Three Essays on Agricultural Trade Policy

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(ABSTRACT)

This dissertation consists of three essays examining the impacts of Sanitary and Phytosanitary (SPS) Measures on agricultural trade. The first essay estimates the impact of the 2003 Bovine Spongiform Encephalopathy (BSE) outbreak in the US on Japanese beef imports. I develop a source-differentiated demand system of fresh/chilled and frozen beef imports augmented with endogenous smooth transition functions. Results suggest that over one-half of the estimated income, own-price, and cross-price elasticities reached a new regime in the post-BSE period of Japanese beef imports where the competitive relationship and substitutability between US and Australian beef exports changed significantly. The second essay develops a product-line structural gravity model to estimate the trade flow effects of SPS measures that have been flagged as specific trade concerns in the World Trade Organization's (WTO's) SPS Committee meetings for the top 30 agricultural trading countries covering four major product sectors. Our findings are striking and call attention to the need for deeper understanding of the impacts of SPS measures on WTO members' agricultural trade. Results show that the trade effects of SPS trade concern measures reduce exporters' agricultural trade by 67%, on average, during periods in which concerns were active. Significant heterogeneity in the trade effect of SPS measures exists with average estimated ad valorem equivalent tariffs ranging from 33% to 106%. The AVE effect of SPS concern measures maintained by the US is estimated at 42%, less than a half (a third) of the AVE effects of SPS concern measures imposed by the European Union (China). China's restrictions on Avian Influenza and ractopamine restrictions in pork exports are estimated to be the most prohibitive, causing an AVE effect of 120.3% and 88.9%, respectively. The third essay develops a discrete-time duration model to examine the extent to which these SPS concern measures affect the hazard rate of US agri-food exports during the 1995-2016 period. Results show that SPS concern measures raise the hazard rate of US agri-food exports by a range of 2.1%~15.3%, causing the predicted hazard rate to increase from 21.8% to a range of 23.6% ~27.9%. This effect is heterogeneous across different agricultural sectors, with the most substantial effects occurring in US exports of meat, fruits, and vegetables.

Three Essays on Agricultural Trade Policy

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(GENERAL AUDIENCE ABSTRACT)

This dissertation consists of three essays on the examination of Sanitary and Phytosanitary (SPS) Measures and their impacts on agricultural trade. The first essay estimates the impact of the US 2003 Bovine Spongiform Encephalopathy (BSE) outbreaks on Japanese beef imports. Using a source-differentiated demand system of fresh/chilled and frozen beef imports embedded with endogenous smooth transition functions, we find that over one-half of the estimated income, own-price, and cross-price elasticities have changed remarkably, causing the Japanese beef import market to reach a new regime in the post-BSE period where the substitution and/or competition relationships between the US and Australia have changed. The second essay develops a product-line structural gravity model to estimate the trade effects of SPS measures flagged as concerns in the WTO's SPS Committee meetings for the top 30 agricultural trading countries covering four major product sectors. Results show that the trade effects of SPS concern measures are negative and significant, with the average estimated AVE tariffs ranging 33% ~106%. The AVE effect of SPS concern measures maintained by the US is estimated to be 42%, less than a half (a third) of the AVE effects of SPS concern measures imposed by the European Union (China). China's restrictions on Avian Influenza and various ractopamine restrictions in the production and export of pork products are estimated to be the most prohibitive, causing an AVE effect of 120.3% and 88.9%, respectively. The third essay applies a discrete-time duration model to examine the extent to which SPS concern measures affect the hazard rate of US agri-food exports in 1995-2016. Results show that SPS concern measures raise the hazard rate of US agri-food exports by a range of 2.1%~15.3%, causing the predicted hazard rate to increase from 21.8% to a range of 23.6% ~27.9%. This effect is heterogeneous across different agricultural sectors, with the most substantial effects occurring in US exports of meat, fruits, and vegetables.

Dedication

To my husband, Junjie Feng, and my parents, Jiejun Ning and Yuzhen Tan, for their unconditional love and support at all times.

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Chapter 1

Introduction

This dissertation consists of three essays examining the impacts of Sanitary and Phytosanitary (SPS) Measures on agricultural trade. The first essay estimates and tests for structural change in the Japanese beef import market using a smooth transition approach. Specifically, this study conducts a retrospective empirical assessment of Bovine Spongiform Encephalopathy (BSE), which was discovered in the United States in December 2003, on Japanese beef imports from the US and competing suppliers. Using a source-differentiated almost ideal demand system of fresh/chilled and frozen beef imports embedded with endogenous smooth transition functions, we find that a nonlinear structural change has occurred in the Japanese beef import market in the wake of the BSE event. BSE led to both an instant and persistent impact on beef imports in the Japanese market over the past decade, causing a significant shift in Japanese consumers' preference for imported beef products from different origins. Over half of the income, own-price and cross-price elasticities changed markedly after the 2003 BSE outbreak, both in terms of magnitudes and variability. Some of the changes have yet to recover from their pre-BSE levels. Our results indicate that the Japanese beef import market has reached a new regime in the post-BSE period where the substitution and/or competition relationships between the US and Australia have changed.

The second essay focuses on new estimates on the *ad valorem* equivalent of SPS measures using evidence from SPS specific trade concerns. Countries maintain a large and diverse set of non-tariff measures (NTMs) to protect plant, animal, and human health. Despite an extensive literature investigating the trade flow effect of NTMs, less is known about the extent to which SPS measures raised as specific trade concerns reduce exporting countries' agricultural and food trade to importing markets maintaining these measures. This study utilizes the World Trade Organization's (WTO) SPS specific trade concerns database to identify a subset of economically meaningful and potentially consequential SPS measures on members' trade. We develop a product-line structural gravity model to estimate the trade effects of non-tariff SPS measures flagged as concerns in the WTO's SPS Committee meetings for the top 30 agricultural exporting and importing countries covering products in meat, dairy, fruits & vegetables, and cereals & preparations. Results show that the trade effect of SPS measures of concern is negative and significant, with estimated ad valorem equivalent tariffs ranging from 33% to 106% for the major agricultural sectors, on average. Comparing SPS measures of concern maintained by the US, EU and China, we find the *ad-valorem* tariff equivalent of US SPS measures is 41%, considerably smaller than the AVE of SPS measures maintained by EU and China. Finally, we select five case-study measures of concern and estimate their trade impact. These include (i) EU aflatoxin limits on groundnuts and cereals; (ii) EU GMOs policies on cereal grains; (iii) BSE restrictions on beef (various countries); (iv) Japan's MRLs restrictions on cereals, fruits and vegetables; (v) China, EU, Russia, Taiwan and Thailand ractopamine restrictions on pork and beef; and (vi) China's restrictions on Avian Influenza in poultry. Results indicate that China's restrictions on Avian Influenza and various ractopamine restrictions in pork are estimated to be the most prohibitive, with an AVE effect of 120.3% and 88.9%, respectively, or roughly 10 and 4 times higher than China's average agricultural tariff of 12%.

The third essay examines the effect of SPS measures on the hazard rate of US agri-food exports using a discrete-time duration approach. Trade duration analysis complements the conventional structural gravity estimation of trade by providing a dynamic view of the extensive margin of trade relationships over time. Unlike tariffs that are more easily observed and quantified, SPS measures are not always transparent, and quantification of their hazardous impacts on trade can be tricky due to the diverse and heterogeneous array of policies and regulatory standards. Similar to the second essay, we utilize the WTO's SPS specific trade concerns database to flag SPS concern measures maintained by the importing countries affecting US agricultural exports. Using these various information about these SPS trade concern measures, such as whether they have escalated to WTO dispute settlement proceedings, how long have they remained active, how many times have they been raised, and the language used by exporters to describe the concern, we examine the extent to which these factors affect US agri-food export duration and survival. Overall, 20% of US agri-food export relationships have a duration of one-year, over a half of trade relationships survive 5 years or less, and less than 2% of them survive for the full sample period. About 44% of US agri-food export relationships have a single spell of service, and 87% of them have three spells of service or less. Our results show that SPS concern measures tend to raise the hazard rate of US agri-food exports by a range of 2.1%~15.3%, causing the predicted hazard rate to increase from 21.8% to a range of 23.6% to 27.9%. Moreover, the hazardous effect of SPS concern measures is heterogeneous across different agricultural sectors, with the most substantial effects being examined in US meat, fruits, and vegetables.

Chapter 2

Estimating Structural Change in the Japanese Beef Import Market: A Smooth Transition Approach

2.1 Introduction

Prior to 2003, the United States was the world's largest exporter of beef and offal products, worth over $3.5 billion (USITC 2008). Over 86 percent of total US beef products by volume were exported to Japan, South Korea, China, Canada, and Mexico. However, the discovery of Bovine Spongiform Encephalopathy (BSE, or mad cow disease) in the state of Washington in December 2003 prompted an immediate ban on US beef exports to nearly every primary destination market, causing severe losses to the US beef industry. Coffey et al. [22] estimated that the associated costs to the US beef industry due to BSE for the year 2004 alone were $200 million resulting from lower export sales and a reduction in unit prices. The US Meat Export Federation estimated that the ten-year cumulative losses of US beef trade as a result of the 2003 BSE outbreak was $16 billion, with most of the predicted losses occurring in the first three years (USMEF [95]). Peterson et al. [86] developed a global partial equilibrium simulation model of meat production and trade and found that the quantity and value of US beef exports would have been 2 million metric tons and $6.1 billion higher if the BSE outbreak had not occurred. While Mexico and Canada re-opened their markets to US beef relatively quickly, following the BSE outbreak, other markets including many top export destinations in Asia remained closed for a much longer time. For example, Japan and South Korea suspended all imports of US beef through 2005/2006, after which both countries eased restrictions on US beef by allowing imports of beef from cattle aged less than 21 and 30 months, respectively. China banned imports of US beef until September 2016, when China announced that it would begin allowing imports of US beef aged less than 30 months, provided US exporters comply with China's traceability and quarantine rules.

Before the discovery of BSE, Japan was the largest importer, accounting for approximately one-third of total US beef and offal exports on a volume basis. Meanwhile, Japanese beef imports from the US represented over one-half of its total beef imports. Figure 2.1 shows the annual Japanese beef imports by major exporting origins from 1996 to 2016[1]. Except for 2001-2002, in which a few BSE cases were detected in the Japanese domestic market, Japan's beef imports increased gradually in the late 1990s and early 2000s. In 2003, Japan imported 687,884 metric tons ($2.7 billion) of beef products. The US share of beef imports in the Japanese market was 51.5 percent by volume, followed by Australia and New Zealand, which accounted for 43.8 and 3 percent of the market, respectively, and nations in the rest of the world captured the remaining share. However, Japan's total beef imports slumped 31 percent in 2004, immediately following the US BSE outbreak. Australia and New Zealand, on the other hand, experienced notable increases in their beef exports to Japan. For example, Australia's share of beef imports in the Japanese market more than doubled during the BSE-ban period, while New Zealand tripled its market share in Japan following the BSE

[1] Before 2003, fresh/chilled beef products represented 42 percent of total imports into Japan, frozen beef products represented 44 percent, and other edible beef offal represented 14 percent. After the outbreak of BSE in the US, Japan began importing more frozen beef products (52%) and less fresh/chilled beef (38%) and edible beef offal (10%) products. In this study, we focus on fresh/chilled and frozen beef imports, which account for over 85 percent of Japanese total beef imports over the sample period from 1996 to 2016.

incident.

As of 2016, Japanese beef imports from the US reached 230,000 metric tons, roughly 65 percent of its pre-BSE level in 2003[2]. Several factors could explain the slow recovery of US beef imports in the Japanese market. First, rising competition from Australia, New Zealand, and other emerging suppliers may have induced a more permanent consumption pattern toward these products. Second, the BSE incident may have altered consumer preferences for imported beef from various suppliers in the Japanese market. Third, the BSE event may have shifted Japanese purchases from imported to domestic beef products. Figure 2.2 presents the annual Japanese beef consumption (imported and domestically produced) from 1996 to 2016. Japan's consumption of imported beef products declined after 2003. However, its consumption of domestic beef products remained quite stable. At a minimum, this suggests that the US 2003 BSE case affected imported beef purchases more severely than domestic beef purchases. moreover, the 2003 BSE event led to increased availability of substitute beef products from non-traditional suppliers and the availability of these products persisted for a significant period. Thus, the absence of US beef in the marketplace and habit formation away from US beef may have resulted in a longer-term structural change in Japanese beef import demand.

