ON THE IMPACTS OF SANITARY AND PHYTOSANITARY MEASURES ON AGRI-FOOD TRADE: NEW EVIDENCE FROM CHINESE FIRMS

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Abstract

Sanitary and phytosanitary (SPS) measures are not new, but their significance in international agri-food trade continues to grow. Despite a growing literature exploring the relationship between SPS measures and agricultural trade flows, firm-level studies are relatively rare. This paper revisits the trade effects of SPS measures on Chinese firm-level trade. We do so by matching a novel panel of Chinese firms' agricultural exports to a recently developed dataset of detailed SPS specific trade concerns that have been raised in the WTO's SPS committee. Three findings emerge from our analysis: (i) SPS trade concerns discourage the presence of Chinese exporting firms in SPS-imposing foreign import markets; (ii) Foreign invested firms have clear advantages in adapting to restrictive regulations compared to any other firm types; and (iii) Although the trade effect of SPS concerns is negative, this result is not generalizable across all measures as some SPS measures positively impact firms' export value.

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1. Introduction

Non-tariff measures (NTMs) refer to government interventions, other than tariffs, that can potentially affect trade in goods changing quantities traded, quality, or prices (UNCTAD, 2012). Governments employ NTMs to achieve various policy objectives, such as economic, national security, environment or food safety interests. Although the establishment of the General Agreement on Tariffs and Trade (GATT) in 1948 significantly advanced trade liberalization efforts, its primary focus was on the negotiation on multilateral tariff reductions. Since the creation of the World Trade Organization (WTO) in 1995, however, the focus of trade policy concerns has shifted to non-tariff issues and the plethora of standards and regulatory issues behind the border. This is because NTMs can dilute or even nullify the value of tariff reductions that have been achieved through decades of trade negotiations and can affect trade in unpredictable ways (WTO, 2012). According to the WTO, not only has the average share of product lines and trade value affected by NTMs increased significantly, the types of measures adopted by countries are diverse and complex driven by growing consumer demands regarding food safety and environmental issues (Grant and Arita, 2017). This has shifted the focus of NTMs from the production side of the equation towards the defense of consumer and societal interests (WTO, 2012).

NTMs are often found to be nearly twice as restrictive as tariffs when measured on a comparable *ad valorem* equivalent basis (Hoekman and Nicita, 2011; Kee et al., 2009; UNCTAD, 2012). As indicated in Kee et al. (2009), the level of NTM trade restrictiveness in agriculture is 30 per cent higher than the manufacturing. Similarly, for agricultural sectors Andriamananjara et al., (2004) finds that non-tariff government interventions appear to be more restrictive and widespread than those in the manufacturing sector. Given the decline in tariff rates, the relative contribution of NTMs to overall trade restrictiveness is likely to have increased and SPS measures are pervasive in agricultural and food trade.

Non-tariff measures can be distinguished by price, quantity, and "quality" (UNCTAD, 2012). Price measures (such as a subsidy) refer to government interventions that change relative prices, while a quantity measure (such as a quota) directly limits the quantity of traded products. Quality measures, such as technical barriers to trade (TBT) or SPS measures, change some features of a product or its underlying production process. Across the three types of NTMs, quality measures are the most widely used in agricultural and food products according to data collected from official sources such as the United Nations Conference on Trade and Development's (UNCTAD) Trade Analysis and Information System (TRAINS) and the new WTO Integrated Trade Intelligence Portal (I-TIP) whereby over 20,000 and 26,000 SPS and TBT measures have been notified to the WTO since 1995.

In contrast with many other non-tariff measures, economic theory does not provide straightforward predictions about the trade effects of SPS measures (Thilmany and Barrett, 1997). As a result, assessing their effects is clearly an empirical issue. Although the results differ (such as Crivelli and Groeschl, 2016; Swann et al.,1996; Fassarella et al., 2011), the predominant view is that SPS measures restrict trade (Beghin et al., 2015; Disdier et al., 2008; Grant and Arita, 2017; Kee et al., 2009; Li and Beghin, 2012; Peterson et al., 2013). Moreover, empirical research has also demonstrated that the impact of SPS measures may differ across sectors, countries and the types of measures imposed. For example, a meta-analysis of 27 papers conducted by Li and Beghin (2012) shows that the trade effects of SPS measures on agricultural trade are less likely to be positive than in other sectors. In another example, Anders and Caswell (2009) provide evidence for the substantially different effects of SPS measures between developed and developing countries.

Previous research quantifying the impact of SPS on trade have typically been conducted at the country level (Beghin et al., 2015; Disdier et al., 2008; Grant et al., 2015; Henson and Ropert, 2001; Kee et al., 2009; Li and Beghin, 2012; Liu and Yue, 2009; Peterson et al., 2013; Swann et al., 1996). However, much less is known about the impact of SPS measures on the actual mediators of trade: firms. Pioneered by Melitz (2003), the "new new" trade theory (see also Bernard et al. (2003); Chaney (2008); Helpman (2006)) stresses the importance of firm-level investigations in trade. It demonstrates that only the most productive firms in a country are engaged in exports. This stylized fact is explained by firm's differing widely in terms of productivity ("firm heterogeneity") and the existence of fixed cost incurred by firms to access a foreign market.

SPS measures often require additional trade costs on the part of exporting firms in order to comply with import standards and regulations. Thus, the increase in firms' trade costs could limit or even remove some firms' export prospects. Moreover, because the WTO Agreement on the Application of SPS Measures permits countries to adopt their own standards provided these measures are based on a risk assessment, not discriminatory between countries with similar conditions, and are minimally trade distorting, quantification of SPS measures at the level of the firm can move us toward a better understanding of the mechanism by which SPS measures impact trade flows.

With this in mind, the purpose of this paper is to shed new light on the impact of SPS measures by quantifying the trade effect of SPS measures on the universe of Chinese firms engaged in international agri-food trade. More specifically, this paper addresses three research questions:

1. Through what channels do SPS measures affect Chinese firms' agri-food trade?
2. Is the ability of Chinese firms to overcome fixed and variable trade costs of SPS measures dependent on the type of SPS measure imposed?
3. What is the differential effect of SPS measures across different types of Chinese firms engaged in international transactions?

Answers to the questions form the basis of our analysis. The remainder of the paper is organized as follows. Section 2 describes the data and some stylized facts about Chinese firm level agri-food exports. Section 3 discusses our empirical strategy, and Section 4 presents the results. The final section concludes.

