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Sanitary and Phytosanitary Measures in Chinese Agricultural Exports: The Role of Trade Intermediaries

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Abstract

We study the effect of sanitary and phytosanitary (SPS) measures on Chinese agricultural exports and the role of trade intermediaries in this process following China's accession to the World Trade Organization. While agricultural exports and SPS regulations have both grown, the use of trade intermediaries has declined sharply. We develop a model of heterogeneous producer-level decisions about choice of export mode that is consistent with this trend. In our econometric analysis, we analyze the effects of SPS measures and trade intermediaries on Chinese fruit and vegetable exports using transaction-level customs data. In contrast to much of the literature, we find a positive relationship between SPS measures and exports. The interaction between SPS measures and the use of trade intermediaries is, however, negative, which is also consistent with our model of producers' export mode decisions.

Keywords: Chinese agricultural exports, trade intermediaries, SPS measures

JEL: F1

1 Introduction

Since joining the World Trade Organization (WTO) in 2001, Chinese exports have benefited from reductions in barriers to trade, including tariffs, quantitative restrictions, and other nontariff trade barriers. There has, however, been increased concern about the impact of sanitary and phytosanitary (SPS) measures on China's agricultural exports. The WTO Agreement on the Application of SPS Measures permits countries to adopt their own sets of regulations based on risk assessment, as long as the enforced measures are not disguised protectionism. While these measures can help protect plant, animal, and human health, they can also be barriers to trade. In this paper, we consider how SPS measures have affected Chinese agricultural exports since China's WTO accession, and we consider the role of intermediaries in facilitating trade and helping producers deal with SPS regulations affecting Chinese agricultural exports.

The importance of trade intermediaries has been documented in some recent studies, such as Ahn et al. (2011), Blum et al. (2010), and Wang and Gibson (2015). One view of trade intermediaries is that they facilitate trade by playing a quality-sorting role. Another view, which we emphasize in this paper, is that trade intermediaries facilitate trade for producers that lack the economies of scale to export directly. These producers tend to be smaller and less efficient and tend to produce goods of lower quality. Wang and Gibson (2015) develop a model of the latter view, and we apply this model here. In the model, firms are heterogeneous in both productivity and quality. A firm's choice of export mode depends on a particular measure of what we refer to as an exporter's *quality-adjusted productivity*. Only those exporters with the highest levels of quality-adjusted productivity choose to export directly. The model can capture the fact that direct exporters tend to be large than indirect exporters and tend to charge higher prices for their goods. Without quality heterogeneity, direct exporters would be larger but would charge *lower* prices than indirect exporters. This is important because there is broad evidence that unit prices are strongly influenced by quality and that larger firms tend to charge higher unit prices (see, for example, Kugler and Verhoogen (2012), Feenstra and Romalis (2013), and Crozet et al. (2012)).

We focus on three issues raised by the model. The model implies that, following China's accession to the WTO and reductions in trade barriers, Chinese producers should increasingly export their goods directly rather than through trade intermediaries. The broad trends in Chinese agricultural exports are consistent with this. Second, if we interpret SPS measures as higher quality standards in the model, then, all else equal, this should lead to increased demand for the affected products. At the same time, SPS measures may raise prices and act as trade barriers in other ways. The model therefore raises the issue of whether SPS measures have been, in the language of Anders and Caswell (2009), standards as barriers or standards as catalysts for Chinese agricultural exports. Third, the model implies that the producers best able to meet the higher quality standards will tend to export directly. This leads us to hypothesize that there is a negative association between the extent of SPS measures and the use of trade intermediaries. This implication of the model is in contrast to the view that trade intermediaries provide a quality-sorting role, so analyzing the data is important in distinguishing between these views.

In our econometric analysis, we consider the last two issues with respect to Chinese fruit and vegetable exports. In addition to our customs data, we collect data on SPS notifications, trade barriers, and foreign demand. We then run three different types of regressions: panel, Poisson, and zero-inflated Poisson. Due to the presence of many zero trade flows, the panel regression is problematic, as shown by Santos Silva and Tenreyro (2006). For the other two regressions, the effects of SPS measures on exports are positive and statistically significant. This suggests that, for Chinese fruit and vegetable exports, SPS measures have been a trade catalyst rather than a trade barrier, perhaps because they signal higher quality and increase demand. When we interact the SPS measure with a dummy for trade intermediaries, however, the effect becomes negative and statistically significant. This suggests that trade intermediaries do not play a particularly important quality-sorting role in reducing SPS measures in Chinese agricultural exports. Rather, consistent with the theoretical model, trade intermediaries are more likely facilitating trade for producers that lack the economies of scale to export directly, and these producers tend not to be as well-positioned to meet SPS requirements.

