.78%	73.38%	95.13%
2005	12.50%	2.80%	6.05%	5.64%	2.51%
2006	8.33%	4.44%	8.74%	0.30%	0.50%
2007	4.17%	0.88%	0.45%	0.00%	0.24%
2008	75.00%	93.78%	90.53%	90.16%	97.05%
2009	20.83%	17.81%	37.09%	70.45%	84.57%
2010	29.17%	74.33%	47.63%	82.19%	82.81%
2011	58.33%	81.66%	86.34%	88.35%	89.46%
2012	20.83%	8.37%	8.11%	3.52%	78.03%
2013	33.33%	26.66%	36.93%	81.31%	5.50%
2014	54.17%	92.45%	89.95%	13.13%	75.60%
Average	35.90%	46.59%	45.29%	51.50%	50.43%

Note: Figures represent the percentage of agricultural products at the HS Code 2-digit level; source: author's calculations using the data obtained from South Korea International Trade Association (KITA) and World Trade Organization (WTO) Integrated-Trade Intelligence Portal (I-TIP) database.

3.2.4. Other Related Variables (Z_{it})

Z_{it} represents several explanatory variables that appear in related gravity models. For the *DIST* variable (the distance between the capital of a particular target country and Beijing, China), it is assumed that the greater the distance a trading partner is from China, the more negative its effect would be on the trading partner's exports to China. For the Linder effect variable (*Linder*, the difference in real GDP per capita between China and a particular target country), we assume that the closer the GDP per capita is between the two countries, the higher the level of trade flow; for the real exchange rate *RER* for the Chinese yuan vis-à-vis a particular target country's currency, it is assumed that an increase in *RER* represents a depreciation in the value of a target country's currency, which makes their exports cheaper and more attractive in the eyes of Chinese consumers. In the case of the *Internet* variable (defined as the number of Internet users per 100 people in China, representing the developmental level of social infrastructure in China), it is assumed that the development of social infrastructure helps to promote a targeted country's exports to China. The data for the *real GDP per capita* and *Internet* variables were obtained from the World Bank, while the nominal exchange rate and Consumer Price Index (2010 = 100) data for China and the respective target countries were obtained from the International Monetary Fund (see Table 2).

Table 2. Dependent and independent variables.

Variable	Description	Predicted Sign	Data Source	Related Studies
Dependent variables				
$EXPC_{it}^{j}$	Targeted country (New Zealand, U.S., South Korea, Japan) exports of industry *j* to China.		South Korea International Trade Association (KITA)	
Explanatory variables				
Target country supply EXS_{it}^{j}				
EXS_{it}^{j}	Targeted country total exports to the world excluding China; it represents their agricultural export supply (HS 01–24) to the world.	(+)	Author's calculations using the data (South Korean total exports and South Korean exports to China) obtained from KITA	
Chinese demand $IMDC_{it}^{j}$				
$IMDC_{it}^{j}$	China's total imports from the world excluding those from a target country. It represents China's agricultural demand (HS 01–24) for the world.	(+)	Author's calculations using the data (China's total imports and China's imports from target country) obtained from KITA	
Tariff and Non-tariff measures imposed by China $TNTM_{it}^{j}$				
$Tariff_{c,\,t}$	The tariff rate for a particular HS 2-digit category is calculated as being the average value for the category's relevant HS 6-digit level tariff rates.	(−)	WTO Integrated Data Base (IDB)	Choi et al. 2015; Hayakawa et al. 2015.
$SPSC_{it}^{j}$	Indicator for China's SPS (Coverage Ratio) against specific target country in industry *j*.		WTO I-TIP database	Choi et al. 2015; Disdier et al. 2008; Hoda et al. 2016; Liu and Yue 2012; Manarungsan et al. 2005; Neeliah and Goburdhun 2010; Sun et al. 2007; Wei et al. 2012.
$SPSF_{it}^{j}$	Indicator for China's SPS (Frequency Index) against specific target country in industry *j*.		WTO I-TIP database	Choi et al. 2015; Disdier et al. 2008; Hoda et al. 2016; Liu and Yue 2012;Manarungsan et al. 2005; Neeliah and Goburdhun 2010; Sun et al. 2007; Wei et al. 2012.
Distance and other related variables Z_{it}				
$DIST_{ic}$	The distance between the capital of the target countries and Beijing of China.	(−)	Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database	Bao and Qiu 2010; Wei et al. 2012; Dong and Zhu 2015.
$Linder_{it}$	The Linder effect (the absolute difference in the real GDP per capita between the target country and China).	(−)	Author's calculations using real GDP per capita information obtained from the World Bank	Choe and Park 2008; Disdier et al. 2010.
RER_{it}	Real exchange rate defined as the value of 1 CNY to the targeted country currency.	(+)	Author's calculations using the nominal exchange rate and Consumer Price Index obtained from the International Monetary Fund	Choe and Park 2008.
$Internet_{\,t}$	The number of internet users per 100 in China.	(+)	World Bank	Park 2014.