2. Data

Two datasets are combined in our analysis. First, to document SPS-related trade frictions between countries, the WTO began collecting information related to complaint-based SPS Specific Trade Concerns (STCs). This database records all the SPS trade concerns that Members have raised against their partner countries' SPS measures since 1995. We use a more detailed version of this database developed by Grant and Arita (2017). For example, the dataset documents the type of SPS measures raised as a concern (i.e., tolerances or maximum residue limits), the duration of concerns, language used in describing the concern, countries and product sectors involved in the concern, and many other indicators. This level of detail is important because studies such as Crivelli and Groeschl, 2016 and Peterson et al., 2013 using country-level data to assess the impact of SPS measures on trade show that different types of SPS measures matter. Moreover, policy makers often can choose from a range of measures that are assumed to equivalently reduce risks but entail different trade costs. In this paper, we explore whether different types of SPS concerns have differential effects on firm's exporting likelihood and value traded.

The second dataset is the Chinese firm-level trade transaction data, which documents the universe of Chinese firms' agricultural import and export transactions during 2000-2010. One unique feature of this dataset is that it records each firm's ownership structure. This structural characteristic is seldom reported in most of firm-level empirical research in international trade (Bernard et al., 2009, 1995; Castellani et al., 2010; Kugler and Verhoogen, 2012; Manova and Zhang, 2012; Pavcnik, 2002; Tybout, 2003). One exception is Manova and Zhang (2009). As shown in Manova and Zhang (2009), firms with different ownership structures have distinct trade patterns. In addition, Fontagné et al. (2015) illustrated that SPS measures have heterogeneous impacts on French firms that differ in firm characteristics. Thus, we attempt to examine whether the impact of SPS concerns on firms' international agri-food trade depends on ownership structure.

The specific trade concern database

The WTO SPS Agreement requires its members to notify to the WTO Secretariat whenever they intend to impose any new or changed requirements that may affect international trade. Since the conclusion of the agreement in 1995, WTO members have submitted over 20,000 notifications of measures to the SPS committee. Among them, the United States accounts for

twenty percent of total notifications, followed by Canada (9.74%), Brazil (7.7%), China (5.77%), and the European Union (5.22%). As developing countries such as Brazil and China start to pay more attention to food safety and environmental protection, a growing number of SPS measures are being notified by developing economies. As indicated in Figure 1, the share of SPS notifications by developing countries grew from 36 per cent in 1996 to 70 per cent in 2016.

However, to achieve plant, animal and human health objectives, policymakers can choose from a range of different SPS measures, which makes sorting through the universe of WTO SPS and TBT notifications difficult (Crivelli and Groeschl, 2016; Grant and Arita, 2017; Peterson et al., 2013). As an alternative, the WTO's SPS Committee provides a forum for Members to raise specific trade concerns (STC) which represent a subset of measures deemed more problematic from an exporter's perspective.[1] The SPS specific trade concerns database[2] provides a summary description of cases, as well as connections to relevant documents since 1995 (see Figure 2). It records which member(s) raised a concern, the date each concern was raised, which country(ies), if any, supported the concern, and which country(ies) maintained a measure deemed to restrict exports. In addition, the data also provide coverage of a concern at the 4-digit level of the Harmonized System (HS), the resolution status (resolved, partially resolved, or unreported), the duration of the concerns, and how many times a concern was subsequently raised. Unlike the SPS notification data, this database allows researchers to focus on the more troublesome SPS obstacles as revealed by exporters (see also Crivelli and Groeschl, 2016; Disdier and van Tongeren, 2010; Fontagné et al., 2015; Grant and Arita, 2017).

Over the past two decades, WTO Members have raised 412 specific trade concerns related to SPS measures. In particular, the top five agricultural exporters (EU, United States, Brazil, China, Canada) who shipped over 40% of global agricultural products in 2016,[3] raised about 45% of total SPS trade concerns.[4] Among all the concerns, about 45 per cent of concerns were subsequently reported as resolved or partially resolved, and 15 specific trade concerns escalated to a formal trade dispute. One important feature of the SPS specific trade concerns dataset developed in Grant and Arita (2017) is that the authors classified SPS concerns into nine categories based on the nature of the concern.[5] Figure 3 shows the percentage breakdown of

[1] For a comprehensive overview of this dataset, see Grant and Arita (2017).
[2] See http://spsims.wto.org/en/SpecificTradeConcerns/Search
[3] See https://www.wto.org/english/res_e/statis_e/wts2016_e/wts16_chap9_e.htm
[4] EU raised 66 concerns following the USA (45), Brazil (29), Canada (22), and China (22). Since developing countries often have a more limited capability for meeting the food safety and plant and animal requirements from developed countries, SPS measures can be discriminatory against developing countries (UNCTAD, 2012).
[5] The SPS classification is: animal disease related (ADR), customs, procedures, certification, licensing (CPCL), conformity standards & risk assessment (CRA), food additives & alterations (FAD), microbiological related (MICB), treatments (PHT), plant contamination (PLCT), production & process requirements (PPR), tolerance and limits (TOL). For more information, see Grant and Arita (2017) table 3.

China's SPS concerns by type from 1995 to 2016. In total, China has raised 22 and supported a further 6 specific trade concerns since becoming a WTO member in 2001. As indicated in Figure 3, 43% (12) of China's SPS concerns are related to tolerances which includes maximum residue limits. Tolerances is followed by customs procedures, certification and licensing concerns at 17% of concerns raised and animal disease related issues at 14%.

Chinese firm-level data

China is currently the world's fourth largest agricultural exporter following the US, Canada, and Brazil. China's major agricultural exporting commodities include vegetables (largest in the world), fish and seafood products (largest), tea (second), and fruits (fourth). Most of these are attributed to the rapid growth of Chinese agricultural exports after China's accession to the WTO in 2001. Total agricultural exports increased by 160 per cent from $14.1 billion in 2000 to $37.1 billion in 2009. In the meantime, the number of destinations increased by eight per cent from 193 destinations in 2000 to 210 in 2009, and the number of shipped products at the HS8-digit level increased by three and a half per cent from 921 products in 2000 to 953 in 2009. By simply looking at the growth of the number of products and destinations, one may erroneously credit this significant growth to the intensive margin (average trade value per product-destination market). However, with the availability of the firm-level data, a new dimension is available through which to examine the growth path of agricultural trade and the impacts of SPS measures at the firm level.