There is a large literature on the trade effects of SPS measures, and we cite some of the most relevant studies here. Calvin and Krissoff (1998) examine the trade and welfare impacts of removing SPS measures and tariffs on U.S. apple exports to Japan. Henson and Loader (2001) find, using survey data, that SPS measures in developed countries impede developing-country exports of agricultural and food products. Peterson et al. (2013) use a product-line gravity equation to investigate the impact of different pest-mitigation measures on trade. They find that these measures generally reduce trade, but not for long: the actual restrictiveness of these measures diminishes as exporters accumulate experience and eventually dies out. We have not found a paper that jointly considers the roles of SPS measures and trade intermediaries.

The paper proceeds as follows. Section 2 presents the model, Section 3 discusses the data, Section 4 presents the econometric analysis, and Section 5 concludes.

2 Model

There is a continuum of monopolistically competitive exporters producing differentiated goods. There is a single factor of production, which we refer to as labor (though it could be considered a composite of factors), and the factor price is normalized to one. Each producer endogenously decides whether to export to a given market and, if so, whether to export directly or through an intermediary. Going through an intermediary lowers the fixed cost of exporting but raises the marginal cost.

2.1 Import Demand

For a given destination country i, there is a continuum of differentiated import goods denoted by X_i and the goods differ in quality. Consumers have CES preferences over imported goods:

$$U_i = \left(\int_{X_i} (\eta(x) c_i(x))^{\frac{\sigma-1}{\sigma}} \, dx \right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $c_i(x)$ is the quantity consumed of variety x, $\eta(x)$ is the quality of variety x, and $\sigma > 1$ is the elasticity of substitution between any two varieties. Utility maximization implies that the demand function for each good takes the form

$$c_i(x) = \eta(x)^{\sigma-1} p(x)^{-\sigma} B_i, \tag{2}$$

where $p(x)$ is the price of the good and B_i is a demand factor that takes into account both the size of market i and the trade barriers involved in exporting to that market.

2.2 Exporters

There is a continuum of monopolistically competitive export firms. Firms are heterogeneous in three state variables: productivity, quality, and export mode. The first two state variables are random draws from a joint probability distribution $G(\cdot,\cdot)$, while the third is endogenously chosen by each firm. If a firm chooses to export, it must choose between being a *direct exporter* (denoted by D) or an *indirect exporter* (denoted by I). Indirect exporters sell their products through *trade intermediaries*. Trade intermediaries raise the marginal cost of exporting but lower the fixed cost of exporting.

Output of a direct exporter with draw (η, z) is given by

$$y_D(\eta, z) = \frac{z l_D(\eta, z)}{\eta^\theta}, \tag{3}$$

where $l_D(\eta, z)$ is the input of labor. Output of an indirect exporter with draw (η, z) is given by

$$y_I(\eta, z) = \frac{z l_I(\eta, z)}{\gamma \eta^\theta}, \tag{4}$$

where $l_I(\eta, z)$ is the input of labor. Here $\gamma > 1$ is the factor increase in marginal cost caused by exporting through a trade intermediary and $\theta \in (0, 1)$ determines the extent to which producing higher-quality goods requires more labor per unit. The fixed cost of operating technology j is f_j. Here $f_D > f_I$ to reflect the role of trade intermediaries in reducing fixed costs of trade. Profits are then given by

$$\pi_j(\eta, z) = p_j(\eta, z) y_j(\eta, z) - l_j(\eta, z) - f_j, \tag{5}$$

$j = D, I$.