3.3. Data

This study analyzes the effect that Chinese SPS measures have on New Zealand, the U.S., South Korean and Japanese agricultural exports (HS codes 01–24) to China over the 2002–2014 period. These countries were selected based on their developed country status, their unique relationships with China and their differing levels of agricultural export strength. Data availability also played an important role in their inclusion. For the purposes of this study, all export data were gathered from KITA; while the tariff and non-tariff measures data were collected from the WTO website. In regards to the other related variables *GDP per capita*, *real exchange rate*, *internet users per 100* and *distance*, the relevant data were gathered from World Bank, International Monetary Fund (IMF) and the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). Given the nature of the descriptive statistics (see Table 3) and the extreme values obtained, our research utilized the PPML methodology in order to conduct our empirical analysis.

From an NTB perspective, using data obtained from the WTO I-TIP database, this study follows the views of the Chinese government and the WTO in which most Chinese SPS measures are interpreted at either the two-digit and four-digit HS code levels.[10] As such, this research examines product data at the HS 4-digit level (203 products).

Table 3. Descriptive statistics of the variables.

	Unit	Mean	SD	Min	Max
EXPC	thousand U.S. $	149,873.90	957,437.4	0	15,259,934
IMDC	thousand U.S. $	1,970,863	493,5715	12,182	45,948,603
EXS	thousand U.S. $	938,307,067.78	3,121,637,833	1	29,508,099,926
Tariff	ratio	2.01	4.23	0	15.24
SPSC	ratio	25.33	41.96	0	100
SPSF	ratio	24.98	40.53	0	100
Linder	ratio	14.49	6.28	6.36	31
RER	currencies per CNY	42.88	67.48	0.12	186
Internet	ratio	24.20	15.80	4.60	49
DIST	kilometer	5632.5	4189.04	956	10,757

4. Empirical Analysis and Discussion

In this section, we document and interpret the results obtained from the empirical analysis that was conducted using an adapted gravity model and the Poisson pseudo maximum likelihood methodology (PPML). Time is also taken to discuss the key policy implications identified in the results.

4.1. Results and Discussion

In order to assess the impact that SPS measures have on a target country's exports to China, we conducted a detailed empirical analysis. As part of this, an examination of the correlation patterns of the explanatory variables was conducted. Using logarithmic transformations (see Appendix A: Table A2), this study found that of the variables measured *coverage ratio (SPSC)* and *frequency index (SPSF)*, *real exchange rate (RER)* and *distance (DIST)* were shown to have high levels of correlation (the absolute correlation to each other is more than 0.8). In order to overcome these multicollinearity issues, we analyze the effect of *SPSC* and *SPSF* and the *RER* and *DIS* separately. Since *DIST* is only analyzed as part of the sample as a whole, the results are divided into two estimations (see Table 4). Within this analysis, we dissected the total sample into specific country groups so as to ascertain if there were any differences in the effects the SPS measures had on the particular countries. Furthermore, in order to

[10] For the affected products at the six-digit level, we also calculated it at the HS 4-digit level; such as HS210310, which is calculated as HS2103.

compare the before and after effects of the New Zealand-China FTA, we dissected the total period into before the FTA (2002–2007) and after the FTA (2008–2014) (see Table A3). Finally, our findings for (Tables 4 and A3) show that our empirical models have substantial explanatory power with R^2 values[11] that range from 0.57–0.94. This is a significant result, as it adds credence to the conclusions drawn from our empirical analysis.