The Chinese firm-level data are from the General Administration of Customs of the People's Republic of China and include the universe of firm import and export transactions crossing the Chinese border from 2000 to 2009[6]. For each year, we observe the importing or exporting firm, product code at the HS8-digit level[7], the destination country in each transaction, the quantity of products exported, and the US dollar value of the transaction (current value). In addition, the data provide information on several other key variables including the individual firm name, firm identification code[8], methods of trading (such as general trade, processing and assembling trade etc.), firm's ownership structure[9] , and an indicator for intermediary firms [10]. The dataset

[6] We have checked that validity and accuracy of the agricultural import and export data by aggregating firm shipments to the country level for China and then comparing these with China's import and export values in the WTO statistics. The two are a very close match. The average difference is within one hundred million current US dollars.
[7] The classification of products is relatively consistent across countries at the 6-digit HS level. The number of distinct product codes in the Chinese 8-digit HS classification is comparable to that in the 10-digit HS trade data for the United States.
[8] The 10-digit firm identification code is uniquely assigned to each firm by China Customs.
[9] In terms of firm ownership structure, each firm is assigned one of eight possible ownership types, which we group into four categories: state owned enterprises (SOEs), privately held firms (privately held firms, collectively-owned firms, and self-employed industrialist), fully foreign-owned affiliates, and joint ventures (with foreign ownership under 100%).
[10] We search for Chinese characters that mean "trading" and "importer" and "exporter". In pinyin (Romanized Chinese), these phrases are: "jin4chu1kou3", "jing1mao4", "mao4yi4", "ke1mao4", and "wai4jing1". For further discussion, please see Ahn et al., 2011.

also contains a number of additional variables which we do not explore in this paper, like the means of transportation (such as air, ship, etc.), the customs office where the transaction was processed, the region or city in China where the product was exported from or imported to, and any potential transfer country or region (such as Hong Kong).

The firm level data cover two important periods in China (see Sheng 2015): fulfilling WTO commitments period (2000-2005) and China's trade policy adjustment period (2006-2009). From 2000 to 2005, China's average manufactured goods tariffs dropped from 14.3% to 8.9%, and from 23.2% to 14.6% for agricultural products. Since 2006, however, domestic criticism on China's weakness in the WTO negotiations decelerated its trade liberalization effort. During this period, the average tariff rate was not significantly reduced. Most empirical investigations using Chinese firm-level data (Ahn et al., 2011; Fernandes and Tang, 2014; Manova et al., 2015; Manova and Zhang, 2012, 2009) focused on the first period. Few have explored firms' performance during the second period. In this paper, the data provide us a longer panel and a closer look at the more recent data.

The number of Chinese agricultural exporting firms increased by 76 per cent from 9,772 in 2000 to 17,199 in 2009. Table 1 provides descriptive statistics of Chinese firms across HS2 Chapters (1-24) between 2000 and 2009. Here, we compare the average exports by firm ($ million), number of destination markets, number of exporters, and number of products (HS 8-digit). As indicated in Table 1, although the growth rates vary significantly from 36% to over 400%, the intensive margin represented by the average exports per firm in a given HS Chapter increased. Moreover, the extensive margin channels have also increased. With a few exceptions in the meat industry, the number of exporters in each HS Chapter also increased, and Chinese exporters have expanded the number of destination markets they can access.

Table 2 provides annual summary statistics of the firm-level data. Although the average export value of each firm increased from $1.45 million in 2000 to $2.16 million in 2009, the average number of country-product combinations for each firm actually declined from 8.94 in 2000 to 7.15 in 2009. However, this trend masks some important difference across firms. As explained later, the declining number of average product-destination combinations per firm is mainly driven by a significant decline among state-owned enterprises (SOEs). For example, the number of state-owned firms involved in agricultural trade dropped by 60 per cent from 4,599 in 2000 to 1,549 in 2009, and the agricultural trade share of state-owned firms had declined from over 60 per cent in 2000 to less than 15 per cent in 2009. Along with the decreased importance of Chinese SOEs in agricultural exports, the average number of country-product combination declined from 13.4 to 11.4. On the other hand, other types of firms such as

privately held domestic firms and foreign invested firms experienced rapid growth in terms of firm numbers, trade value per firm, and country-product combinations per firm (Table 3).

Combine SPS concern data and Chinese firm level data

As indicated in Table 2, there are over 25,000 unique Chinese exporters in agricultural trade, 200 destinations, and 190 products (at HS 4-digit level) in our data. Since the Chinese Customs only document firm's positive trade flows, we had to further augment the database with zero trade flows. As suggested by Fontagné et al. (2015), a data restriction strategy to keep the sample size manageable is necessary. First, we calculate total export flows by destination market and retain markets with above-median exports. Second, we keep firms that exported to at least one product-destination market for four years within the sample period to remove occasional exporters. Third, we generate zero trade flows if a firm's export to a product-destination market in a certain year is missing. Table 4 provides the comparison of descriptive statistics on the churning rate of firms between our estimation sample and Fontagné et al. (2015).

In the sample period, China raised/supported 28 STCs to the WTO SPS Committee. However, because concerns raised often impact multiple HS4-digit product sectors and the Chinese firm-level data are at the HS8-digit level, when we combine the two datasets we disaggregated the HS4-digit data in the SPS STC database to the HS8-digit product dimension in the Chinese customs data. In total, there were 5,384 product-destination-year concern triplets including 281 SPS measures related to trade bans, 17 prohibitions, 3,450 trade restrictions due to SPS measures, and 1,636 new SPS regulations. Approximately, 50 per cent of all concerns raised by China in the period were reported as resolved or partially resolved, which is a similar resolution rate to that of the EU (Grant and Arita, 2017). Only seven per cent of Chinese concerns ended up in dispute settlement proceedings with the WTO. The average duration between a concern first being raised and its resolution is about five and a half years, slightly longer than the 3.5 years average for all concerns(Grant and Arita, 2017). In addition, the number of times that a specific concern was subsequently raised is four times.