Taking the demand function (2) as given, each firm chooses the price of its good to maximize profits. As usual, the profit-maximizing prices are constant markups over marginal cost:

$$p_D(\eta, z) = \frac{\sigma}{\sigma - 1} \frac{\eta^\theta}{z} \tag{6}$$

$$p_I(\eta, z) = \frac{\sigma}{\sigma - 1} \frac{\gamma \eta^\theta}{z}. \tag{7}$$

2.3 Selection of Export Mode

Each firm endogenously decides whether to export and, if so, which export mode to use. The choice of export mode depends on a particular measure of *quality-adjusted productivity*:

$$q(\eta, z) = \eta^{(\sigma-1)(1-\theta)} z^{\sigma-1}. \tag{8}$$

Given our restrictions on σ and θ, this measure is increasing in both quality and productivity. To see why export mode depends on this measure, notice that we can express profits as

$$\pi_{iI}(\eta, z) = q(\eta, z) \gamma^{1-\sigma} \bar{B}_i - f_I \tag{9}$$

$$\pi_{iD}(\eta, z) = q(\eta, z) \bar{B}_i - f_D, \tag{10}$$

where $\bar{B}_i$ is a constant that depends on B_i.

We can now define cutoffs in terms of quality-adjusted productivity. Let

$$\overline{q}_{iI} = \frac{f_I}{\gamma^{1-\sigma} \bar{B}_i} \tag{11}$$

$$\overline{q}_{iD} = \frac{f_D - f_I}{\left(1 - \gamma^{1-\sigma}\right) \bar{B}_i}. \tag{12}$$

Assuming that $f_I / \gamma^{1-\sigma} < (f_D - f_I) / \left(1 - \gamma^{1-\sigma}\right)$, firms will be partitioned into different export modes by quality-adjusted productivity: a firm with draw (η, z) will not export to country i if $q(\eta, z) < \overline{q}_{iI}$, will export through an intermediary if $\overline{q}_{iI} \leq q(\eta, z) < \overline{q}_{iD}$, and will export directly if $q(\eta, z) \geq \overline{q}_{iD}$.

2.4 Model Implications to Test

Our goal is to bring data to bear on some implications of the model with respect to Chinese agricultural exports, SPS measures, and trade intermediaries. We are particularly interested in the following three issues.

First, an important implication of the model is that, following China's accession to the WTO and reductions in trade barriers (leading to increases in demand factor B_i), Chinese producers should increasingly export their goods directly rather than through trade intermediaries.

Second, though the model does not explicitly consider SPS measures, we can interpret SPS measures as higher quality standards (that is, a higher lower bound on η). All else equal, this should lead to increased demand for the affected products. At the same time, SPS measures may raise prices and act as trade barriers in other ways. The model therefore raises the issue of whether SPS measures have been, in the language of Anders and Caswell (2009), standards as barriers or standards as catalysts in Chinese agricultural exports.

Third, the model implies that the producers best able to meet the requirements of SPS measures (higher quality standards) will tend to export directly. This leads us to hypothesize that there is a negative association between the extent of SPS measures and the use of trade intermediaries. This implication of our model is in stark contrast to models in which trade intermediaries provide a quality-sorting role, so analyzing the data is important in distinguishing between these types of models.

3 Data

For our trade data, we use Chinese customs data at the transaction level from 2000–2006. For each shipment, there is data on value, f.o.b. unit price, destination country, 8-digit HS product code, and exporting firm name. We identify firms that are acting as trade intermediaries following the method of Ahn et al. (2011).[1] To identify agricultural products, we primarily use the 2-digit HS code, with a product being considered agricultural if the code is 24 or less. In addition to this, we classify certain other products at more disaggregated HS levels as agricultural.[2]

Table 1 shows a number of major trends from the Chinese customs data. Total exports increased dramatically during this period. Agricultural exports also increased, but at a slower rate than total exports, so agriculture's share of Chinese export value fell by more than half. Our main interest, however, is in the fact that the share of agricultural export value going through trade intermediaries declined sharply. This is consistent with the model's implication that, following China's accession to the WTO, Chinese producers should increasingly export their goods directly rather than through trade intermediaries.

In Figures 1 and 2, we map the role of trade intermediaries in Chinese agricultural exports by province in 2000 and 2006, respectively. In 2000, before China joined the WTO, only a few provinces directly exported more than half of the value of their agricultural exports. These provinces were primarily coastal and thus better positioned to export directly. By 2006, however, a large majority of Chinese

[1] Specifically, we search firms' names for Chinese characters that mean trading, export, or import. In pinyin (Romanized Chinese), these phrases are *jinchukou*, *jingmao*, *waijing*, *kemao*, *shangmao*, *maoyi*, and *waimao*.