Structural change and meat demand have been studied extensively (Alston and Chalfant [3], Chavas [19], Choi and Sosin [20], Davis [25], Eales and Unnevehr [34, 35], Holt and Balagtas [56], Mangen and Burrell [71], McGuirk et al. [72], Moschini and Meilke [76]). Though the data, sample periods, and estimation methods vary, most studies find a structural shift in consumer preferences for different types of meats due to new information about fat, cholesterol, and other food and health-related issues. Jin and Koo [61], Jin [60], and Ishida et al. [58] investigated the impacts of animal disease outbreaks, such as BSE and foot-and-mouth

[2]By value, Japan imported $1.49 billion of US beef products in 2016, or 92.5 percent of its pre-BSE level in 2003.

diseases, on consumers' preference for meat. These studies found that animal disease outbreaks could result in significant structural change in consumer demand for meat products. Empirically, many assume that structural change is a one-time, discrete event employing the Chow test (Chow [21]), or a linear trend using the linear switching approach (Mangen and Burrell [71], Moschini and Meilke [76]). Choi and Sosin [20] introduced a trans-log utility framework embedded within a logistic function to capture a multiplicative structural change and found supporting evidence for a structural decline in US red meat demand since the early 1970s. Holt and Balagtas [56] considered a nonlinear structural change framework for US meat demand using a time-varying smooth regression originally proposed by Lin and Teräsvirta [70] and found that structural change has been non-monotonic over time.

While the Japanese beef import market experienced sudden changes followed by gradual recovery in expenditure shares after BSE, the extent to which the import market is characterized by a (possibly nonlinear) structural change remains an open empirical question. Moreover, despite a large body of literature testing for structural change and meat demand, few studies have considered structural change in beef import demand following a severe food safety event such as BSE and its impact on international markets. This article contributes to the literature by testing for a nonlinear structural change caused by transmissible animal disease outbreaks, with a focus on the US 2003 BSE event and its impact on the Japanese beef import market. Specifically, we develop a source-differentiated almost ideal demand system (SDAIDS) that embeds endogenous time-varying smooth transition functions to capture the presence of structural change, using monthly Japanese fresh/chilled and frozen beef imports from 1996 to 2016.

The results indicate that a nonlinear structural change has indeed occurred in the Japanese beef import market in the wake of BSE. Changes in the estimated parameters in the SDAIDS model via the time-varying smooth transition function result in changes to the estimated beef import demand elasticities in the Japanese market. These elasticities are important tools in assessing the impact of trade policies between Japan and its trading partners, especially the US, Australia, and other emerging suppliers (Alston et al. [4], Hertel et al. [51], Hillberry and Hummels [54], Kee et al. [64]). The pre- and post-BSE elasticities thus shed light on the changing sensitivity of Japan's beef import purchases, the persistence of these changes, as well as where the post-BSE elasticities are compared to those in the pre-BSE period. Our findings provide important implications regarding the impact of significant food safety outbreaks on consumer preferences and expenditures on imported agricultural and food products.

The remainder of the article is organized as follows. In the next section, the SDAIDS model of Japanese beef import demand nested with smooth transition functions is developed. Data are described in section three. Section four provides a detailed discussion of the empirical results. Conclusions are summarized in the last section.

2.2 Empirical Model

The source-differentiated almost ideal demand system is an extension of the almost ideal demand system (AIDS) that has been widely used to approximate import consumption behavior of goods from different countries or regions (Andayani and Tilley [5], de Gorter and Meilke [26], Grant et al. [44], Henneberry and Hwang [50], Yang and Koo [99]). Opposite to the Armington model, which suffers from restrictive assumptions of homotheticity and constant elasticity of substitution (Alston et al. [4]), the SDAIDS model ensures a flexible estimation of the elasticity of substitution between goods from different origins. This is particularly important for international trade, whereby importing countries like Japan may perceive US beef differently from Australia beef because of preferences and quality differences

(Miljkovic and Jin [73], Obara et al. [81]). Moreover, different transaction costs involved in international trade lead to heterogeneous movements of import prices, making constant relative prices, and thus, the Hicks' Aggregation Theorem (Diewert [29]), invalid in our case.

In the SDAIDS model, the import share of good i imported from origin h at time t, w_{iht}, is expressed as a function of prices $p_{jk,t}$, $\forall j, k$ and expenditures E_t,

$$w_{ih,t} = \alpha_{ih} + \sum_j \sum_k \gamma_{ihjk} \ln p_{jk,t} + \beta_{ih} \ln(\frac{E_t}{P_t}) \tag{2.1}$$

where $\ln P_t$ is the deflator price index,

$$\ln P_t = \alpha_0 + \sum_i \sum_h \alpha_{ih} \ln p_{ih,t} + \frac{1}{2} \sum_i \sum_h \sum_j \sum_k \gamma_{ihjk} \ln p_{ih,t} \ln p_{jk,t} \tag{2.2}$$

The subscripts i and j indicate goods ($i, j = 1, ..., M$), and h and k indicate origins of imported goods ($h, k = 1, ..., N$). For each good, the number of origins is not necessarily the same. Good i may be imported from N_1 different origins, while good j may have N_2 origins (when $i \neq j,\ h = 1, ..., N_1,\ k = 1, ..., N_2$). p_{ih} is the price of good i imported from origin h, and E is total expenditures on beef imports from all sources. The SDAIDS model has $(MN+2)$ parameters in each equation if all goods have the same number of import origins[3].

Empirically, the SDAIDS model can be rewritten as:

$$\begin{aligned} w_{ih,t} &= \alpha_{ih} + \sum_j \sum_k \gamma_{ihjk} \ln p_{jk,t} + \beta_{ih}(\ln E_t - \ln P_t) + \xi_{ih,t} \\ &= f(\mathbf{x}_t; \theta) + \xi_{ih,t} \end{aligned} \tag{2.3}$$

[3]The SDAIDS model often suffers from degrees-of-freedom issues in empirical applications, depending on the number of imported goods and the number of origins per good. To this burden, Yang and Koo [99] proposed a restricted SDAIDS model by introducing the assumption of block substitutability, $\gamma_{ihjk} = \gamma_{ihj}, \forall k \in j \neq i$, which means that the cross-price effects of good j from either origin on the demand for good i from origin h are the same for all goods j regardless of their origins. We test and reject the assumption of block substitutability in Japanese beef import demand in favor of the unrestricted SDAIDS model.

where $\mathbf{x}_t$ contain all the explanatory variables; θ is a vector of parameters to be estimated including α, β and γ; $\xi_{ih,t}$ are the joint-normally distributed error terms with mean zero. The theoretical constraints are imposed and tested in the SDAIDS model, which are: (i) adding-up $\sum_i \sum_h \alpha_{ih} = 1$, $\sum_i \sum_h \gamma_{ihjk} = 0$, $\sum_i \sum_h \beta_{ih} = 0$; (ii) homogeneity $\sum_j \sum_k \gamma_{ihjk} = 0$; and (iii) symmetry $\gamma_{ihjk} = \gamma_{jkih}$. Due to the imposition of adding-up restriction in the demand system, the contemporaneous covariance matrix is singular. Hence, the last equation in the demand system is dropped for estimation purposes and the parameter estimates from the omitted equation are recovered using the theoretical restrictions.

One concern about the SDAIDS model is that expenditures on a given partition of the utility function are likely to be endogenous when assuming weak separability (Dhar et al. [28], Eales [33], Eales and Unnevehr [35], Hausman [47], LaFrance [67]), and ignoring this endogeneity can render the estimates biased and inconsistent. To address this issue, we specify a reduced-form equation of total beef import expenditures in Japan with a set of explanatory controls,

$$\begin{aligned} \ln E_t = c + c_1 BSE_t + \kappa \ln GDP_t + \sum\nolimits_i \sum\nolimits_h \psi_{ih} \ln p_{ih,t} \\ + \psi_d \ln p_{d,t} + \psi_c \ln p_{c,t} + \psi_r \ln p_{r,t} + \zeta_t \end{aligned} \tag{2.4}$$

where BSE_t is an indicator equal to one if the observation is in the period in which beef imports from the US were banned due to BSE (January 2004 - August 2006) and zero otherwise. GDP_t is the Gross Domestic Product (GDP) in Japan at time t. $p_{d,t}$, $p_{c,t}$ and $p_{r,t}$ denote the Japanese beef retail price for domestic beef products, Japanese consumer price index (CPI) of all commodities, and the Japanese real effective exchange rate at time t, respectively. ζ_t denotes a well-behaved error term. To test for the endogeneity of expenditures, we first run the reduced-form expenditure regression and retain the residuals $\hat{\zeta}_t$. We then add $\hat{\zeta}_t$ to each demand equation as an additional explanatory variable and conduct a joint test of the significance of the residual coefficients in the demand system. If these coefficients are statistically indifferent from zero, it can be concluded that the endogeneity of import expenditures does not exist. However, if not, we estimate the demand system equations and the expenditure equation jointly using nonlinear SUR (seemingly unrelated regression) - iterative FGNLS (feasible generalized nonlinear least squares), which is equivalent to nonlinear full information maximum likelihood estimation assuming the correct model specification with multivariate normal disturbances (Dhar et al. [28]).

To construct a nonlinear and/or nonmonotonic structural form of the Japanese beef import demand, we follow Dijk et al. [30] and Holt and Balagtas [56] to incorporate a time-varying smooth transition function into the SDAIDS model,

$$w_{ih,t} = f(\mathbf{x}_t;\theta_1)\cdot[1-G(s_t;\lambda,c)] + f(\mathbf{x}_t;\theta_2)\cdot G(s_t;\lambda,c) + \xi_{ih,t} \tag{2.5}$$

where $s_t = t/T$ is a time transition variable. The transition function $G(\cdot)$ is a smooth, continuous function bounded between zero and one according to s_t. The SDAIDS model in eq. 2.5 can be thought of as a two-regime switching model, each associated with the extreme value of $G(\cdot) = 0$ and $G(\cdot) = 1$, where the transition from one regime to the other is continuous and smooth. θ_1 and θ_2 are the parameter sets identifying the two regimes of the SDAIDS model. λ is the speed-of-adjustment parameter that determines how quickly the model shifts from one regime to another. c is the threshold parameter that defines at what point the transition is 50 percent complete or at what point the transition is symmetric. In this setup, the consumer preferences represented by the underlying model parameters could be varying over time as the transition function changes.

One benefit of the smooth transition function is that it is a data-driven process to determine regime changes and when the transition started and ended, while noting that the transition function could find an approximately linear transition path. Moreover, it allows for multiple regimes, permitting more flexibility of the model fit within the actual policy context. In fact, in our situation, there are three distinct policy regimes: the pre-BSE period (up to December 2003), the BSE-ban period (Jan 2004 - Aug 2006), and the post-BSE recovery period (post Sep 2006). A two-regime model would be restrictive since it essentially forces demand in the middle regime to be a weighted combination of the demand in the pre- and post-BSE regimes. As a result, a three-regime framework is employed by adding a second nonlinear component yielding

$$\begin{aligned} w_{ih,t} &= f(\mathbf{x}_t;\theta_1)\cdot[1-G_1(s_t;\lambda_1,c_1)] \\ &\quad +f(\mathbf{x}_t;\theta_2)\cdot[G_1(s_t;\lambda_1,c_1)-G_2(s_t;\lambda_2,c_2)] \\ &\quad +f(\mathbf{x}_t;\theta_3)\cdot G_2(s_t;\lambda_2,c_2)+\xi_{ih,t} \end{aligned} \tag{2.6}$$

If it is assumed that $c_1 < c_2$, the parameters in this model change smoothly from θ_1 via θ_2 to θ_3 for increasing values of s_t, as the first function G_1 changes from 0 to 1, followed by a similar change of G_2 (Dijk et al. [30]).

A crucial step in the smooth transition approach is the selection of a proper transition function among a series of candidates to represent the observed situation. In this article, we consider two standard specifications maintaining the smoothness and bounds of nonlinear transition functions (Dijk et al. [30], Lin and Teräsvirta [70], Teräsvirta [92]). The first is the logistic smooth transition (LSTR) function, specified as,

$$G(s_t,\lambda,c) = \left\{1+\exp\left[-\lambda(\frac{s_t-c}{\sigma_{s_t}})\right]\right\}^{-1} \tag{2.7}$$

where the speed-of-adjustment parameter λ is expressed as $\lambda = \exp(-\lambda^*)$ to ensure that λ is positive by definition, and σ_{s_t} is the standard deviation of the normalized trend variable to ensure that λ is unit invariant. The threshold parameter c in this specification is the centrality parameter, indicating the point at which the transition is 50 percent complete. The LSTR function changes monotonically from zero to one as s_t increases. As $\lambda \to 0$, $G(\cdot)$ in eq.2.7 is effectively linear in s_t, whereas when $\lambda \to \propto$, it becomes a Heaviside indicator function that equals zero if $s_t < c$ and one otherwise. Consequently, the change of $G(\cdot)$ from zero to one is instantaneous at $s_t = c$ when $\lambda \to \propto$.