After merging the STC and firm-level datasets, some preliminary summary statistics indicate that STCs do impact Chinese firms' agricultural exports. When comparing the number of product-destination markets before and after the STCs were raised, the total number of firms dropped by 3.5% or from 4,099 to 3,954 firms. To put this in context, recall that the average annual growth rate of firms over our sample period is 7.6 per cent. In the meantime, Chinese firms stopped exporting to 53 out of 397 markets in total when STCs were in effect. Although the total export value in the affected product-destination markets slightly raised from $3.04

billion to $3.12 billion, the export quantity, however, decreased by 11.7 per cent on average suggesting that some underlying price dynamics may be operating when SPS concerns are active.

2. Empirical analysis

In this paper, we focus on three potential channels through which SPS measures may affect firms' agri-food trade: firm's extensive margin, intensive margin, and pricing. The extensive margin refers to a firm's decision to export to a certain product-destination market in a year. The intensive margin refers to the magnitude (positive trade flow in US dollars) of a firm's export to a certain product-destination market.

Although, economic theory does not provide straightforward predictions about the trade effects of SPS measures (Thilmany and Barrett, 1997), heterogeneous-firm models (Bernard et al., 2007; Helpman et al., 2008; Melitz, 2003) demonstrate that the incremental costs of SPS regulations likely has negative impacts on exporters' trade decision. In contrast, firms' trade volume and aggregate welfare effects of SPS measures remain ambiguous (Fontagné et al., 2015; Thilmany and Barrett, 1997). On the one hand, safety regulations may increase effective demand by relieving consumers' concerns about product quality. On the other hand, regulatory barriers can act just like a de-facto quota "disguised in scientific rhetoric" (Thilmany and Barrett, 1997, pg. 95).

As for average price responses of exporters, Fontagné et al., 2015, argued that firms may increase their prices in the presence of SPS concerns. First, to comply with more stringent SPS requirements, firms will pass some of the cost increase on to the consumer. Second, as higher compliance cost reduces firms' participation in exporting, it decreases competitive pressure in the importing market potentially leading to higher markups which puts upward pressure on export prices.

Against this background, our first estimating equation is as follows:

$$y_{isjt} = \alpha + \beta_1 \, ln\left(firmsize_{i,t}\right) + \beta_2 \, ln(visibility + 1)_{i,HS2,t} + \beta_3 STC_{sjt} + \kappa_s + \delta_j + \eta_t + \varepsilon_{i,s,j,t} \quad (1)$$

where *i*, *s*, *j*, and *t* denote respectively firm, HS 4-digit product category, destination country, and year. The dependent variables are: (i) a dummy variable for positive trade flows into a certain product-destination market combination to capture the extensive margin of trade; (ii) the firm's export values (in logs) to each product-destination market per year as a measure of

the intensive margin; and (iii) the unit value price of exported goods (in logs) to each product-destination market per year.[11]

For the explanatory variables, STC_{sjt} represents the existence of an ongoing SPS trade concern in product category *s* between China and an importing country *j* at time *t*.[12] An SPS measure may have been already imposed before it was raised as a concern. To capture the lead-lag effects of SPS measures, we include a one-year lead variable of STC_{sjt}, STC_{lead} in our analysis. $ln(firmsize_{i,t})$ is firm *i's* total agricultural exports to the world and is intended to capture heterogeneous export performance related to firm productivity. Since we do not have direct information on Chinese exporters' balance sheets, we calculate the size variable in this way which has been shown to be a good proxy for the overall size of a firm (Mayer and Ottaviano, 2008). In addition, we follow Fontagné et al., 2015, by adding a firm visibility variable, $\ln(\text{visibility}+1)_{\text{i,HS2,t}}$, to capture a firm's competitiveness and market share in a certain product-destination market. We calculate a firm's visibility in a product-destination market in year *t* as the share of firm *i's* exports over total Chinese exports to a given product-destination market.

To control for commodity, country, year specific unobserved effects, we include three sets of fixed effects in the model: κ_s is the product (HS 4-digit level) specific characteristics that affect trade performance; δ_j represents the country specific factors such as multilateral trade resistance (Anderson and Wincoop, 2003); η_t represents the year fixed effects, such as business cycles. To summarize the variables, Table 6 lists the descriptive summary statistics of each variable.

To investigate whether the ability of firms to overcome additional trade costs of SPS measures depend on the type of SPS measures imposed, in the second model, we add dummy variables for each type of SPS measures[13].

$$(2)\quad y_{isjt} = \alpha + \beta_1\, ln(firmsize_{i,t}) + \beta_2\, ln(visibility+1)_{i,HS2,t} + \beta_3 STC_{sjt_{ADR}} + \beta_4 STC_{sjt_{CPCL}} + \beta_5 STC_{sjt_{CRA}} + \beta_6 STC_{sjt_{PHT}} + \beta_7 STC_{sjt_{PLCT}} + \beta_8 STC_{sjt_{TOL}} + \kappa_s + \delta_j + \eta_t + \varepsilon_{i,s,j,t}$$

In the last model, we study the existence of differential SPS effects across firms' ownerships structure by including firm ownership variables and the interaction between firm types and the SPS variables (i.e., $\text{type}_\text{i} \times STC_{sjt}$)[14].

[11] For analyzing the impact of SPS concerns on firms' intensive margin and pricing strategy, the dependent variables include only positive trade values.

[12] For now, we focus on the average trade effects of SPS trade concerns on firm level exports. Later, we will distinguish between different types of SPS.

[13] There are six types of SPS concerns raised by China： Animal Disease Related (ADR), Customs, Procedures, Certification, Licensing (CPCL), Conformity Standards & Risk Assessment (CRA), Treatment (PHT), Plant Contamination (PLCT), Tolerance and Limits (TOL).

[14] Since foreign invested firms and foreign affiliates share similar trade patterns, we combine the two types of firms together and call the combined type foreign invested firms (Manova and Zhang, 2009). As a result, there are only three types of firms in our analysis: SOEs, foreign invested firms and privately held domestic firms.

$$(3)\quad y_{isjt} = \alpha + \beta_1 ln(firmsize_{i,t}) + \beta_2 ln(visibility + 1)_{i,HS2,t} + \beta_3 state_i + \beta_4 foreign_i + \beta_5 state_i * STC_{sjt} + \beta_6 foreign_i * STC_{sjt} + \beta_7 STC_{sjt} + \kappa_s + \delta_j + \eta_t + \varepsilon_{i,s,j,t}$$

Despite the discrete nature of some our dependent variables, we estimate the models via ordinary least square (OLS). We rely on simple linear probability models (LPM) rather than non-linear probit (or logit) to avoid incidental parameter problem (Fontagné et al., 2015) due to the sizeable set of fixed effects we include in all regressions. In addition, LPMs provide simple direct estimates of the sample average marginal effect.