[2] These are products with HS codes 3301, 3501–3505, 4101–4103, 4301, 5001–5003, 5101–5103, 5201–5203, 5301, 5302, 29054300, and 29054400.

Table 1: Value of Chinese Exports

Year	Obs. (mils.)	Total ($\$10^{10}$)	Ag. ($\$10^{10}$)	Ag. share (% of total)	Int. ag. ($\$10^{10}$)	Int. ag. share (% of ag.)
2000	5.1	24.6	1.5	6.2	0.77	51.3
2001	6.4	29.0	1.7	5.9	0.77	45.3
2002	7.4	32.6	1.8	5.5	0.75	41.7
2003	9.2	43.8	2.1	4.8	0.82	39.0
2004	11.3	59.4	2.3	3.9	0.71	30.9
2005	13.7	75.7	2.7	3.6	0.72	26.7
2006	17.5	105.0	3.1	3.0	0.98	31.6

provinces were directly exporting more than half of the value of their agricultural exports.

To obtain data on SPS measures, we use the WTO's SPS Information Management System. These regulations can be complicated and difficult to quantify, so we focus on the number of SPS notifications by year. Admittedly, these count data are a crude measure of the extent of SPS regulations, but they capture an important trend. From 2000–2006, the total number of SPS measures increased from 271 to 1,100. With rare exceptions, SPS measures are enforced unilaterally by importing countries and are applicable to all exporting countries (Disdier, Fontagné, and Mimouni (2007)). The database does not classify SPS measures by HS code. We therefore had to categorize them manually and did so only by broad sector. Table 2 shows the share of SPS notifications by sector from 2000–2006.

Since fruits and vegetables are the products most affected by SPS measures (and the most easily categorizable), the analysis that follows focuses on these products only. In the Chinese customs data, we identify fruits and vegetables as those products with 2-digit HS codes from 06–14. For data on other barriers to trade, we use data on tariff rates (from the WTO) and great-circle distances from China