The results for estimations (see Table 4) showed the coefficient estimates for *EXS* to be positive and statistically significant (0.74–1.31) for both the whole sample and the specific targeted countries (the exception being the U.S., which was found to be positive (0.06), but statistically insignificant), which was in line with our initial projections. The results for *IMDC* were found to be positive and statistically significant (0.07–1.28) for all target countries, except New Zealand, where it was found to be statistically significant, but negative (−0.37–−0.36). This suggests that a possible substituting effect exists between China's agricultural imports from New Zealand and China's imports from other countries. A comparative analysis of New Zealand's before and after FTA results with China, as identified in Table A3, shows that this substitutional relationship did not exist before the FTA and has only grown to prominence since it came into force in 2008.

For the estimate (see Table 4), the coefficient results for the *Tariff* variable were significant and negative (−0.50–−0.15) for the whole sample and the U.S., which is line with the expectation that increases in tariff levels should lead to a reduction in imports. In contrast to this, New Zealand and Japan's results were found to be positive (0.19–0.66) during the 2002–2014 period. These findings can be explained when one analyzes the relationship between primary product tariff rate trends and their related export values for the target countries. As Table 5 shows, the tariff rate for Chinese primary products fell sharply from 2002 (19.29%) to 2005 (3.45%); however, the associated export values for the targeted countries, especially those of New Zealand, did not increase much. This suggests that growing levels of NTBs (see Table 1) may have helped to overcome any possible trade gains that may have been made by lower tariff rates.

For the estimation results (see Table 4), the coefficient estimates of SPS, while using the coverage ratio, reflect the relative value of the affected products. In this regard, the SPS measure is negatively signed, but statistically insignificant (−0.02–−0.01) for the study as a whole and all countries, except Korea, where the SPS measures are positive and statistically significant (0.06).

In an effort to overcome some of the potential limitations identified in the coverage ratio analysis, this study also developed a frequency index for the SPS requirements used. In this instance, Table 4 demonstrates that SPS measures are statistically insignificant (−0.02–0.0) for three estimation categories (the whole sample, Japan and United States) and positive and statistically significant for Korea (0.06), which is in line with the earlier noted coverage ratio findings; while the SPS results for New Zealand are positive, but insignificant (0.01–0.04) when using the frequency index. The estimation results documented in Table A3 showed that from a frequency index perspective, there was little change in the effect of the measures before and after the China-New Zealand FTA was implemented. However, the results from the coverage ratio estimation showed a positive, but insignificant effect (0.03) for before the FTA signed and a negative, but insignificant effect (−0.02) in the period after the FTA came into force. In summary, these results show that the SPS measures imposed by China promote Korean agricultural goods exports, while they have a negative, albeit statistically insignificant impact on the other three countries agricultural exports to China. This is an important result, as it highlights the fact that despite the efforts of the Chinese trade policy makers, the SPS measure implemented provide little barrier to the developed economies included in this study.

[11] The coefficient of determination denoted R^2 is a number that indicates the proportion of variance in the dependent variable that is predictable from the independent variables. It is defined as the proportion of the total sum of squares explained by the regression model.

Table 4. Estimation results of Equation (1).