3. Results

3.1.SPS and the extensive margin of trade

The regression results quantifying the impact of SPS measures on export participation are shown in Table 6. We find a negative and significant effect of SPS specific trade concerns on the extensive margin of Chinese firms' trade. For example, in columns 1 and 2, SPS specific trade concerns reduce the probability of exporting to a product-destination market by 5%. This result is consistent with Fontagné et al. (2015). Compared to foreign invested firms and privately held domestic firms, SOEs are the most unlikely to export. Moreover, a restrictive non-tariff measure has larger negative impact (8%) on SOEs' probability of exporting to foreign markets more than any other type of firms. This is in line with our expectations: it is harder for Chinese SOEs to adapt to more restrictive SPS regulations. The coefficient on firm size and visibility are in line with the heterogeneous-firm trade theory (Melitz, 2003). Bigger and more visible firms are more likely to export.

3.2.SPS and the intensive margin of trade

We now turn to the impact of firms' size, visibility, ownership structure and SPS trade concerns on the intensive margin of Chinese firm export values. Firm size and visibility are significantly and positively correlated with firms' intensive margin. As a firm's size (visibility) changes by one percent, its intensive margin increases by 0.25 (4) percent. In addition, Table 7 shows that SPS measures raised as trade concerns negatively affect Chinese firms' intensive margin of trade. SPS measures raised as concerns at the WTO reduce Chinese firms' export values by 17%, on average. As illustrated by Fontagné et al. (2015), a ten percent increase in tariffs reduced French firm export values by 1.4%. Here, the 17% decline in Chinese firm's export value corresponds to a much more significant impact.

Column 3-4 illustrate the various trade intensive margin effects across firm's ownership structure. On average, state-owned firms exported 42% less than privately held domestic firms. In contrast, foreign invested firms exported 8% more than the private domestic firms on average. Similar to the extensive margin discussed previously, SPS concerns have differential effects on firms' export values across ownership structure. Although, there is no significant difference in the trade flow effect of SPS concerns on state-owned versus domestic private firms, foreign invested firms have clear advantages in adapting to SPS specific trade concerns. As a result, the aggregate effect of STCs on foreign invested firms is two fifths of the negative impact on domestic private firms and SOEs.

3.3.SPS and firm pricing

The price regressions appear in Table 8. As expected, average export prices rise by 6% when a new SPS measure is introduced. One interesting finding is that average export price of Chinese state-owned firms is the lowest among all three types of firms. As suggested by Manova and Zhang (2012), it may imply that product quality of SEOs is the lowest across different ownership structure. In terms of firm characteristics, firm size does not affect a firm's export price much. In contrast, as a firm is more visible to the destination market, the firm charges higher price in the specific market.[15] As indicated in Table 8, if a firm's market share increases by 1%, the export price increases by 23%.

Next, we turn to the impact of SPS measures on the pricing strategy across firms' ownership structure. The influence of SPS concerns on the prices of Chinese state-owned firms and foreign invested firms are in contrast to one another. Column 4 shows that the aggregate impact of SPS concern on foreign invested firms' export prices is negative, while it is positive for SOEs. The imposition of SPS measures increases SOEs' export prices by 18%, and reduces foreign invested firms by 6%. This result is somewhat unexpected. It may imply that foreign invested firms tend to adjust product quality instead of rising prices to maintain competitiveness in destination market.

3.4.Differential effect of SPS measures

As expected, different types of SPS measures have differential effect on firms' trade performance (Crivelli and Groeschl, 2016; Grant and Arita, 2017; Peterson et al., 2013). Table 9 shows the impact of different types of SPS measures on firm's extensive and intensive

[15] Our results are an approximation of this price effect. To better get at this effect, one would need to include destination-by-HS8 product fixed effects to more accurately state visibility increases prices charged by Chinese firms for a given product-and-destination market.

margins and pricing strategy. By ranking the impact of different types of SPS concerns on firms' extensive and intensive margins, phyto-sanitary treatment concerns (PHT) is clearly the most problematic for Chinese exporters. These concerns reduce Chinese firms' exporting likelihood by 14% and trade value by a striking 52%. On the other hand, not all the SPS measures are trade restrictive. Column 2 shows mixed impacts of different SPS measures on intensive margin. Two out of six different SPS measures (Conformity Standards & Risk Assessment (CRA) and Plant Contamination (PLCT)) have significantly positive impact on firms' export value. Particularly, the imposition of CRA can double firms' trade value perhaps because conformity and risk assessment requirements may signal important food safety benefits for consumers.

4. Conclusions

The additional costs brought by SPS measures affect firms' trade decisions from three channels: probability of firms' participation, export values and pricing strategies. Our results show that the imposition of stringent SPS measures reduces the participation of firms in export markets and the value of the exports of the firms that remain in the market. We also find evidence of a price-increasing effect of SPS imposition. Further, SPS measures have differential effects on trade conditional on the ownership structure of firms. Here, we find that SPS measures raised by China at the WTO on the measures maintained by its importing partners impact SOEs relatively more. In addition, the extensive and intensive margins and export prices for SOEs' are all below domestic private and foreign invested firms.

As economic structural reform continues, China's move to private firms and foreign invested enterprises appear to be able to better adapt to destination market regulations. Thus, the decline in SOEs can contribute to a more efficient market structure for firms engaged in agri-food trade. The mixed results of different SPS measures on intensive margin demonstrate that SPS measures are not necessary trade restrictive but have heterogeneous effects.