Figure 1: Share of Agricultural Exports that were Intermediated in 2000

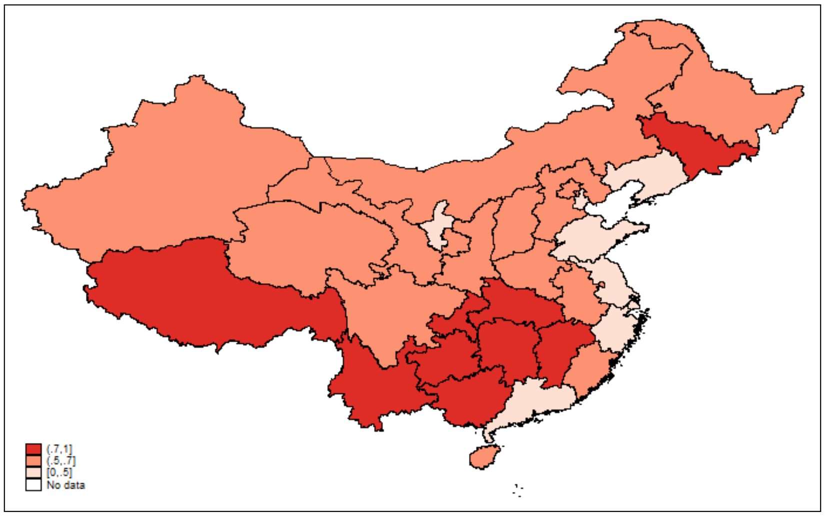

Figure 2: Share of Agricultural Exports that were Intermediated in 2006

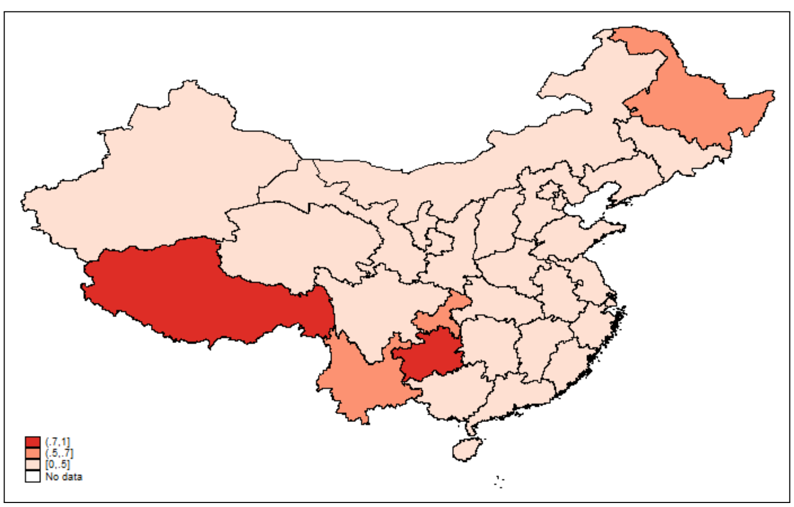

Table 2: Share of SPS Measures by Sector, 2000–2006

Sector	Share (%)
Fruits and vegetables	49.2
Animals and animal products	38.7
Processed foods	5.0
Prepared foodstuffs	2.3
Wood products	2.1
Chemical products	1.2

to other countries. For data on overall demand in export destination countries, we use a monthly industrial production index from the OECD (GDP is not available on a monthly basis). For the econometric analysis that follows, we merge these data sets.

4 Econometric Analysis

Econometric analysis of bilateral trade flows typically uses some version of a gravity equation. Anderson and van Wincoop (2003), among others, provide theoretical foundations for a gravity equation. We are only analyzing unilateral trade flows, so we take a similar but simpler approach and do so at the level of the 8-digit HS code. In the context of our simple theoretical model, expenditure by country i on imported good z is given by

$$p(z)c_i(z) = \left(\frac{\eta(z)}{p(z)}\right)^{\sigma-1} B_i. \tag{13}$$

We interpret the demand factor, B_i, as taking into account not only overall demand in country i but also the effects of trade barriers such as distance, tariffs, and potentially SPS measures. The quality variable, $\eta(z)$, may be thought of as taking into account the positive effects of SPS measures on demand.

We estimate export demand as follows:

$$\log exports_{iket} = \alpha_{ike} + \alpha_t + \beta_1 \log dist_i + \beta_2 \log(1+\tau_{ikt}) + \beta_3 \log p_{iket} + \beta_4 \log Y_{it} + \beta_5 SPS_{it} + \beta_6 SPS_{it-1} + \beta_7 SPS_{it} int_e + \varepsilon_{iket}. \quad (14)$$

Here $exports_{iket}$ is the value of a shipment from China to country i of a product of type k by exporting firm e at time t; α_{ike} is the fixed effect for importing country i, product-type k, and exporting firm e; α_t is the fixed effect for time; $dist_i$ is the great-circle distance between China and country i; τ_{ikt} is the tariff rate imposed by importing country i on product-type k at time t; p_{iket} is the f.o.b. unit price of a type-k product shipped to country i by exporting firm e at time t; Y_{it} is industrial production in country i at time t; SPS_{it} is the number of SPS notifications made by country i at time t; SPS_{it-1} is the lag of SPS_{it}; int_e is a dummy variable indicating whether exporting firm e is a trade intermediary; and ε_{iket} is an error term. Table 3 provides the summary statistics for the data.

Baldwin and Taglioni (2006) stress the importance of allowing for fixed effects in gravity-type models. We thus allow for fixed effects for destination countries, 8-digit HS codes, and exporting firms (α_{ike}) in addition to time (α_t). Since SPS measures may take time to be fully enforced, we allow for SPS notifications with a lag (SPS_{it-1}). We are particularly interested in the interaction between SPS measures and the use of trade intermediaries, so we capture this with the product of SPS_{it} and the dummy variable for a trade intermediary, int_e.

In addition to the panel regression, we consider both the Poisson and zero-inflated Poisson (ZIP) regressions. We consider the Poisson regression because there are many instances of zero trade flows in our data. As Santos Silva and Tenreyro (2006) show, estimating (14) directly without considering zero trade flows gives biased results, particularly if the reason for the existence of zero trade is correlated with trade costs. Firms may not self-select into exporting because of SPS measures, which could account for why zeros exist but not for random reasons. Following Peterson et al. (2013), we also consider a ZIP regression. This is because the Poisson specification has been criticized for two reasons. First, it assumes equal dispersion between the conditional mean and variance (Cameron and Trivedi (1990)). Second, it cannot deal with excessive zeros that may be the result of a different data-generating process (Burger, van Oort, and Linders (2009)). Peterson et al. (2013) address these concerns by employing a ZIP regression as a robustness check on the Poisson regression.