An alternative is the exponential smooth transition (ESTR) function, expressed as,

$$G(s_t, \lambda, c) = 1 - \exp\left[-\lambda(\frac{s_t - c}{\sigma_{s_t}})^2\right] \quad (2.8)$$

where the parameters λ and σ_{s_t} are defined the same way as in LSTR except that the threshold parameter c in this specification indicates the point at which the transition is symmetric. Structural change implied by the ESTR function in eq.2.8 is non-monotonic and is symmetric around c. For either $\lambda \to 0$ or $\lambda \to \propto$, $G(\cdot)$ approaches zero and one, respectively. When $s_t \to \pm \propto$, $G(\cdot) \to 1$, whereas $s_t = c$, $G(\cdot) = 0$.

The estimated import demand elasticities are important parameters in trade policy analysis as they reflect the import demand responsiveness with respect to the changes in import prices or incomes. Using a three-regime SDAIDS model, the unconditional income elasticities (η_{ih}) and uncompensated (Marshallian) price elasticities (ε^u_{ihjk}) are obtained as[4],

$$\eta_{ih} = \frac{\kappa}{\bar{w}_{ih}} \left\{ \beta^1_{ih} \times (1 - G_1) + \beta^2_{ih} \times (G_1 - G_2) + \beta^3_{ih} \times G_2 \right\} + 1 \tag{2.9}$$

$$\begin{aligned} \varepsilon^u_{ihjk} = \frac{1}{\bar{w}_{ih}} \Bigg\{ &\left[\gamma^1_{ihjk} + \beta^1_{ih} \left(\psi_{jk} - \alpha^1_{jk} - \sum_r \sum_m \gamma^1_{jkrm} \ln \bar{p}_{rm} \right) \times (1 - G_1) \right] \\ &+ \left[\gamma^2_{ihjk} + \beta^2_{ih} \left(\psi_{jk} - \alpha^2_{jk} - \sum_r \sum_m \gamma^2_{jkrm} \ln \bar{p}_{rm} \right) \times (G_1 - G_2) \right] \\ &+ \left[\gamma^3_{ihjk} + \beta^3_{ih} \left(\psi_{jk} - \alpha^3_{jk} - \sum_r \sum_m \gamma^3_{jkrm} \ln \bar{p}_{rm} \right) \times G_2 \right] \Bigg\} - \triangle_{ihjk} \end{aligned} \tag{2.10}$$

where $\bar{w}$ and $\bar{p}$ are the sample mean budget shares and prices; κ and $\psi_{jk}, \forall j, k$ are the income and price coefficients from the auxiliary expenditure equation; $\triangle_{ihjk}$ is the Kronecker delta that equals one if $i = j, h = k$, and zero otherwise[5].

[4] The Hicksian price elasticities are available upon request.

[5] There are two parts of variations of the estimated elasticities, one is from the changing budget shares (holding the price terms constant), another is from the varying parameters according to the smooth transition functions. To see this, total differentiating the estimated elasticities with respect to all the varying components, and we get,

$$d\eta_{ih} = \frac{\kappa}{w_{ih}} d\beta_{ih} - \frac{\beta_{ih}\kappa}{w^2_{ih}} dw_{ih}$$

$$\begin{aligned} d\varepsilon^u_{ihjk} = &-\frac{\beta_{ih}}{w_{ih}} d\alpha_{jk} \\ &+ \frac{\psi_{jk} - \alpha_{jk} - \sum_r \sum_m \gamma_{jkrm} \ln p_{rm}}{w_{ih}} d\beta_{ih} \\ &+ \frac{1 - \beta_{ih} \ln p_{ih}}{w_{ih}} d\gamma_{ihjk} \\ &- \frac{[\gamma_{ihjk} + \beta_{ih}(\psi_{jk} - \alpha_{jk} - \sum_r \sum_m \gamma_{jkrm} \ln p_{rm})]}{w^2_{ih}} dw_{ih} \end{aligned}$$

2.3 Data

Monthly data for the quantities and values of Japanese beef imports from different origins, from January 1996 to December 2016, are collected from the Global Trade Atlas Database[6]. Four exporting countries/regions are included in the SDAIDS model. The major three source countries are selected based on their significant market shares in Japan, which are the United States (USA), Australia (AUS), and New Zealand (NZL). The remaining exporting countries are combined into a composite rest of the world (ROW) as the fourth source region. To account for competition across goods imported from different origins, we distinguish beef imports into two groups using the Harmonized System (HS) of commodity classification: fresh/chilled beef (HS 0201) and frozen beef (HS 0202), which account for approximately 80 percent of total beef and offal imports in Japan[7]. Table 2.5 provides summary statistics of model data.

Import prices for beef products from different origins are not publicly reported. Hence, unit values are employed as a proxy for import prices,and are obtained by dividing import value by import quantity (Andayani and Tilley [5], Grant et al. [44], Henneberry and Hwang [50], Muhammad et al. [77], Yang and Koo [99]). To minimize aggregation bias in unit values, we compute the Stone price (unit value) index for each source-differentiated beef product in HS 4-digit codes using the observed import values and quantities in HS 6-digit codes, with the weights being average import shares in each HS 4-digit product sector and time period[8]. For

[6]Data are retrieved from https://www.gtis.com/gta/, which requires subscription.

[7]We exclude beef offal and variety meat imports (HS 0206)in this study because of their relatively small shares and difficulty of obtaining reliable estimates. Also, due to the heterogeneity of products within the beef offal category (which also includes pork offal), it is not likely the case that offal imports will satisfy the requirement of product aggregation. Since we use unit values to represent prices for each product group, a single unit value price representing very heterogeneous individual products could be problematic. Lastly, from a policy perspective, we consider it more relevant to identify potential structural change in import demand for fresh/chilled and frozen beef products because of their substantial market shares in Japanese imports.

[8]In regard to the missing prices of US beef imports in the BSE-ban period, we approximate the prices using monthly maximum plus a standard deviation.

fresh/chilled beef imports, we include HS 020110, HS 020120, and HS 020130. For frozen beef imports, we include HS 020210, HS 020220, and HS 020230. Separability between imported and domestic beef products in the Japanese market is imposed in this article for two reasons. First, because of the distinct genetic attributes of imported and domestic beef as well as different channels in marketing imported and domestic beef products (Muhammad et al. [77], Obara et al. [81]), it is preferable to examine, specifically, how the foreign BSE outbreak affected Japanese consumer preferences for beef imported from different sources through international trade. Second, due to the data limitations associated with obtaining monthly domestic beef purchases and comparable quantities and/or domestic market prices in Japan, it is not feasible to include domestic beef consumption in the analysis. We could aggregate the time dimension to match available domestic beef expenditures and prices in Japan, however, at the expense of insufficient degrees of freedom to permit flexibility in estimating the smooth transition function augmented SDAIDS model. Here, we opted to impose separability to retain degrees of freedom and estimation flexibility.

In the reduced-form regression of the expenditure term (eq.2.4), quarterly GDP (in constant 2010 $US dollars, seasonally adjusted)[9], monthly CPI (in 2010 base year, seasonally adjusted) and monthly real effective exchange rates (in 2010 base year) are collected from the Global Economic Monitor, World Bank[10]. The monthly domestic beef retail prices (in 2010 base year) are collected from Japanese Agriculture and Livestock Industries Corporation (ALIC)[11].

[9]We apply the cubic spline interpolation to get the estimates of monthly GDP data from quarterly GDP data for empirical analysis in this study.

[10]https://datacatalog.worldbank.org/dataset/global-economic-monitor

[11]http://www.alic.go.jp/english/

2.4 Empirical Results

The results are reported in two subsections. Subsection one summarizes the statistical tests of the theoretical assumptions as well as the various model specifications. Subsection two discusses the estimated own-, cross-price, and income elasticities using preferred three-regime switching SDAIDS model.

2.4.1 Tests for model assumptions

The demand system contains all prices of beef imported from different origins in each equation. To determine whether the SDAIDS model is valid in estimating Japanese beef import demand compared to the canonical AIDS model, the assumption of product aggregation and block separability is tested (Alston et al. [4], Hayes et al. [48], Henneberry and Hwang [50]). Results show that the null hypothesis of aggregated beef imports with no differentiation of exporting sources is rejected at the 1% significance level. We also test the block substitutability assumed in Yang and Koo [99] and reject it at the 1% significance level, suggesting that there are important cross-price substitution effects between fresh/chilled and frozen beef imported from different origins in the Japanese market. Thus, the data support the unrestricted SDAIDS model[12].

Estimates from the demand model without accounting for the potential endogeneity of import expenditures may be biased and inconsistent, and policy inference can be misleading. To address this issue, we include the estimated residual terms from the reduced-form expenditure regression in the SDAIDS model and apply the Wu-Hausman statistic to test for the significance of the residual coefficients (Hausman [47], Wu [98]). The null hypothe-

[12] After imposing homogeneity and symmetry restrictions in the SDAIDS model, the test statistic for product aggregation in the system is $\chi^2(36) = 126288$; the test statistic for block separability is $\chi^2(24) = 234.44$; the test statistic for block substitutability is $\chi^2(12) = 91.03$.

sis of strict exogeneity of the expenditure term (insignificant correlation of the expenditure variable with the demand system error terms) is rejected at the 1% significance level[13]. As a result, we estimate the demand system equations and the expenditure equation jointly, leading to 49, 86, and 123 parameters to be estimated for the baseline, two-regime, and three-regime switching SDAIDS models, respectively.

Table 2.5 reports the key measures of model fit, the test statistics, and the transitional function parameter estimates for the Japanese beef import demand model under various specifications. The likelihood ratio (LR) tests for the null hypothesis of no structural change (i.e., $\theta_2 = 0$ in eq.2.5, or $\theta_2 = \theta_3 = 0$ in eq. 2.6) are rejected at the 1% significance level, suggesting that the estimated parameters in the Japanese beef import demand model vary significantly over the sample period. Further, the LR tests for the null hypothesis of a two-regime switching demand model are rejected at the 1% significance level, in favor of a three-regime smooth transition SDAIDS model. By comparing these models in terms of the log-likelihood value, system Akaike information criterion (AIC) and Bayesian information criterion (BIC), we conclude that the three-regime SDAIDS model provides a better model fit and ability to capture both the instantaneous and longer-run structural change led by the BSE event. Thus, we focus on the three-regime SDAIDS model in the remainder of the paper[14]. The estimated coefficients of the three-regime SDAIDS model and the smooth transition functions are provided in Table A.1 and Figure A.2 in the Appendix.

To see whether the estimated parameters vary over time according to the transition functions, we plot the time series of the estimated α_{ih} and β_{ih}, $\forall i, h$ in Figure 2.3. Intuitively, the intercept α can be viewed as the estimated budget shares at the sample mean prices and

[13]After imposing homogeneity and symmetry restrictions, the test statistic for expenditure exogeneity is $\chi^2(7) = 74.27$ in the SDAIDS model.

[14]We also estimated the three-regime SDAIDS model using two exponential transition functions, or two logistic transition functions. Our results indicate the three-regime SDAIDS model using one exponential function and one logistic transition function performs best.

expenditures. Over one half of α_{ih} have significantly changed during the BSE-ban period (Jan 2004 - Aug 2006) and not fully recovered to the pre-BSE levels even after the ban on US beef products imported into Japan was lifted. Similarly, a few β_{ih} have permanently changed in the post-BSE period[15]. In other words, the results have shown a nonlinear structural change in consumer preferences for the source-differentiated beef imports in the Japanese market in the wake of BSE. Though Japanese consumers reestablished confidence in the demand for imported beef products, US exporters have undergone changing product compliance standards and marketing channels in the Japanese market that likely prevented a full and immediate recovery.