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Figure 1: SPS notifications by WTO Members

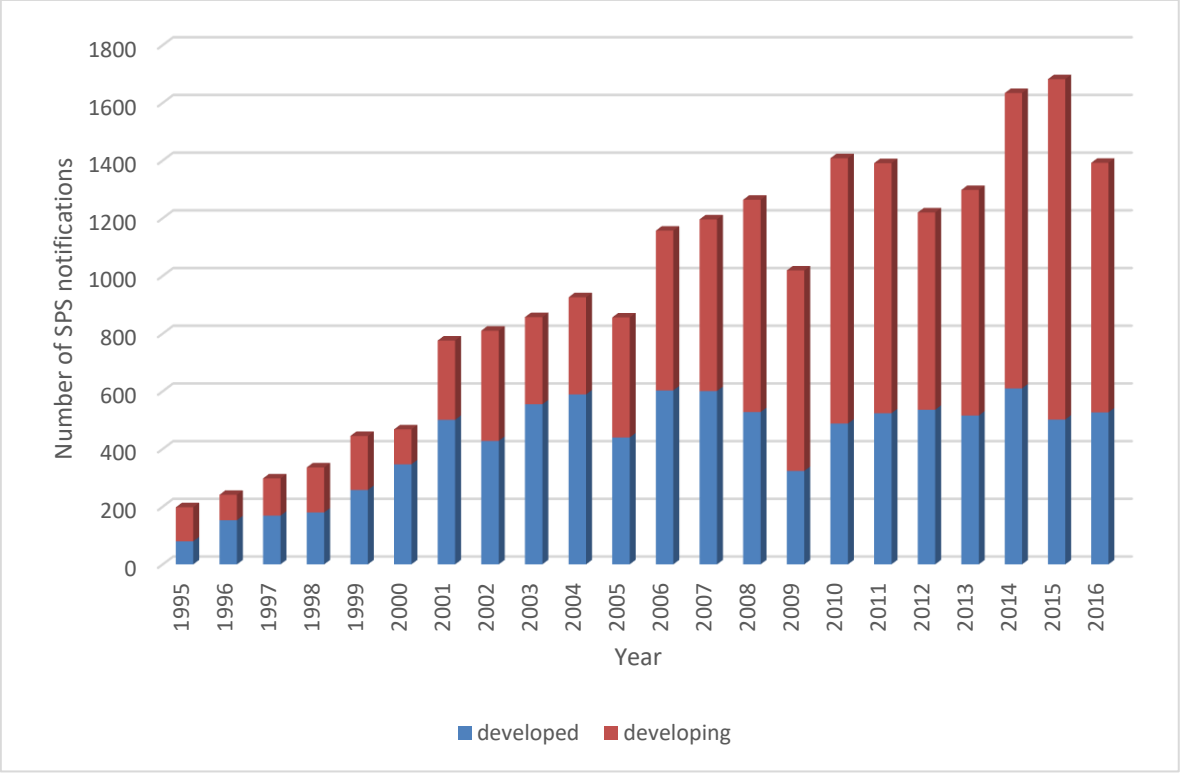

Figure 2: SPS concerns raised by WTO Members

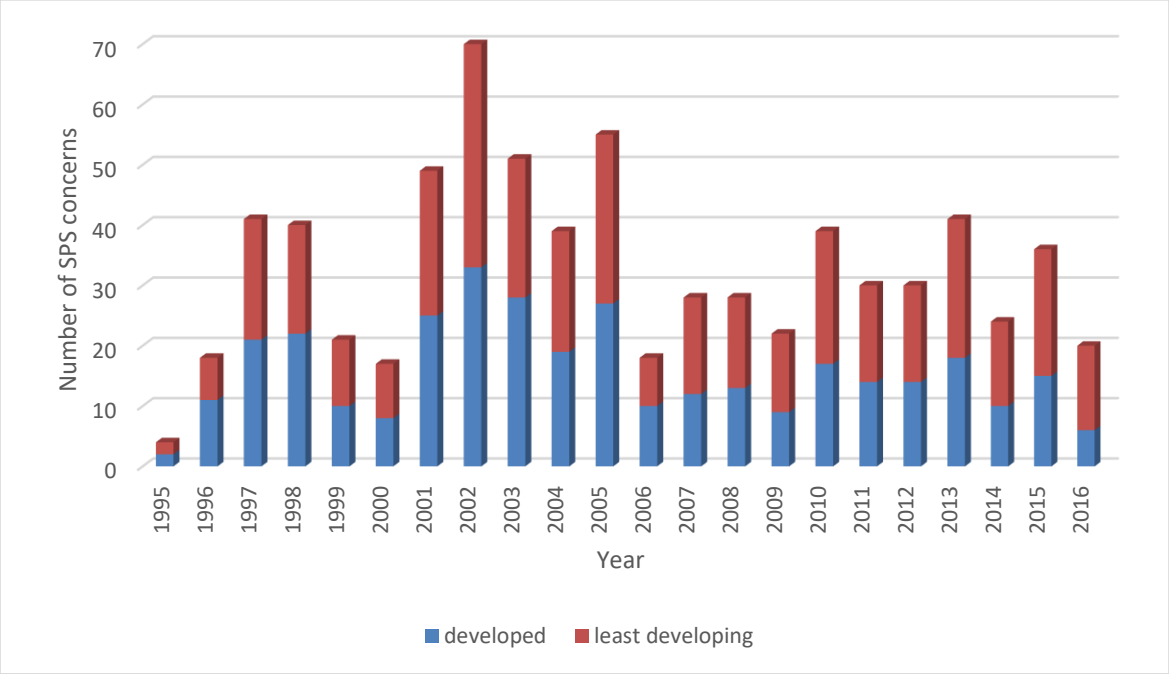

Figure 3: Percentage breakdown of China's SPS STCs by Type (1995-2016)