Table 4 presents the estimation results for each of the three specifications. As we discuss below, the panel regression performs poorly, as expected due to the presence of many zero trade flows. The Poisson and ZIP regressions provide sensible and very similar results. Table 4 also reports the results of a Vuong test comparing the Poisson and ZIP models. The test indicates that the ZIP regression fits the data better than the Poisson regression.

Examining Table 4, we see that, with the panel regression, the effect of SPS measures is not statistically significant. The panel regression also gives the implausible result that tariffs have a positive effect on Chinese agricultural exports. With the Poisson and ZIP regressions, the estimated coefficients for price, destination country production, tariffs, and distance have the anticipated sign and are statistically significant. In contrast to many of the studies cited in Section 1, the effects of SPS notifications and their lag are both statistically significantly positive. This suggests that, for Chinese fruit and vegetable exports, SPS measures fit the role of standards as catalysts better than standards as barriers. Finally, when we interact

Table 3: Summary Statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
$exports_{iket}$	$436,959$	$39,342.5$	$160,906.9$	0	$7.64e+07$
$\log p_{iket}$	$436,760$	-0.354	1.230	-10.127	6.685
$\log Y_{it}$	$390,790$	24.118	1.729	17.445	26.318
$\log(1+\tau_{ikt})$	$426,636$	0.163	0.117	0	1.975
$\log dist_i$	$410,631$	$4,642.985$	$3,638.585$	956.172	$19,285.97$
SPS_{it}	$332,222$	1.884	5.691	0	59

the SPS measure with a trade intermediary dummy, the effect becomes statistically significantly negative. This suggests that, consistent with our model, trade intermediaries are primarily facilitating trade for producers that are not well-positioned to meet SPS requirements, such as those that are smaller, less efficient, and producing lower-quality goods. This is also consistent with the general trend, discussed in Section 3, of declining use of trade intermediaries despite growing SPS regulations.

Table 4: Estimation Results

	Dependent variable: $exports_{iket}$		
Estimation method	Panel	Poisson	ZIP
Vuong test			94.65^{***}
			(0.00)
constant	6.130^{***}	1.912^{***}	44.117^{***}
	(0.179)	(0.017)	(1.013)
$\log p_{iket}$	0.451^{***}	0.025^{***}	0.025^{***}
	(0.006)	(0.001)	(0.000)
$\log Y_{it}$	0.138^{***}	0.018^{***}	0.018^{***}
	(0.006)	(0.001)	(0.000)
$\log(1+\tau_{ikt})$	0.152^{***}	-0.028^{***}	-0.029^{***}
	(0.066)	(0.007)	(0.004)
$\log dist_i$	-0.018^{***}	-0.009^{***}	-0.009^{***}
	(0.012)	(0.001)	(0.001)
SPS_{it}	0.001	0.001^{***}	0.001^{***}
	(0.001)	(0.000)	(0.000)
SPS_{it-1}	0.0003	0.0004^{***}	0.0004^{***}
	(0.001)	(0.000)	(0.000)
$SPS_{it}int_e$	-0.002	-0.002^{***}	-0.002^{***}
	(0.001)	(0.000)	(0.000)
Observations	167,820	167,820	167,820

5 Conclusion

We study the effect of SPS measures on Chinese agricultural exports and the role of trade intermediaries in this process following China's accession to the WTO. While agricultural exports and SPS regulations have both grown, the use of trade intermediaries has declined sharply. We develop a model of producer-level decisions about choice of export mode that is consistent with this trend. In our econometric analysis, we analyze the effects of SPS measures and trade intermediaries on Chinese fruit and vegetable exports. In contrast to much of the literature, we find a positive relationship between SPS measures and exports. The interaction between SPS measures and the use of trade intermediaries is, however, negative. This is also consistent with our model of producers' export mode decisions. We think the intersection of trade, intermediaries, and SPS and other regulations is a fruitful area for future research and worth studying in contexts beyond the one considered here.

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