Variables	**Whole Sample**				**Japan**		**South Korea**		**New Zealand**		**United States**	
EXS	0.74 *** (0.14)	0.74 *** (0.14)	0.74 *** (0.14)	0.74 *** (0.14)	1.18 *** (0.05)	1.18 *** (0.05)	0.93 *** (0.04)	0.93 *** (0.04)	1.32 *** (0.09)	1.31 *** (0.09)	0.06 (0.06)	0.06 (0.06)
IMDC	0.74 *** (0.05)	0.74 *** (0.06)	0.74 *** (0.06)	0.74 *** (0.06)	0.29 *** (0.04)	0.29 *** (0.04)	0.07 *** (0.02)	0.07 *** (0.02)	−0.36 *** (0.10)	−0.37 *** (0.10)	1.28 *** (0.07)	1.28 *** (0.07)
Tariff	−0.15 ** (0.07)	−0.15 ** (0.07)	−0.15 ** (0.07)	−0.15 ** (0.07)	0.19 *** (0.04)	0.19 *** (0.04)	0.05 (0.04)	0.05 (0.04)	0.66 *** (0.08)	0.66 *** (0.09)	−0.50 *** (0.10)	−0.50 *** (0.10)
SPSC	−0.02 (0.03)		−0.01 (0.03)		−0.01 (0.02)		0.06 ** (0.03)		−0.01 (0.04)		−0.01 (0.03)	
SPSF		−0.02 (0.03)		−0.01 (0.03)		−0.01 (0.02)		0.06 ** (0.03)		0.03 (0.05)		−0.02 (0.03)
DIST	26.59 *** (6.81)	26.52 *** (6.75)										
Linder	0.76 (1.45)	0.74 (1.45)	0.26 (1.53)	0.25 (1.54)	0.49 (1.39)	0.50 (1.38)	−0.90 (1.72)	−0.61 (1.72)	−7.88 *** (2.59)	−9.12 *** (3.05)	2.14 (1.81)	2.29 (1.82)
RER			−1.04 (0.95)	−1.04 (0.98)	−0.17 (0.46)	−0.17 (0.46)	−0.79 (0.49)	−0.85 * (0.49)	0.24 (0.90)	−0.04 (0.87)	−0.65 (2.24)	−0.36 (2.26)
Internet	0.29 (0.58)	0.28 (0.58)	0.25 (0.57)	0.25 (0.57)	−0.09 (0.57)	−0.09 (0.57)	0.21 (0.50)	0.30 (0.50)	−2.00 ** (1.00)	−2.47 ** (1.15)	0.76 (0.62)	0.77 (0.62)
Constant	−258.34 *** (66.52)	−257.64 *** (65.97)	−17.67 *** (6.45)	−17.60 *** (6.43)	−9.35 * (5.54)	−9.39 * (5.50)	3.00 (5.35)	2.47 (5.38)	23.17 ** (9.35)	27.33 ** (10.71)	−16.33 ** (6.54)	−16.27 ** (6.49)
No. Observations	1248	1248	1248	1248	312	312	312	312	312	312	312	312
R^2	0.906	0.905	0.909	0.909	0.905	0.905	0.782	0.779	0.846	0.850	0.939	0.937

Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5. The tariff rate and export value of targeted countries (2002–2014).

Year	Tariff Rate	Export Value for Primary Products (Thousand U.S. $)			
		Japan	South Korea	New Zealand	United States
2002	19.29	177,627.6	161,718	463,598	1,565,238
2003	5.74	210,836.3	221,102	578,772	3,871,588
2004	6.24	326,282.1	310,465	849,598	3,842,778
2005	3.45	390,123.9	330,704	694,221	3,541,127
2006	3.54	464,718.5	328,125	779,925	4,276,752
2007	2.99	438,689.5	450,987	818,232	6,514,058
2008	2.37	379,081.3	515,027	1,164,430	10,153,037
2009	1.81	440,649	499,850	1,811,821	12,164,976
2010	1.8	569,600.6	718,449	2,632,858	15,171,614
2011	1.55	382,210.9	1,132,190	3,171,457	16,192,489
2012	1.55	444,638.6	1,091,775	3,782,081	22,162,560
2013	1.55	446,996.4	1,146,664	5,788,524	23,060,744
2014	1.61	484,100.3	1,101,180	5,799,769	23,026,562

Source: author's calculations using data from WTO and KITA.

In other results, *DIST*, which measures the physical distance of the exporting country from China, is positively signed and highly significant (26.59.62–26.52) in the tables (1-1). These results suggest that a targeted trading partners' agricultural exports to China are directly related to their distance from the country. A finding that represents the fact that agricultural exports from the U.S. and New Zealand dominate the Chinese marketplace.[12] The result for the *Linder effect* (see Table 4) was found to be insignificant (0.25–0.76) for the sample as a whole, while the target countries themselves recorded mixed, but also insignificant findings. The results for the *Internet*, were positive, but insignificant (0.25–0.29) for the sample as a whole, while the result for New Zealand was negative and significant (−2.00–−2.47), which was surprising. Finally, for the estimation tables (1-1), the *real exchange rate* was found to be negative, but statistically insignificant (−1.04) for the whole sample, while the results for the specific countries were insignificant with mixed signs (the exception being South Korea), which indicates that the exchange rate has no clear impact on export levels to China.