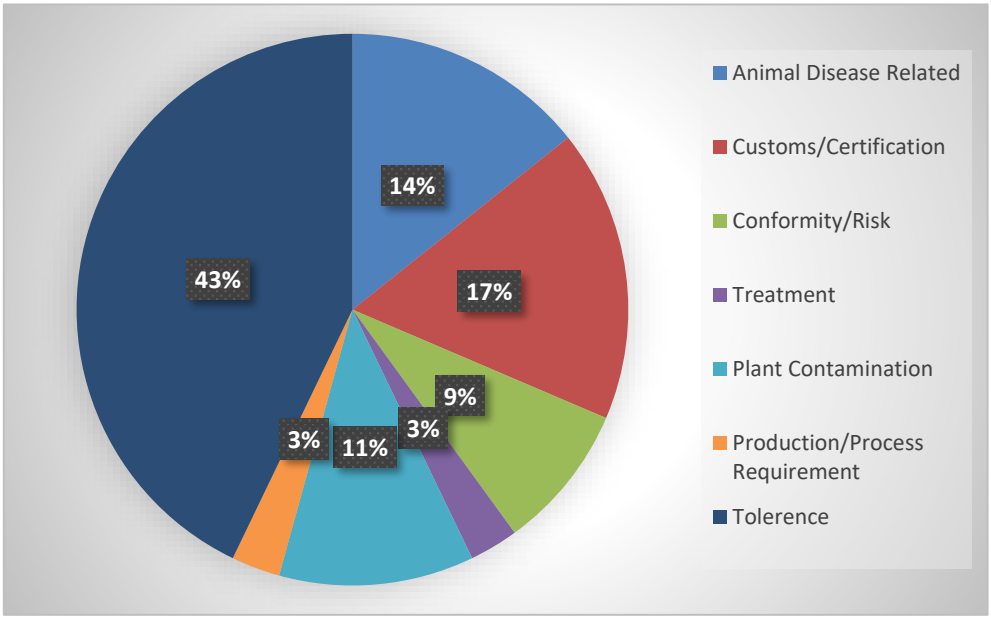

Table 1: Descriptive statistics of Chinese agricultural firms by Chapter

Chapter	2000				2009			
	Average exports by firms (in mil.)	Exporter number	Market number	Product number	Average exports by firms (in mil.)	Exporter number	Market number	Product number
1	1.60	241	27	22	2.20	229	29	24
2	1.54	486	81	56	2.67	293	60	46
3	1.09	2031	80	110	2.88	1745	126	112
4	0.36	496	74	37	1.15	498	114	29
5	0.77	975	79	34	1.50	849	110	30
6	0.06	567	66	19	0.22	655	87	27
7	0.44	3443	131	87	0.91	4413	170	105
8	0.26	1441	69	66	0.95	2137	122	66
9	0.41	1222	124	39	0.77	1577	146	34
10	5.02	303	65	25	2.05	311	102	21
11	0.14	559	73	31	0.82	655	112	30
12	0.34	2475	110	97	0.73	2617	136	88
13	0.13	358	51	18	0.79	542	97	15
14	0.05	805	69	12	0.07	871	90	9
15	0.31	397	77	37	0.87	664	121	39
16	1.49	1258	96	36	3.46	1658	140	46
17	0.33	516	91	16	0.71	866	164	17
18	0.42	69	28	9	1.12	163	113	9
19	0.29	1243	130	20	0.64	1499	170	18
20	0.57	2290	136	73	1.68	3257	183	94
21	0.20	1675	136	19	0.60	1882	172	20
22	0.26	788	102	20	0.96	863	148	25
23	0.33	743	71	28	1.41	1107	111	24
24	7.76	33	68	10	16.13	46	90	10

Table 2: Annual summary statistics of Chinese firms

year	Firm number	Average destinations per firm	Average products per firm	Average country-product combination per firm	Average export per firm (in mil $)
2000	9,772	3.39	5.72	8.94	1.45
2001	10,389	3.5	5.49	8.89	1.55
2002	10,756	3.65	5.41	8.92	1.55
2003	11,987	3.66	4.97	8.5	1.65
2004	13,475	3.58	4.72	8.13	1.59
2005	13,312	3.67	4.52	8.04	1.81
2006	17,776	3.45	4.37	7.49	1.63
2007	19,212	3.46	4.22	7.29	1.73
2008	16,731	3.81	3.48	7.01	2.21
2009	17,199	3.79	3.56	7.15	2.16

Table 3: Annual summary statistics by ownership structure.

year	State-owned			Foreign joint venture			Foreign affiliates			Domestic private		
	firm number	avg export value (in $ mil)	avg country-product comb	firm number	avg export value (in $ mil)	avg country-product comb	firm number	avg export value (in $ mil)	avg country-product comb	firm number	avg export value (in $ mil)	avg country-product comb
2000	4,599	1.9	13.4	2,645	1.2	4.7	1,613	0.9	4.9	904	0.9	5.9
2001	4,556	1.9	13.1	2,597	1.6	5.2	1,804	1.2	5.3	1,429	0.9	6.6
2002	4,196	1.9	13.0	2,427	1.8	5.8	1,868	1.3	6.0	2,263	0.9	7.2
2003	3,736	2.3	12.8	2,436	2.0	6.2	2,098	1.4	6.3	3,715	0.9	6.9
2004	3,144	2.1	12.7	2,425	2.5	6.8	2,236	1.7	6.6	5,669	0.9	6.8
2005	2,581	2.6	12.3	2,292	2.9	7.2	2,287	2.0	6.8	6,151	1.0	7.1
2006	2,239	2.8	12.1	2,287	3.3	7.6	2,533	2.2	6.9	10,717	0.9	6.6
2007	1,938	3.6	11.8	2,103	3.8	7.7	2,561	2.4	6.9	12,602	1.0	6.6
2008	1,692	3.8	11.3	2,001	4.4	7.8	2,352	2.9	6.7	10,677	1.4	6.3
2009	1,549	3.6	11.4	1,968	4.3	8.1	2,334	2.8	6.6	11,320	1.5	6.5

Table 4: Churning rates in the conditional sample

Panel A: Churning rates of firm-HS4-destinations

	Fontagné et al. (2015)			Chinese firm data	
	Number of firm-HS4-destinations	Share of total		Number of firm-HS4-destinations	Share of total
Exporting for the whole period	28,787	16%	Exporting for the whole period	2,601	5%
Exporting =4 times	14,752	8%	Exporting =4 times	21,856	39%
Exporting >4 times	137,356	76%	Exporting >4 times	30,975	56%

Panel B: HS4-destinations Influenced by SPS concerns

	Fontagné et al. (2015)			Chinese firm data	
	Number of HS4-destinatiosn	Share of total		Number of HS4-destinatiosn	Share of total
Variance in SPS	110	1%	Variance in SPS	234	5.3%
No variance in SPS	11,553	99%	No variance in SPS	4,210	94.7%

Table 5: Sample descriptive statistics

Variable	**Obs.**	**Mean**	**Std Dev**	**Min**	**Max**
SPS concern	554,320	0.04	0.20	0	1
Firm size (ln)	413,972	14.46	2.02	0	20.40
Firm visibility (ln)	547,982	0.02	0.08	0	0.69
State-owned firms	554,320	0.34	0.47	0	1
Foreign-invested firms	554,320	0.36	0.48	0	1
Extensive	554,320	0.55	0.50	0	1
Intensive	305,417	11.35	2.14	0	19.75
Price(ln)	305,383	0.37	1.26	-9.71	9.56