2.4.2 Elasticities in SDAIDS model

Income Elasticities

To examine how changes in preference parameters may have affected income elasticities of demand (η_{ih}, in eq. 2.9) in the Japanese beef import market, we present in Figure 2.4 the time series plots of the estimated income elasticities for Japanese beef imports from the US, Australia, and New Zealand. The red solid line indicates estimates using sample average budget shares and prices; the blue dashed line indicates estimates using individual budget shares and prices. The panels in the left-hand column display the estimated income elasticities of Japanese demand for chilled beef imports from selected exporting countries, and those in the right-hand column depict the corresponding estimated income elasticities of Japanese demand for frozen beef imports. As a reference, we report the 5% lower bound and 95% upper bound confidence intervals in the grey-shaded area in each panel.

[15] The joint test statistic for $\alpha^1_{ih} = \alpha^3_{ih}, \forall i, h$ is $\chi^2(7) = 122.67$, the joint test statistic for $\beta^1_{ih} = \beta^3_{ih}, \forall i, h$ is $\chi^2(7) = 53.12$, and the joint test statistic for $\gamma^1_{ihjk} = \gamma^3_{ihjk}, \forall i, h, j, k$ is $\chi^2(21) = 54.01$, meaning that the null hypothesis of no changes of α_{ih}, β_{ih}, and γ_{ihjk} pre-vs-post are all significantly rejected.

As can be seen from Figure 2.4, all of the income elasticities, except for New Zealand frozen beef demand, are positive and statistically significant at the 5% level, meaning that these source-differentiated beef imports are treated as normal goods to Japanese consumers. Before the outbreak of the 2003 US BSE case, Japan had relatively more stable income elasticities for beef imports from the US, while those for Australian and New Zealand beef showcased more variation. However, this pattern reversed after 2004, whereby Japanese income elasticities for US beef imports became more volatile compared to its income elasticities for Australian and New Zealand beef.

Before the 2003 BSE outbreak, the income elasticities for chilled beef imports from the US were relatively less elastic to the change of Japanese incomes compared to those from non-US suppliers. On the contrary, the income elasticities for frozen beef imports from the US were much more income elastic compared to those from non-US nations. For example, using the pre-BSE sample average, a 10 percent increase in incomes would lead to an average of 9.58 or 9.17 percent increase in Japanese demand for chilled beef from the US or Australia, while it would induce an average of 14.01 or 8.98 percent increase in its demand for frozen beef from the same origin, respectively. It seems that Japanese consumers considered chilled beef from New Zealand as well as frozen beef from the US more luxurious compared to those from other origins.

The BSE outbreak led to an immediate ban on US beef products exported to Japan. The income elasticities gradually decline as the budget shares on US beef imports recover, though, none of them reached their pre-BSE levels (in terms of the estimated parameters). Specifically, using the recent six-year (2011-2016) average estimates, we find that a 10 percent increase in incomes led to an average 15.57 or 8.18 percent increase in Japanese demand for chilled beef from the US or Australia, while the corresponding increase for frozen beef is an average of 9.37 or 8.57 percent, respectively. Japanese income elasticities for US chilled (frozen) beef increased (dropped) significantly, by 62.53% (33.12%), while that for Australia chilled and frozen beef were little changed. The changes in the pre-vs-post comparison of the income elasticities for US beef imports in the Japanese market are statistically significant at the 5% level, implying that, for any given increase in incomes, Japan has become more willing to increase its demand for chilled beef products at the expense of frozen beef from the US. Therefore, the BSE outbreak not only changed Japan's overall beef imports from the different origins (particularly those from the US), it also led to a persistent and lasting preference shift in the combination of the beef varieties from the same suppliers.

Own-Price Elasticities

Figure 2.5 presents the time series plots of the uncompensated own-price elasticities (ε^{u}_{ihih}, in eq. 2.10) for Japanese beef imports from the US, Australia, and New Zealand, with the panels in the left-hand column for source-differentiated chilled beef imports and those in the right-hand column for source-differentiated frozen beef imports. Again, the sample average estimates, the individual estimates, and the 5% lower bound and 95% upper bound confidence intervals are reported.

With the exception of New Zealand beef demand in the BSE ban period, all own-price elasticities were negative and statistically significant at the 5% level, consistent with the law of demand. Japanese own-price elasticities for US beef imports were quite stable in the pre-BSE period but more volatile in the post-BSE era, whereas the own-price elasticities for Australian and New Zealand beef imports were more variable before the outbreak but more stable afterward. On average, given a 10 percent decrease in the corresponding own price in the pre-BSE period, Japanese demand for chilled beef from the US (Australia) increased by 17.47 (13.58) percent, or 3.87 (7.14) percent for US (Australia) frozen beef imports. The results show that the own-price elasticities for chilled beef imports from the three major origins were much price elastic (greater than one in absolute value) while that for frozen beef imports were less sensitive to the price change (less than one in absolute value).

Changes in the preference parameters (and the budget shares) have led to persistent changes in the Japanese beef import own-price elasticities, thus, causing the own-price elasticities not able to reach their pre-BSE levels in the wake of BSE. For instance, in the post-BSE period, we find that there would be an average of 7.78 (9.28) percent increase in Japanese demand for US (Australia) chilled beef, or 12.54 (7.06) percent increase in its demand for US (Australia) frozen beef imports, given a 10 percent decrease in the respective own price. Japanese own-price elasticities for US (Australia) chilled beef imports had declined dramatically by 55.47% (31.66%) in absolute terms, and that for US frozen beef imports had almost tripled in absolute term. Again, these pre-vs-post changes are statistically significant at the 5% level, implying that, after 4~6 years of recovery after the BSE outbreak, Japanese demand for US beef products has become much less responsive to its own-price change while that for Australian beef imports has been more own-price responsive.

Cross-Price Elasticities

To examine the possibly changing competitiveness of major beef suppliers in the Japanese market, we also estimate the cross-price elasticities (ε^{u}_{ihjk}, in eq. 2.10). Most of the estimates are statistically significant at the 5% level and mixed with positive and negative signs, implying a mixed relationship of substitutes and complements among source-differentiated beef imports in the Japanese market. In particular, Japanese demand for source-differentiated beef imports of one group (i.e., chilled beef) seems to be especially responsive to the change of beef import price of another group (i.e., frozen beef), meaning that there are significant cross-product-group substitution effects in the Japanese beef import market (thus rejecting the block substitutability assumption imposed in Yang and Koo [99]). Additionally, over one-half of the cross-price elasticities have changed remarkably due to the changes in the demand parameters, indicating a significant shifting in suppliers' competitiveness in the Japanese beef import market in the post-BSE period. Below we first discuss the cross-price elasticities for the different beef products from the same origins (within origins across product categories), then move to the cross-price elasticities for the different beef products from different origins (across origins and product categories).

In Figure 2.6, we present the time series plots of the within-origin cross-price elasticities ($\varepsilon^u_{ihik}, \forall h \neq k$) in the Japanese beef import market. Interestingly, before the end of 2003, all of the within-origin cross-price elasticities were negative, meaning that the different beef products imported from the same origin tend to have a complement relationship in the Japanese market. In other words, any price change of chilled beef imported from a certain source would negatively affect the demand for frozen beef imported from the same source, vice versa. However, changes have occurred to the cross-price elasticities in the wake of BSE, and some of them have been positive (though not statistically different from zero), representing a competing relationship between the different beef products imported from the same origin in the Japanese market.

To economize the space, we present in Figure 2.7 and 2.8 the time series plots of the cross-origin cross-price elasticities ($\varepsilon^u_{ihjk}, \forall i \neq j, h \neq k$) involving only the US and Australia, which are the top two suppliers of beef products in the Japanese market. Before the BSE outbreak, Japanese cross-price elasticities for US beef imports were more stable with respect to the price change of Australian beef, while the cross-price elasticities for Australian beef imports in response to the change in US beef prices depicted a larger variation. However, a reversal occurred after 2004. By comparing each sub-plot in Figure 2.7 and 2.8, we find that Japanese demand for US beef was generally more responsive (in absolute magnitude) to the change of Australian beef prices as opposed to its demand for Australian beef in response to the change of US beef prices. Before the BSE outbreak, most of the cross-price elasticities for US and Australia beef imports (except for the frozen beef case in panel (d)) were positive. These substitution effects were intensified in 2004-2007 owing to the ban on US beef imports in the Japanese market. To take one example, Japanese demand for US beef imports was more than twice sensitive in response to the change of Australian beef price in the ban period, while that for Australia beef was slightly more responsive to the change of US beef price. After 4~6 years of market recovery, the cross-price elasticities have now become less positive and even negative in most cases (though statistically insignificant from zero), implying that Japanese beef imports from the US and Australia have become more complements than ever in the sample period.

In summary, our results show that a significant nonlinear structural change has occurred in the Japanese beef import market led by the US 2003 BSE outbreak. Because of the changes in the consumer preferences represented by the underlying parameters in wake of BSE, a large proportion of the unconditional income, own-price, and cross-price elasticities have endured persistent changes in the Japanese market, some of them have yet recovered back to its pre-BSE levels. Together, we find that the 2003 US BSE outbreak has altered not only Japan's demand for each beef variety from different origins, but also the combination of different beef varieties from the same origins.

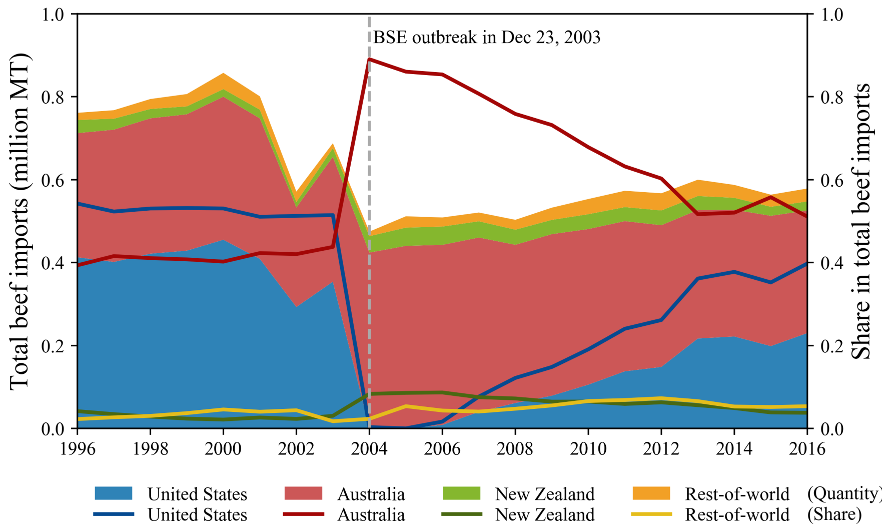
2.5 Conclusions

This article develops a smooth transition function augmented SDAIDS model to examine the impact of the US 2003 BSE outbreak on the Japanese beef import market and tests for nonlinear structural changes. Although predicting future animal disease outbreaks is challenging, this paper highlights many potential implications of such events by investigating the

2003 BSE case. Several important findings emerged. First, the BSE incident led to a persistent and long-lasting impact on source-differentiated beef import demand in the Japanese market, causing a non-reversing shock to the market regime. Though the ban on US beef exported to Japan was lifted after August 2006, it took a much longer time (about 4~6 years) for Japanese consumers to rebuild confidence in US beef products. Second, the BSE-induced structural shock appears to be nonlinear. Hence, the estimates without consideration of the nonlinear structural shock would result in incomplete and misleading policy implications. Third, economically important changes in the magnitudes and variability of the estimated elasticities took place before and after the 2003 BSE outbreak. In particular, during the recovery period, Japan has become more likely to increase purchases of fresh/chilled beef but less frozen beef from the US as incomes increase. Given that consumers generally consider fresh/chilled beef better and more valued than frozen beef, it seems reasonable that they tend to be more income-sensitive to fresh/chilled beef demand compared to frozen products. In contrast, the model estimated very little change in Japanese income elasticities for Australia beef imports. Further, Japanese demand for US (and Australian) chilled beef imports has become less own-price elastic, compared to its demand for US frozen beef imports, which is more own-price elastic. Import demand substitutability has varied a lot over time owing to parameter changes. Our results indicate that, because of the persistent longer-term consequences of BSE, the Japanese beef import market has entered into a new regime period in the 2010s, rather than recovered to its pre-BSE regime. Therefore, future studies should focus more on international trade and regulation analysis of the Japanese beef import market using the post-BSE estimates.