4.2. Policy Implications

As a country with tremendous marketplace opportunities, both developed and developing economies have made significant efforts to enhance their agricultural exports to China.[13] However, in response to not only these competitive demands, but also an increasing awareness among its consumers of health and food safety standards, the Chinese government has implemented a range of SPS measures that specifically target agricultural imports. As a consequence of these developments, our study has unveiled a number of important issues that require further discussion.

Given our developed country focus, the empirical analysis showed that the SPS measures had a range of impacts. From a general perspective, we found that the SPS requirements had a negative, albeit statistically insignificant, impact on agricultural exports to China. This finding in large part contrasts earlier developing country studies by (Maskus et al. 2005; Hoda et al. 2016) that SPS measures can create additional costs to exporters, which can in turn restrict export opportunities. Our results also show that while their impact is negative, they are not necessarily enough to significantly affect export volumes. This suggests that as key Chinese developmental strategies, such as "Made in China 2025" and "Industrial 4.0", continue to take shape, more will need to be done by policy makers if they

[12] According to the United Nations (UN) Comtrade International Statistics Database, in 2015, the total amount of agricultural exports to China in USD from Japan are ($5,155,555,000), South Korea ($8,008,236,000), New Zealand ($28,335,286,000) and the U.S. ($145,543,523,000) (UN Comtrade 2017).

[13] Chinese total exports in USD are $2.280 trillion, while their total imports are $1.601 trillion (World Bank 2017b).

want to implement initiatives that balance trade liberalization goals with a more protectionist domestic policy agenda.

From an individual country perspective, our study demonstrated that SPS measures have a negative effect on Japanese and U.S. agricultural exports. These findings support the statistics that show the SPS coverage ratios of Japan and the U.S. to be higher than those of Korea and, in the years before the China-New Zealand FTA came into effect, New Zealand (see Table 1). This indicates that the policy initiatives put in place target specific industries that Japan has a competitive advantage in; while the U.S., as an agricultural powerhouse, is perhaps targeted more aggressively across the board. It may also highlight some of the potential geopolitical issues confronting the region and the steps that China is taking to help illustrate any grievances it may have. In contrast to this, the stipulated measures have had a positive and statistically-significant impact on Korean agricultural exports to China, a finding that supports previous efforts by Maertens and Swinnen (2009) and Henson and Humphrey (2010). As Korea faces the lowest level of SPS measure coverage among the targeted countries, this result may reflect a perception that Korean agricultural products present little immediate threat to Chinese domestic producers. However, whilst this may be the case, our finding may highlight the fact that Korean exporters have been more successful in not only adapting their production methods, but also in producing higher quality products that are well liked by Chinese consumers.

Finally, in terms of New Zealand, it was interesting to note that the SPS measures had a positive effect on New Zealand's exports before its FTA with China came into force, while they were seen to have a negative impact in the years following its implementation. This result helps to bring into focus the notion that NTBs such as SPS measures are an effective means of neo-protectionist trade policy. For many years, tariffs were utilized as a traditional form of protection against import competition. However, as documented above, other policy instruments such as SPS measures can also have a detrimental impact on export growth. Given their growing importance, it is therefore imperative that governments, like New Zealand, educate industry about the potential ramifications of these requirements and the steps that agricultural exporters can take to manage any potential shortcomings or growth opportunities. In addition, governments must also look to adjust the ways in which they negotiate future bilateral or regional trade agreements, so that their terms better reflect the impact that NTB measures may have. It is therefore conceivable to believe that as more becomes known, existing deals, such as the Korea-China FTA, may require some adaptations at some point. The removal of NTBs in this instance will involve a higher or more complex level of negotiation as the two countries look to seek out reciprocal countermeasures. Any compromises that are made to a particular good or sector must therefore be carefully considered so that the economic consequences of such measures are fully understood.

5. Conclusions

Using variables clearly identified in academic literature, this study utilized a gravity model and the Poisson pseudo maximum likelihood method to empirically assess the effect that Chinese SPS measures have on agricultural exports from Japan, Korea, New Zealand and the U.S. While our empirical analysis showed that these measures have a negative, albeit statistically insignificant, effect on agricultural exports, the results from an individual country perspective evoked a range of responses.