Table 6: Extensive-margin estimations

	(1)	(2)	(3)	(4)
lnsize	0.01***	0.01***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
lnvis	1.10***	1.10***	1.08***	1.08***
	(0.01)	(0.01)	(0.01)	(0.01)
stc	-0.05***		-0.05***	-0.01*
	(0.00)		(0.00)	(0.01)
stc_lead		-0.05***		
		(0.00)		
SOE			-0.12***	-0.11***
			(0.00)	(0.00)
foreign			-0.05***	-0.05***
			(0.00)	(0.00)
SOE_stc				-0.08***
				(0.01)
foreign_stc				-0.04***
				(0.01)
Observations	411,030	411,030	411,030	411,030
Adjusted R-squared	0.079	0.079	0.089	0.089
rmse	0.419	0.419	0.417	0.417

Note: Standard errors are in parentheses Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% level. The dependent variable is firm's export status (export=1, 0 otherwise) to a given product (at HS 4-digit level)-destination market in each year. *lnsize* and *lnvis* denotes the natural logarithm of firms' size and visibility. *stc* represents the existence of an ongoing SPS trade concern in product category *s* between China and an importing country *j* at time *t. stc_lead* is a one-year lead variable of *stc* to capture the lead-lag effect. *SOE* and *foreign* are dummy variables representing SOEs and foreign invested firms respectively. *SOE_stc* and *foreign_stc* are the interaction term of SPS concerns and different types of firms. Three sets of fixed effects are included in each of the models: country, products (at HS 4-digit level) and year fixed effects.

Table 7: Intensive-margin estimation

	(1)	(2)	(3)	(4)
lnsize	0.24***	0.24***	0.27***	0.27***
	(0.00)	(0.00)	(0.00)	(0.00)
lnvis	4.16***	4.16***	4.02***	4.02***
	(0.04)	(0.04)	(0.04)	(0.04)
stc	-0.17***		-0.17***	-0.20***
	(0.02)		(0.02)	(0.03)
stc_lead		-0.17***		
		(0.02)		
SOE			-0.55***	-0.55***
			(0.01)	(0.01)
foreign			0.09***	0.08***
			(0.01)	(0.01)
SOE_stc				-0.06
				(0.04)
foreign_stc				0.09**
				(0.04)
Observations	305,417	305,417	305,417	305,417
Adjusted R-squared	0.266	0.266	0.281	0.281
rmse	1.835	1.835	1.817	1.817

Note: Standard errors are in parentheses Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% level. The dependent variable is firm's positive export value to a given product (at HS 4-digit level)-destination market in each year. *lnsize* and *lnvis* denotes the natural logarithm of firms' size and visibility. *stc* represents the existence of an ongoing SPS trade concern in product category *s* between China and an importing country *j* at time *t. stc_lead* is a one-year lead variable of *stc* to capture the lead-lag effect. *SOE* and *foreign* are dummy variables representing SOEs and foreign invested firms respectively. *SOE_stc* and *foreign_stc* are the interaction term of SPS concerns and different types of firms. Three sets of fixed effects are included in each of the models: country, products (at HS 4-digit level) and year fixed effects.

Table 8: Price estimation

	(1)	(2)	(3)	(4)
lnsize	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
lnvis	0.27***	0.27***	0.23***	0.23***
	(0.02)	(0.02)	(0.02)	(0.02)
stc	0.06***		0.06***	0.13***
	(0.01)		(0.01)	(0.01)
stc_lead		0.06***		
		(0.01)		
SOE			-0.05***	-0.05***
			(0.00)	(0.00)
foreign			0.11***	0.12***
			(0.00)	(0.00)
SOE_stc				0.05***
				(0.02)
foreign_stc				-0.19***
				(0.02)
Observations	305,383	305,383	305,383	305,383
Adjusted R-squared	0.574	0.574	0.577	0.577
rmse	0.820	0.820	0.817	0.817

Note: Standard errors are in parentheses Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% level. The dependent variable is firm's export price in a given product (at HS 4-digit level)-destination market in each year. *lnsize* and *lnvis* denotes the natural logarithm of firms' size and visibility. *stc* represents the existence of an ongoing SPS trade concern in product category *s* between China and an importing country *j* at time *t. stc_lead* is a one-year lead variable of *stc* to capture the lead-lag effect. *SOE* and *foreign* are dummy variables representing SOEs and foreign invested firms respectively. *SOE_stc* and *foreign_stc* are the interaction term of SPS concerns and different types of firms. Three sets of fixed effects are included in each of the models: country, products (at HS 4-digit level) and year fixed effects.

Table 9: Impact of different types of SPS measures

	Extensive margin	Intensive margin	Price
lnsize	0.01***	0.24***	0.01***
	(0.00)	(0.00)	(0.00)
lnvis	1.10***	4.16***	0.27***
	(0.01)	(0.04)	(0.02)
ADR	0.09**	-0.02	0.35***
	(0.04)	(0.20)	(0.09)
CPCL	-0.04***	-0.16***	-0.34***
	(0.01)	(0.05)	(0.02)
CRA	-0.03	1.01***	0.14
	(0.05)	(0.25)	(0.11)
PHT	-0.14***	-0.52**	0.23**
	(0.05)	(0.24)	(0.11)
PLCT	0.03*	0.36***	0.05
	(0.02)	(0.08)	(0.04)
TOL	-0.06***	-0.21***	0.14***
	(0.00)	(0.02)	(0.01)
Observations	411,030	305,417	305,383
Adjusted R-squared	0.079	0.266	0.575
rmse	0.419	1.835	0.819

Note: Standard errors are in parentheses Single, double, and triple asterisks (*, **, ***) denote significance at the 10%, 5%, and 1% level. lnsize and lnvis denotes the natural logarithm of firms' size and visibility. ADR denotes animal disease related; CPCL denotes customs, procedures, certification and licensing; CRA denotes conformity standards & risk assessment; FAD denotes food additives & alterations; MICB denotes microbiological related; PHT denotes treatments; PLCT denotes plant contamination; PPR denotes production & process requirements; and TOL denotes tolerance and limits. For more information, see Grant and Arita (2017) table 3. Three sets of fixed effects are included in each of the models: country, products (at HS 4-digit level) and year fixed effects.