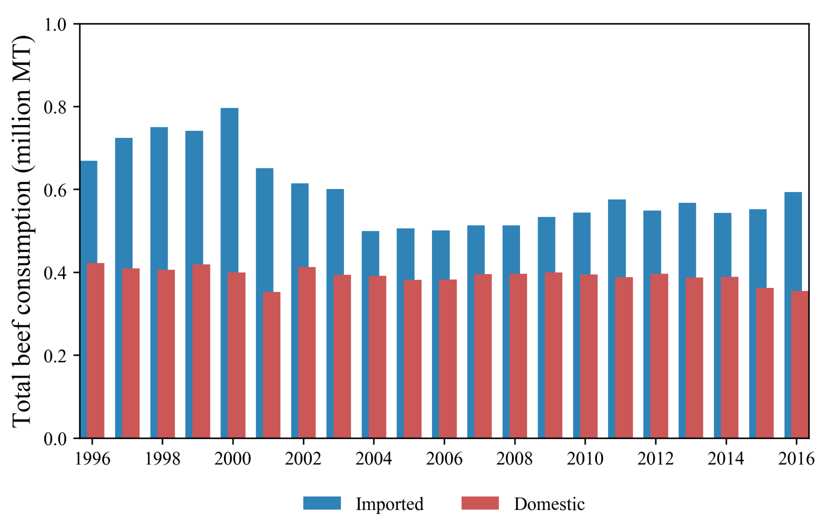
Finally, several caveats are worth mentioning. First, the source-differentiated AIDS model employed here does not include Japanese domestic beef purchases in the demand system. Consumers can choose between domestic and imported beef products, and the foreign BSE event may have caused consumers in Japan to substitute imported products with what they considered safer domestic products. Future studies should address this issue should data availability allow for an examination of the relationships between domestic and imported beef products. Second, the BSE outbreak may have affected Japanese demand for other meat varieties, such as pork, poultry and seafood products. Future studies could extend this demand system to include a wider set of meat varieties from different origins. Third, due to the limited sample size, this study uses up to three-regime switching demand models. Future studies can consider incorporating and comparing higher regimes switching models for more flexibility, provided there is enough degrees of freedom in the estimation. Nevertheless, this study contributes to the demand and structural change literature by examining the impact of the 2003 US BSE outbreak on Japanese beef import demand and provides important policy implications for assessing the impact of future transmissible disease outbreaks on foreign demand and import market conditions.

Figure 2.1: Japanese total beef imports by different origins, 1996-2016



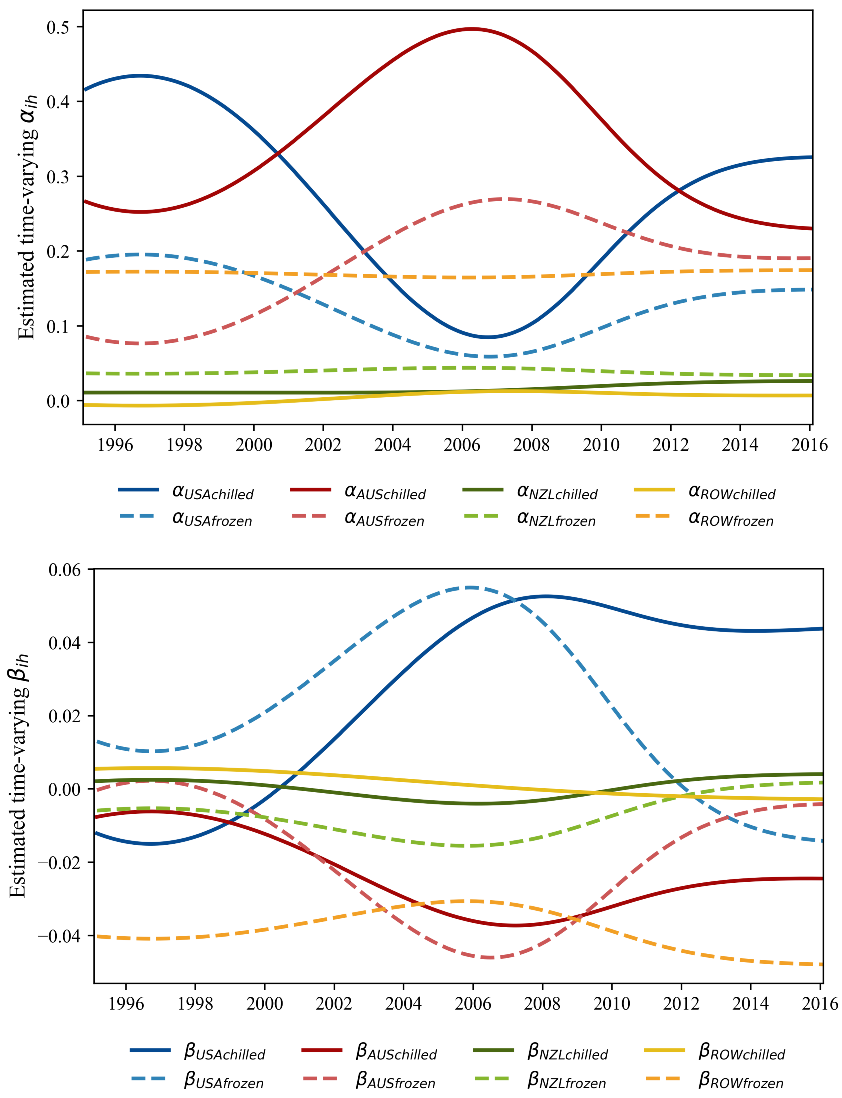
Note: Total beef imports include products in the Harmonized System (HS) of commodity classification: 0201, 0202, 020610, 020621, 020622, 020629 and 160250.
Source: Authors' calculation using data from Global Trade Atlas.

Figure 2.2: Japanese total beef consumption, 1996-2016



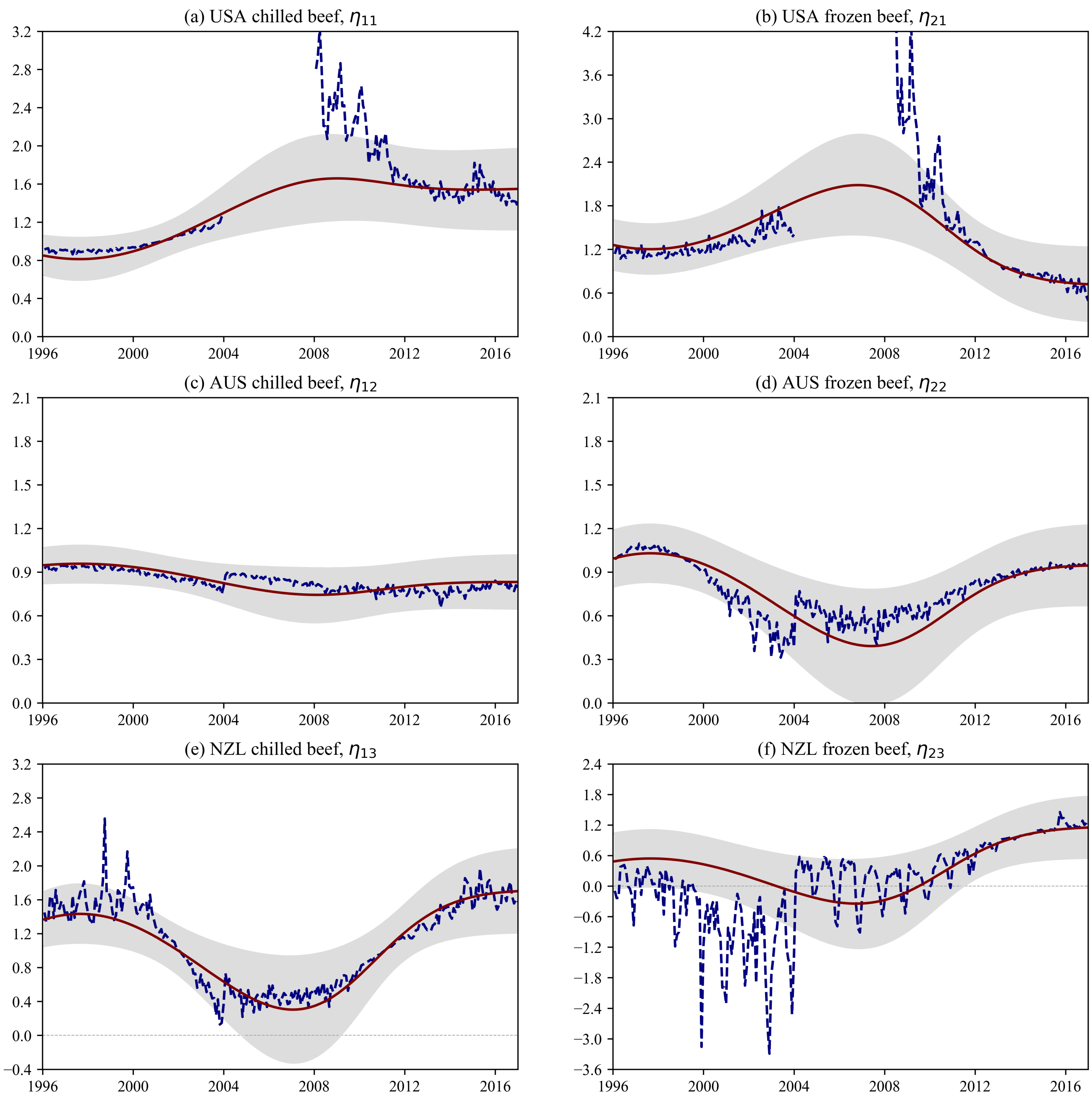
Note: Total beef consumption in Japan consists of imported and domestically produced beef products. We use the annual estimated marketing quantity from 1996 to 2016.
Source: Japanese Agriculture and Livestock Industries Corporation (ALIC).

Figure 2.3: Estimated time-varying α_{ih} and β_{ih} in the Japanese beef import demand model



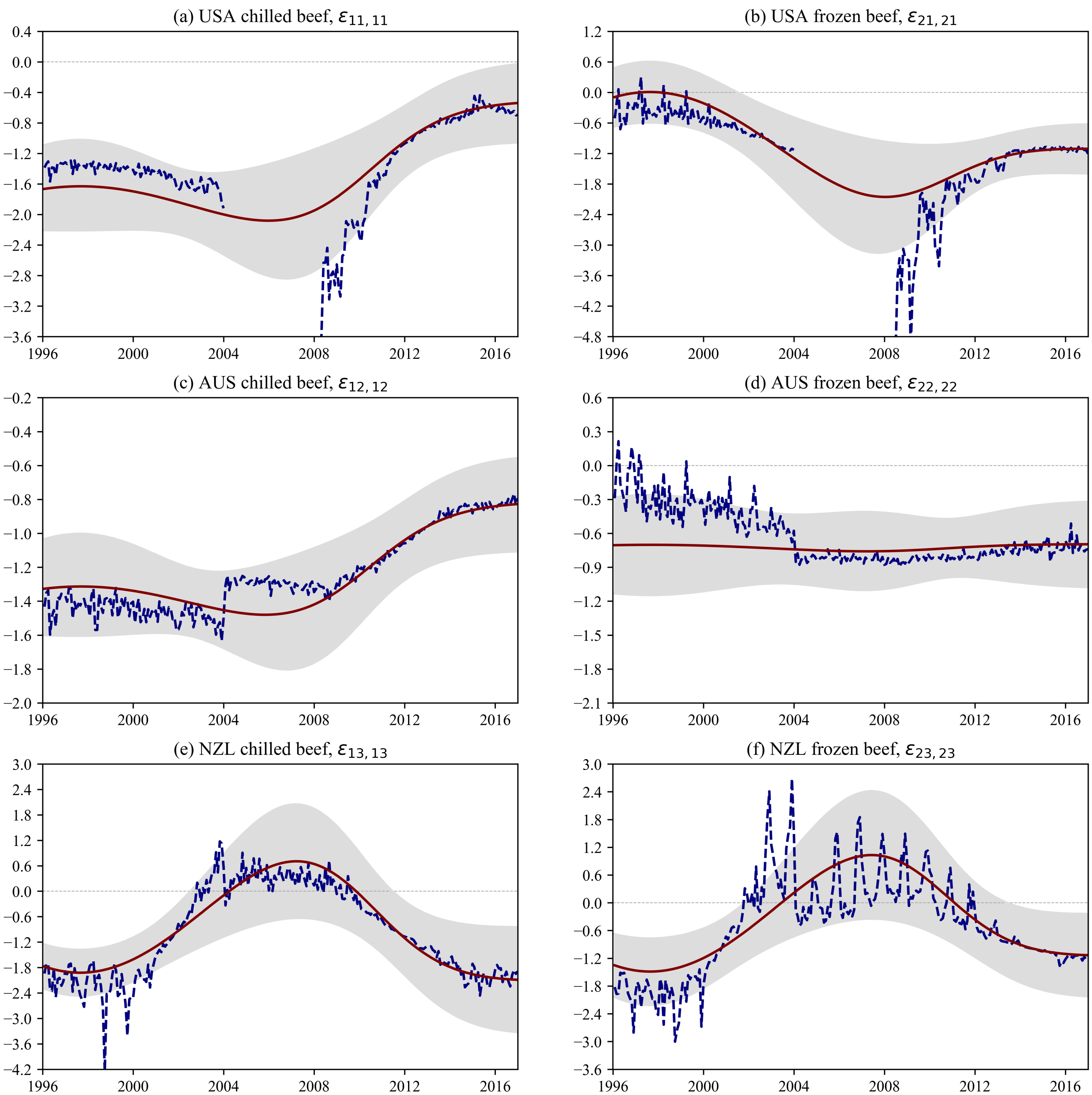
Note: Time series plots of α_{ih} and $\beta_{ih}, \forall i, h$ derived from the three-regime smooth transition SDAIDS model.