Our study demonstrated that SPS measures have a negative effect on Japanese and U.S. agricultural exports, while the estimations for Korea showed that Chinese requirements helped to promote agricultural exports. In terms of New Zealand, the SPS requirements were found to have a positive impact on agricultural exports in the years leading up to its FTA with China. However, since coming into force, their impact has had a negative effect of export performance. These results demonstrate the protectionist use of SPS measures, particularly against highly competitive agricultural exporters, such as the U.S. and New Zealand. It also shows how FTAs can influence the impact of NTBs. A finding that provides a reference point from which we can compare the before and after effects of the Korea-China FTA in the future. Finally, given this study's developed country focus, future empirical efforts need to examine the impact of Chinese SPS measures on developing countries in the Asian region.

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Appendix A

Table A1. The trend of China's non-tariff measures.

Year	TBT	SPS	CV	ADP	QR	Total
2002	12	155	0	35	4	206
2003	28	28	0	54	0	110
2004	22	37	0	44	1	104
2005	108	15	0	40	1	164
2006	62	4	0	34	0	100
2007	90	4	0	16	0	110
2008	185	6	0	18	2	211
2009	206	98	3	29	2	338
2010	63	254	3	23	1	344
2011	90	171	2	11	2	276
2012	83	26	2	14	1	126
2013	81	90	1	19	0	191
2014	48	69	2	20	14	153
2015	99	179	0	3	0	281
Total	1177	1136	13	360	28	2714

TBT: technical barriers to trade; SPS: sanitary and phytosanitary; CV: countervailing; ADP: anti-dumping; QR: quantitative restrictions; Source: WTO I-TIP database.

Table A2. Explanatory variables (by natural logarithm) correlations.

Variable	IMDC	EXS	Tariff	SPSC	SPSF	Linder	RER	Internet	DIST
IMDC	1								
EXS	0.13 ***	1							
Tariff	0.15 ***	0.08 **	1						
SPSC	0.12 ***	0.04	0.00	1					
SPSF	0.13 ***	0.04	0.00	0.96 ***	1				
Linder	−0.35 ***	0.40 ***	0.01	0.04	0.02	1			
RER	0.05	−0.58 ***	−0.00	0.03	0.01	−0.47 ***	1		
Internet	0.44 ***	0.07 *	−0.02	−0.04	−0.02	−0.72 ***	0.03	1	
DIST	−0.03	0.50 ***	0.00	−0.03	−0.01	0.40 ***	−0.99 ***	0.00	1

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; the figures marked in red represent that the absolute correlation between two explanatory variables exceeds 0.8.

Table A3. Estimation results of New Zealand.

Variable	Whole Period		Before FTA		After FTA	
EXS	1.32 *** (0.09)	1.31 *** (0.09)	0.89 *** (0.12)	0.89 *** (0.12)	1.40 *** (0.10)	1.39 *** (0.10)
IMDC	−0.36 *** (0.10)	−0.37 *** (0.10)	−0.17 (0.11)	−0.17 (0.11)	−0.42 *** (0.12)	−0.42 *** (0.12)
Tariff	0.66 *** (0.08)	0.66 *** (0.09)	0.60 *** (0.09)	0.60 *** (0.09)	0.66 *** (0.11)	0.66 *** (0.11)
SPSC	−0.01 (0.04)		0.03 (0.07)		−0.02 (0.05)	
SPSF		0.03 (0.05)		0.01 (0.07)		0.04 (0.06)
Linder	−7.88 *** (2.59)	−9.12 *** (3.05)	0.28 (7.58)	1.17 (7.57)	−3.62 (7.13)	−4.91 (7.19)
RER	0.24 (0.90)	-0.04 (0.87)	−1.46 (1.46)	−1.45 (1.46)	0.78 (2.10)	1.66 (2.21)
Internet	−2.00 ** (1.00)	−2.47 ** (1.15)	0.24 (2.77)	0.51 (2.75)	0.59 (3.86)	0.31 (3.87)
Constant	23.17 ** (9.35)	27.33 ** (10.71)	−3.37 (26.50)	−6.41 (26.40)	4.86 (30.58)	10.24 (30.89)
No. Observations R^2	312 0.846	312 0.850	144 0.571	144 0.571	168 0.872	168 0.878

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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