Figure 2.4: Time series plots of the income elasticities for Japanese beef imports



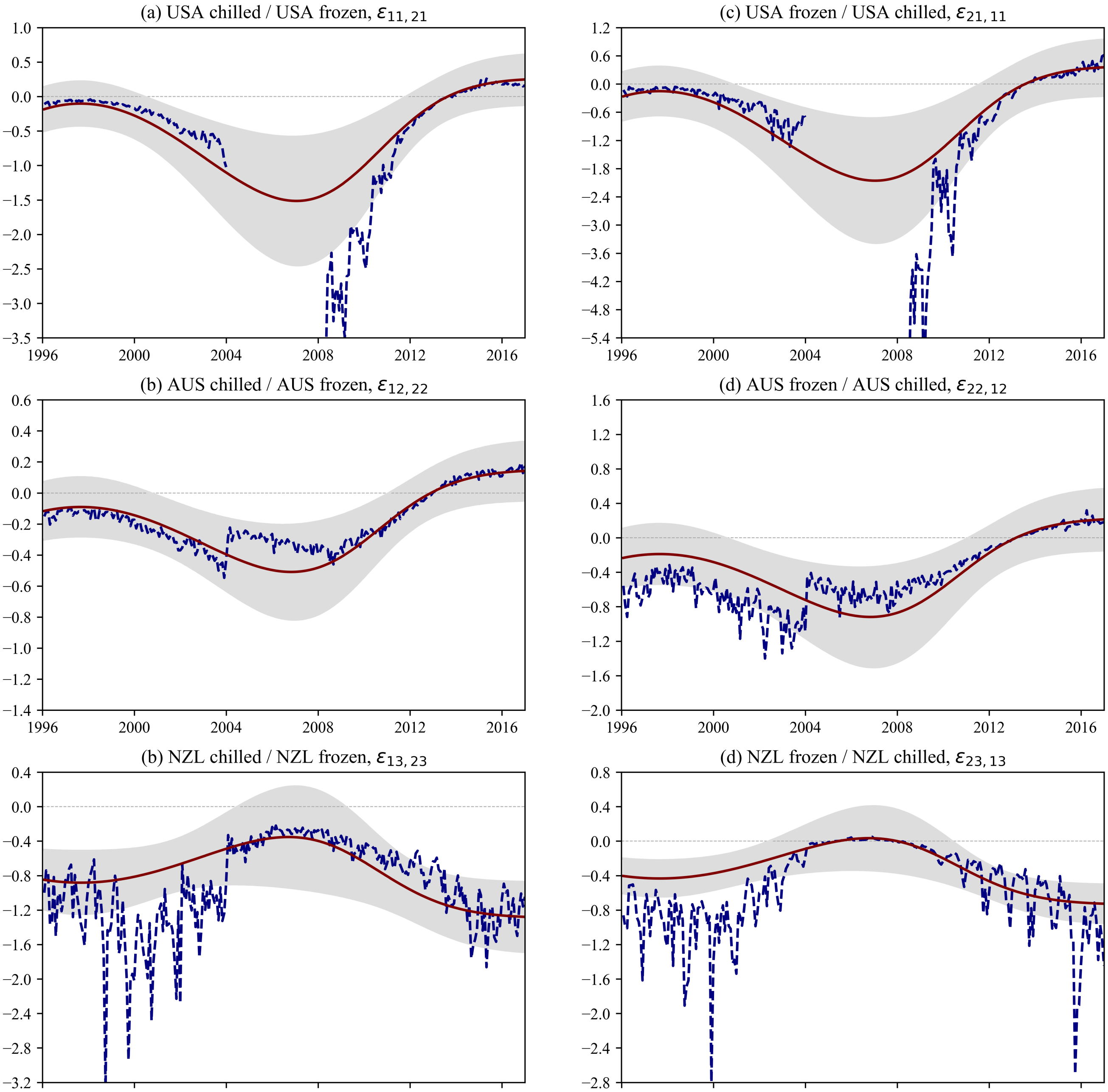
Note: Time series estimates and their 95% confidence intervals (grey areas) derived from the three-regime smooth transition SDAIDS model. Red solid line indicates sample average estimates with time-varying coefficients; blue dashed line indicates individual estimates with time-varying coefficients.

Figure 2.5: Time series plots of the own-price elasticities for Japanese beef imports



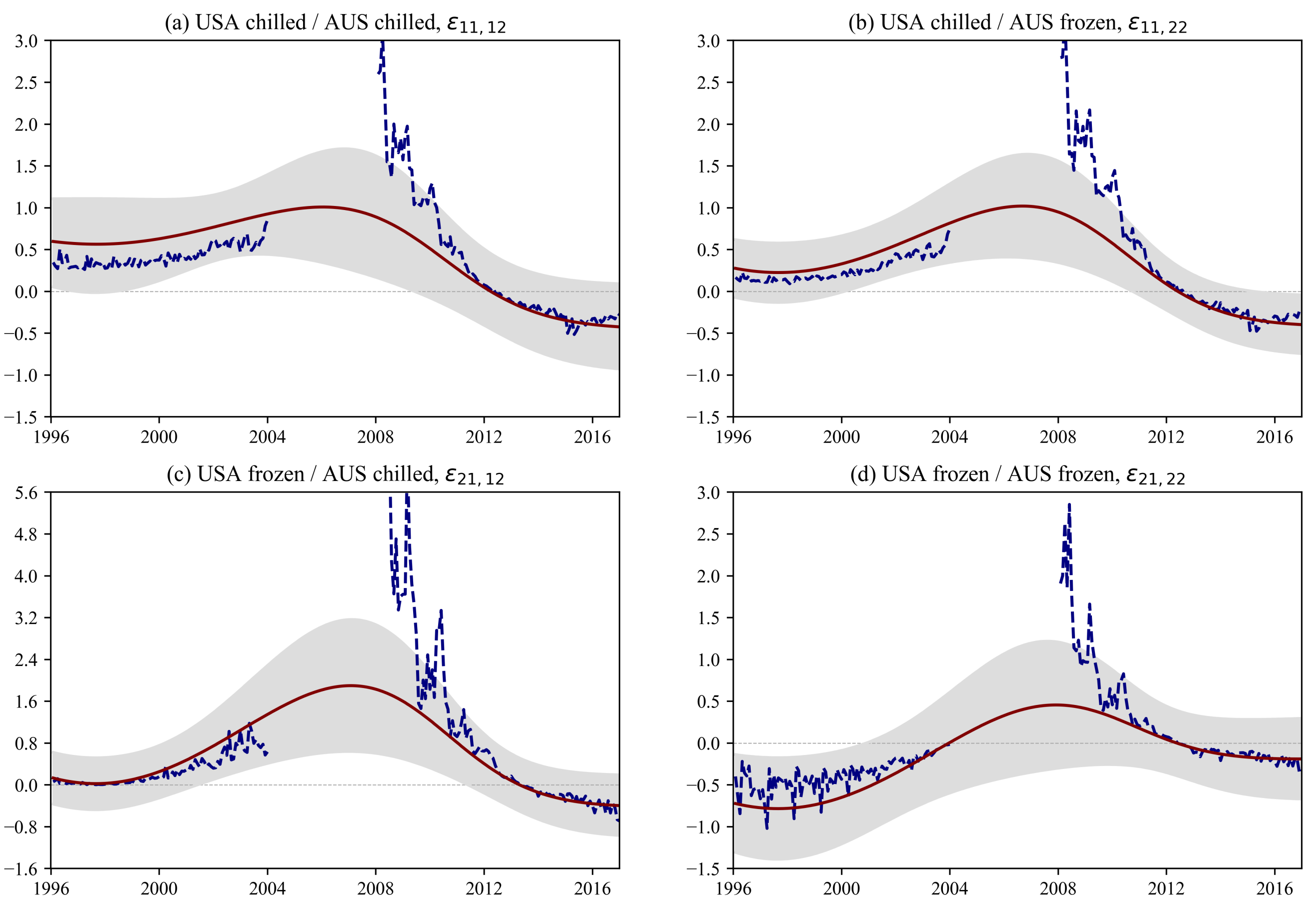
Note: Time series estimates and their 95% confidence intervals (grey areas) derived from the three-regime smooth transition SDAIDS model. Red solid line indicates sample average estimates with time-varying coefficients; blue dashed line indicates individual estimates with time-varying coefficients.

Figure 2.6: Time series plots of the within-origin cross-price elasticities for Japanese beef imports



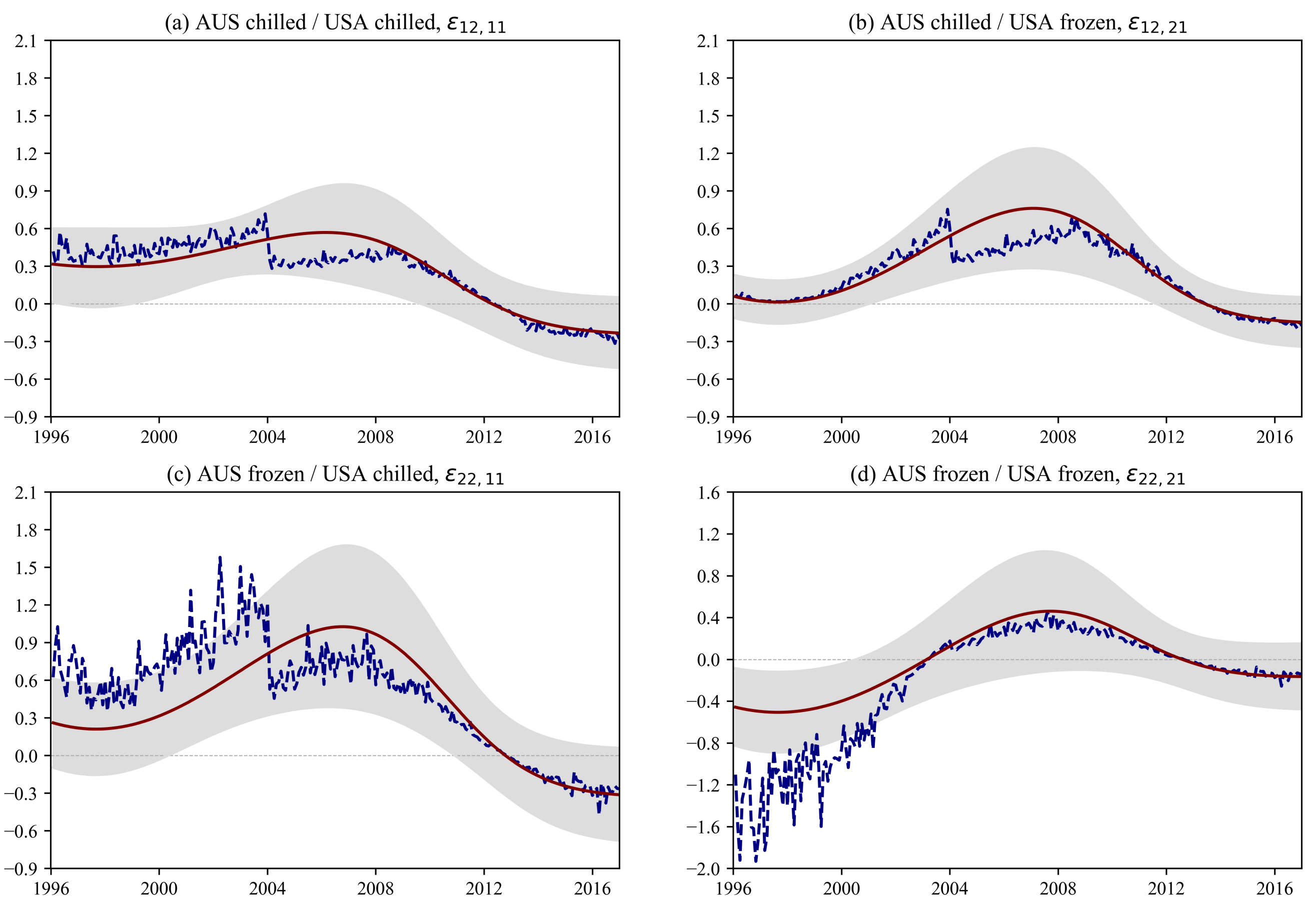
Note: Time series estimates and their 95% confidence intervals (grey areas) derived from the three-regime smooth transition SDAIDS model. Red solid line indicates sample average estimates with time-varying coefficients; blue dashed line indicates individual estimates with time-varying coefficients.

Figure 2.7: Time series plots of the (selected) cross-price elasticities for Japanese beef imports



Note: Time series estimates and their 95% confidence intervals (grey areas) derived from the three-regime smooth transition SDAIDS model. Red solid line indicates sample average estimates with time-varying coefficients; blue dashed line indicates individual estimates with time-varying coefficients.

Figure 2.8: Time series plots of the (selected) cross-price elasticities for Japanese beef imports (cont')



Note: Time series estimates and their 95% confidence intervals (grey areas) derived from the three-regime smooth transition SDAIDS model. Red solid line indicates sample average estimates with time-varying coefficients; blue dashed line indicates individual estimates with time-varying coefficients.

Table 2.1: Summary statistics of variables

		Import expenditure ($, million)			Import share (%)			Price ($/kg)		
		Pre-BSE	BSE-ban	Post-BSE	Pre-BSE	BSE-ban	Post-BSE	Pre-BSE	BSE-ban	Post-BSE
Chilled	USA	66.22	0.00	34.93	34.10	0.00	16.10	6.30	9.20	6.98
		(16.81)	(0.00)	(18.85)	(5.09)	(0.00)	(7.18)	(0.84)	(1.40)	(0.70)
	AUS	56.52	99.51	76.50	29.60	62.42	38.40	3.81	5.66	6.43
		(10.50)	(20.01)	(12.50)	(4.03)	(4.93)	(9.71)	(0.36)	(0.14)	(0.68)
	NZL	1.88	2.54	3.84	0.98	1.62	1.90	4.99	6.80	7.34
		(0.77)	(0.52)	(0.79)	(0.38)	(0.35)	(0.39)	(0.46)	(0.30)	(0.82)
	ROW	1.71	1.32	2.48	0.90	0.82	1.21	6.72	7.83	7.39
		(0.82)	(0.93)	(0.73)	(0.42)	(0.59)	(0.32)	(2.49)	(1.02)	(2.93)
	ALL	126.30	103.37	117.75	65.64	64.86	57.70	4.85	5.70	6.60
		(26.76)	(20.52)	(19.73)	(7.70)	(5.03)	(6.09)	(0.44)	(0.14)	(0.68)
Frozen	USA	44.02	0.00	22.34	21.80	0.00	10.10	2.93	6.43	4.41
		(23.84)	(0.00)	(15.31)	(6.13)	(0.00)	(5.51)	(0.49)	(0.48)	(0.53)
	AUS	18.70	44.16	52.72	9.74	27.64	25.60	1.88	2.78	3.49
		(5.88)	(11.01)	(14.31)	(2.59)	(4.05)	(4.72)	(0.14)	(0.13)	(0.54)
	NZL	2.78	9.61	7.19	1.40	5.91	3.54	2.61	3.38	4.32
		(1.45)	(4.21)	(2.95)	(0.49)	(1.93)	(1.34)	(0.32)	(0.25)	(0.90)
	ROW	2.62	2.12	6.52	1.37	1.30	3.04	3.40	5.07	4.99
		(1.50)	(1.47)	(4.00)	(0.73)	(0.78)	(1.50)	(5.04)	(2.10)	(2.50)
	ALL	68.13	55.88	88.77	34.36	34.85	42.31	2.50	2.92	3.71
		(29.71)	(14.80)	(28.15)	(7.70)	(4.70)	(6.09)	(0.32)	(0.14)	(0.56)

Note: The pre-BSE period is Jan 1996-Dec 2003; the BSE-ban period is Jan 2004-Aug 2006; and the post-BSE period is Sep 2006-Dec 2016. Import expenditures are the monthly average expenditures on the corresponding beef imports. Import shares are the sample average expenditure shares of the corresponding beef imports. Prices are the sample average unit value per kilogram for the corresponding beef imports. Standard errors in parentheses.

Table 2.2: Model fits, test statistics, and select parameter estimates for the Japanese beef import demand models

	Basic SDAIDS (1)	Two-regime SDAIDS (2)	Two-regime SDAIDS (3)	Three-regime SDAIDS (4)
No. of observations	2016	2016	2016	2016
No. of parameters	49	86	86	123
Log likehood	4939	5254	5258	5444
System AIC	-9780	-10336	-10343	-10641
System BIC	-9607	-10033	-10040	-10207
LR test statistic	-	638.38	645.41	1017.58
		[0.001]	[0.001]	[0.001]
Smooth transition function	-	logistic	exponential	exponential & logistic
λ_1^*	-	-1.318	-7.966	-1.117
		(0.267)	(0.259)	(0.199)
λ_2^*	-	-	-	1.131
				(0.111)
c_1	-	4.855	-1.157	0.077
		(0.641)	(0.394)	(0.015)
c_2	-	-	-	0.680
				(0.013)
Expenditure regression	YES	YES	YES	YES

Note: In the column (4), the first exponential transition function has a speed-of-adjustment parameter $\lambda_1 = \exp(-1.117) = 0.327$ and a symmetry parameter $c_1 = 0.077$; the second logistical transition function has a speed-of-adjustment parameter $\lambda_2 = \exp(1.131) = 3.099$ and a centrality parameter $c_2 = 0.68$. AIC denotes the Akaike information criterion. BIC denotes the Bayesian information criterion. Smaller value (i.e., more negative) of AIC and BIC indicates a better model fit. LR denotes the likelihood ratio test. Test statistic p-values in brackets. Standard errors in parentheses.

Chapter 3

New Estimates on the Ad-valorem Equivalents of SPS Measures: Evidence from Specific Trade Concerns

3.1 Introduction

Non-tariff measures (NTMs) are not new, but their prominence in global agricultural trade continues to increase. The United Nations Conference on Trade and Development (UNCTAD [94]) defines NTMs as policy measures other than ordinary customs tariffs that can affect international trade in goods, changing the price of traded products, the quantity traded, or both. World Trade Organization (WTO) members are permitted to adopt regulations under the Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT) Agreements in the pursuit of social, public, environmental, and other policy objectives. These objectives include ensuring the safety of imported food, the protection of animal and plant health, and the well-being of consumers. Under the SPS and TBT Agreements, Members are obligated to notify the WTO when new regulations or standards governing agricultural imports are adopted or changed. SPS and TBT standards are often justified based on the need to correct market failures that may arise due to the lack of information, sufficient monitoring, and control of the quality, characteristics, and safety of imported agri-food products.

The increasing use of NTMs across international borders has stimulated a significant research effort investigating the effects of these measures on international trade (Arita et al. [6], Beghin et al. [12], Cadot and Gourdon [18], Crivelli and Gröschl [24], Deardorff and Stern [27], Disdier et al. [31], Ferrantino [38], Grant et al. [45], Hoekman and Nicita [55], Kee et al. [65], Moenius [74], Nicita and Gourdon [79], Peterson et al. [84], Swinnen [91]). On the one hand, standards and regulations can enhance trade by increasing consumers' confidence[1]. For example, in economies where consumer awareness of food safety, animal welfare, and plant health is particularly sensitive, SPS measures may increase demand for products that are more stringently regulated (Josling et al. [62]). On the other hand, regulatory measures can deliberately or unintentionally restrict trade, particularly for developing countries that may lack monitoring, testing, and certification infrastructure to demonstrate compliance with regulatory requirements. Trade disputes over SPS measures can also occur between highly developed economies, such as between the US and the EU, where acceptable risk levels and interpretation of appropriate science differs among policymakers[2]. Disdier et al. [31] examine the impact of SPS and TBT measures using notification-based data from UNCTAD and find that these measures significantly reduce developing countries' exports to OECD countries, but do not affect trade between OECD members. Kee et al. [65] use 78 developed and developing countries to estimate the trade restrictiveness indices and the *ad-valorem* tariff equivalents (AVEs) of NTMs and find that poor countries not only have more restrictive trade regimes, they also face higher barriers on their exports. Averaging across countries, NTMs almost double the level of trade restrictiveness imposed by tariffs. Nicita and Gour-

[1] Beghin et al. [12] make this argument in the context of maximum residue limits.

[2] For example, Barlow et al. [10] describe differences between risk assessment and exposure determinations versus hazard-based approaches where even the detection of harmful agents is used to formulate regulatory policy.

don [79] utilize newly collected data from UNCTAD and the World Bank to investigate the use of NTMs in 26 countries and found that the incidence of SPS/TBT measures varies greatly across countries and economic sectors, with a large part of concerns raised by developing countries. Staiger [90], Beghin et al. [11], Beghin et al. [12] and Swinnen [91], on the other hand, provide a detailed exploration of NTMs and emphasize the complexity involved in determining the economic impact on trade and welfare in the presence of externalities, political issues and other market imperfections.

Among the NTMs affecting agricultural trade, SPS and TBT measures are the most frequently encountered measures according to the data collected by the UNCTAD's Trade Analysis and Information System (TRAINS) and the WTO's Integrated Trade Intelligence Portal (I-TIP) (Ederington and Ruta [36], WTO [97]). They are also considered among the most relevant impediments to exports according to a small sample of NTM business surveys conducted by the World Bank and International Trade Centre (UNCTAD [94], World Bank [96]). The importance of NTMs in agricultural trade has led to significant research interest in quantifying their impacts. Cadot and Gourdon [18] and Grant and Arita [41] note that SPS/TBT measures overwhelming account for the largest component of NTM costs impacting agri-food trade. Kee et al. [65] find that the average estimated NTM AVEs for agricultural products is about three times higher than those for manufactured goods. Hoekman and Nicita [55] concur the findings in Kee et al. [65] that agricultural trade is much more restricted than manufactured products, reflecting both higher tariffs and greater use of NTMs.

Arita et al. [6] and Arita et al. [7] find significant negative effects of SPS regulations maintained by the European Union (EU) for certain agricultural sectors such as cereals, beef, pork, and to lesser extent, fruits and vegetables. Peterson et al. [84] and Grant et al. [45] find negative effects of SPS measures on US fresh fruit and vegetable exports but at a diminishing rate as importers and exporters accumulate SPS treatment experience in the global marketplace. Fontagné et al. [39] use a panel of French firm-level exports to estimate the effect of SPS measures on the intensive and extensive margins of trade and find that SPS measures reduces export participation by 4 percent and the exported value by 18 percent. Conversely, Crivelli and Gröschl [24] find negative effects on the probability of trade occurring but positive on the value of trade conditional on market entry. Because WTO members have considerable flexibility in formulating regulatory mesasures, policymakers often neglect to take account of the potential trade effects of these policies (Orden and Roberts [82]).

While existing studies have certainly advanced our understanding of the impacts of non-tariff measures on international trade, the effects of SPS measures in agri-food trade are generally not well understood in part because of the sheer number of measures making it difficult to sort out the more troublesome measures affecting exports from those that serve legitimate objectives to ensure the quality and safety of animal, plant and human health. Figure 3.1 illustrates the number SPS and TBT measures notified to the WTO since 1995. Cumulatively, over 24,000 SPS and 35,000 TBT measures have been notified. The number of SPS notifications has consistently exceeded 1,000 notified regulations per year since 2006, and exceeded the number of TBT notifications, which cover a much larger set of products beyond agriculture, in 2006, 2007, 2008, 2011, 2014, and 2015.

A critical challenge in estimating the effects of NTMs is selecting the sample of regulatory standards to evaluate. While collecting and tabulating SPS and TBT notifications illustrated in Figure 3.1 allows researchers to examine the widest possible scope of measures, such examinations treat all notifications equally. For example, Japan's October 3, 2019 SPS notification (G/SPS/N/JPN/684) that certain plant products need to be accompanied by a phytosanitary certificate is likely far less impactful on trade than China's 2009 emergency notification of restrictions on US swine exports (G/SPS/N/CHN/117) due to H1N1 swine flu concerns, or China's 2015 restrictions on US poultry exports due to Highly Pathogenic Avian Influenza (AI), or the EU Commission's 2010 regulation (Commission Regulation (EU) No. 165/2010) setting maximum limits on aflatoxin in ready-to-eat peanuts at 2 ug/kg for aflatoxin B1 and 4 ug/kg for total aflatoxin[3]. In the latter case, the EU's ML's are considerably lower than the 10 ug/kg recommended by the Food and Agricultural Organization and World Health Organization (FAO/WHO) Joint Expert Committee on Food Additives (JECFA) and current options under consideration by Codex.

The purpose of this study is to address these challenges in the literature on estimation of the trade effects of NTMs: How do we identify economically meaningful and potentially consequential SPS measures in order to evaluate and quantify their trade effects? Critical research questions for agricultural policy-makers include: (i) By how much do SPS measures that have been flagged as trade concerns impact members' agricultural trade? (ii) What types of SPS measures are responsible for the more significant trade shocks? (iii) In which destination markets and product sectors are these measures occurring? (iv) How does bilateral trade respond when the resolution of non-tariff measures is achieved?

While case-study approaches have the benefit of signaling out a specific measure (i.e., Li and Beghin [69], Peterson et al. [84]), it is difficult to compare across different types of SPS measures. Broad-based approaches are useful for an overall picture (i.e., Beghin et al. [12], Cadot and Gourdon [18], Disdier et al. [31], Kee et al. [65], Nicita and Gourdon [79]), yet it is difficult to distinguish between important and unimportant measures in terms of their trade impacts. Following Grant and Arita [41], this study adopts a targeted approach. Specifically, this study: (1) identifies a subset of SPS measures that have been flagged as specific trade concerns (STCs) by agricultural exporting countries in the WTO's SPS Committee meetings for SPS measures maintained by importing countries over the 1995-2016

[3]For comparison, most countries have set aflatoxin maximum limits of 10-15 ug/kg. Japan's ML is set at 10 ug/kg.

period; (2) uses the specific trade concerns to identify active country-pair and product relationships that may have been affected by SPS measures of concern, and estimates their trade impacts; and (3) converts the econometric trade impacts of SPS measures into *ad-valorem* tariff equivalents (AVEs) to provide academic researchers and policy-makers with SPS trade impact estimates for use in computational partial and genera equilibrium simulations of bilateral trade negotiations seeking to harmonize regulatory differences.

An important feature of the SPS STCs database is that it provides a bilateral (importer-by-exporter) dimension of trading partners potentially affected by product-specific SPS measures. This bilateral dimension is often absent from the broader class of WTO notifications of non-tariff measures. SPS specific trade concerns also contain a rich set of underlying information in terms of the frequency with which the concern is raised, the nature of the SPS measure (animal health, plant health, or food safety), the severity of the concern measure in terms of the language used to describe the concern by exporting countries, the duration of the SPS concern, and approximate time periods in which the resolution of the concern was(is) achieved.

We expand each selected SPS specific trade concern into a country-pair-by-product time series of bilateral trade flows to estimate econometrically and evaluate and rank their trade impacts. In particular, our empirical strategy allows for identification of the trade effects of these measures not only during the period in which SPS trade concerns were active but also after resolution is achieved for a subset of concerns to shed light on the potential gains available through the multilateral process of the WTO's SPS Committee meetings. We produce four trade impact assessments: (1) the trade impact of SPS concern measures globally, (2) a decomposition of trade impacts into global animal, plant, and food safety based SPS concern measures, (3) trade impacts specific to the US, EU and China for measures it faces in export markets as well as the measures it maintains on its imports, and (4) the trade impact of six specific case-study SPS measures of concern facing the US and other large agricultural exporters.

The remainder of this article is organized as follows. Section 2 describes the sources and summary statistics of SPS specific trade concerns, bilateral trade, and other explanatory variables. Section 3 presents the methodology used to estimate the trade effects and AVEs of SPS measures raised as specific trade concerns by exporters. Section 4 provides the empirical results. Section 5 concludes.

3.2 Data and Descriptive Overview

SPS specific trade concerns identify a set of cross-cutting SPS issues based on measures that have been flagged by exporting countries as trade concerns. In this section, we describe trends in SPS specific trade concerns and products and countries included in the bilateral trade database.

3.2.1 SPS Specific Trade Concerns

Through July 2019, the WTO's SPS Committee has recorded 464 specific trade concerns dating back to 1995. These records comprise SPS measures maintained by importers that have been flagged as specific trade concerns by exporters at the WTO's SPS committee meetings[4]. For each concern, the WTO's SPS Information Management System (IMS) reports the exporting country raising or supporting the SPS concern, the importing country

[4]The WTO's "Understanding the WTO Agreement on Sanitary and Phytosanitary Measures," states that the SPS Agreement established a committee on SPS Measures (The "SPS Committee") to provide a forum for consultations about food safety or animal and plant health measures which affect trade, and to ensure the implementation of the SPS Agreement. See https://www.wto.org/english/tratop_e/sps_e/spsund_e.htm

maintaining the measure, the Harmonized System (HS) product code(s) affected (typically at the HS 4-digit level), the first and last date the SPS issue was raised, the number of times the SPS issue was raised, the subject keywords, and the resolution status.

For the purposes of matching specific trade concerns to bilateral trade data, we collected 417 SPS specific trade concerns from 1995-2016. However, a number of concerns contain incomplete information. After dropping the observations with missing country or product details[5], as well as non-food sectors (e.g., wood or cosmetic products)[6] and non-SPS related subjects (e.g., technical labeling or packaging issues)[7], the SPS trade concern dataset contains 374 concerns.

Figure 3.2 plots the number of SPS specific trade concerns raised for each of the WTO's SPS subject categories - animal health (AH), plant health (PH), food safety (FS), and other concerns not elsewhere specified (OTH) - and the cumulative number of countries involved in SPS specific trade concerns from 1995-2016. Animal health concerns comprise 152 STCs or 41% of all SPS-related trade concerns, 119 concerns (32%) are related to food safety, 87 (23%) are related to plant health, and the remaining 16 concerns (4%) are related to the other issues such as licensing, certification requirements, and control or inspection procedures. The number of countries participating in SPS trade concerns increased rapidly in the 2001-2006 period due, in part, due to multiple outbreaks of food safety diseases such as BSE (bovine spongiform encephalopathy), or mad cow diseases. The number of raised SPS specific trade concerns gradually slowed in recent years. An average of 17 SPS specific concerns has been raised annually since 2010. Through 2016, 79 countries raised or supported, and 75 countries maintained at least one SPS trade concern[8].

[5] For example, STC 7, 26, 190, 235, 384, etc.
[6] For example, STC 59, 81, 143, 182, etc.
[7] For example, STC 13, 214, 240, etc.
[8] We treat the European Union (EU 28) as one single country in our data.

Figure 3.3 provides a breakdown of participating countries by income status. The majority of SPS trade concerns (97%) are raised, supported, or maintained by high-income developed and middle-income developing countries. STCs that are raised/supported by developing country exporters against the measures maintained by developed country importers make up the largest share, 35%, followed by 25% for STCs raised/supported and maintained among developed countries. 24% of concerns raised or supported by developed countries are against the measures maintained by middle-income developing countries, and 13% of STCs are raised or supported by developing countries against the measures maintained by other developing countries. Least developed countries are not well represented in SPS specific trade concerns.

Using the first and last date SPS trade concerns were raised, we calculate the average number of times SPS trade concerns were subsequently raised and the average duration or length of time each STC continued to be an issue for exporters. The distribution for each of these calculations are plotted in Figure 3.4. Many SPS trade concerns are raised 1~3 times and are of relatively short duration (1~3 years). For context, the WTO's SPS Committee holds three regular meetings each year. However, countries may not raise/support the same STC consecutively in all three meetings of every year. Thus, the total number of times the STC is raised is not necessarily equal to three times the number of active years.

Nonetheless, there are some extreme cases. First, the highest solid circle above any of the animal health, plant health, food safety and other concern categories is STC 193, an animal health related SPS concern over restrictions on BSE that was subsequently raised 34 times by the EU and the US and supported by Canada, Switzerland, and Uruguay. Second, STC 238 - a food safety related SPS concern about the EU's regulation of novel foods - was subsequently raised 23 times by Colombia, Ecuador, and Peru and supported by another 20 countries. STC 193 related to BSE restrictions on beef lasted nearly 15 years and STC 238 lasted 12 years before exporting countries stopped raising the concern.

Figure 3.5 plots the incidence of SPS specific trade concerns by subject across the WTO's Multilateral Trade Negotiating (MTN) product sectors[9]. Several results are worth noting. First, livestock and meat products (MEAT) is the sector most impacted by SPS trade concern measures with over 500 product incidences. Within the MEAT category, animal health related SPS concerns make up the largest share and are responsible for over 80% of SPS concerns impacted by trade restrictions. Food safety concerns is a distant second with nearly 20% of concerns impacting products in this category. MEAT is followed by Fruits and vegetables (FV) with nearly 420 SPS trade concerns covering products in this sector. Contrary to the livestock and meat sector, fruit and vegetables are impacted by a number of plant health and food safety related SPS trade concerns split roughly equal between the two categories. Cereals & preparations and dairy products follow meat and fruits and vegetables each with roughly 200 SPS trade concerns covering products in these sectors. Sugar and confectionary candy products (SGR) are the least impacted by SPS trade concern measures.

To gain further insight with respect to countries and products actively engaged in raising/supporting and maintaining SPS trade concerns Figures 3.6 and 3.7 present the top 10 countries raising/supporting and maintaining SPS STCs across each of the WTO's MTN categorization of agricultural products, respectively. Both the US and EU are leading participants in SPS trade concerns with each country raising or supporting 116 and 110 SPS concerns, and maintaining 39 and 81 SPS measures of concern against other exporting countries, respectively. US exporters expressed a considerable number of SPS concerns against BSE, AI (Avian Influenza) and MRL restrictions, which affect meat and fruit & vegetable

[9]MEAT denotes animal products; FV denotes fruits & vegetables; DAIRY denotes dairy products; CER denotes cereals & preparations; OILS denotes oilseeds, fats & oils; SFD denotes fish & fish products; CTS denotes coffee, tea, mate & spices; BT denotes beverages & tobacco; SGR denotes sugars & confectionery; OTHAG denotes other agricultural products. See Table A.3 in the Appendix for what product codes are covered in each sector.

product exports. For example, in October 2008, the US raised and Canada, Brazil, Costa Rice, Ecuador, and Peru supported a concern on Taiwan's restrictions on the use of ractopamine – a veterinary drug that increases swine feed efficiency (STC 275). Because a certain fraction of the drug can remain in processed meat cuts, some countries have argued that small amounts of residue (<10 parts per billion (ppb) for the main types of meat products) are proven safe, while other countries including China, Thailand, Russia, and the EU have prohibited the use of ractopamine even though an international Codex (the Codex Alimentarius Commission) MRL has been in place since 2012 (Alemanno and Capodieci [2])[10]. The ractopamine SPS concern has subsequently been raised 5 times and remains unresolved.

Like the US, EU exporters have also raised numerous SPS trade concerns against BSE, AI, ASF (African swine fever), and other food additives restrictions. For instance, in June 2004, the EU (and the US) raised concerns about many countries' ban/restrictions on their beef exports due to concern about BSE (STC 193). Since the first confirmed case of BSE in 1986 in the United Kingdom and subsequent BSE outbreaks in the EU and North America (Canada and the US) in the early 2000s, many destination markets ceased importing beef from these countries. Destination markets specifically mentioned in the concern include Australia, Brazil, China, Japan, South Korea, Thailand, Turkey, Ukraine, and Saudi Arabia. After raising the concern over 34 times (the most recent in November 2018), the concern is now considered partially resolved.

Unlike the US, however, EU SPS trade measures are more likely to be flagged as concerns by exporters. Related to its hazard-based approach to enact regulatory legislation, EU countries often maintain more stringent SPS standards than international food standards (i.e., FAO/WHO Codex Alimentarius, the World Organization for Animal Health (OIE) and the International Plant Protection Convention (IPPC)). Long-standing issues include

[10] See also: "U.S. Presses Taiwan on Ractopamine Ban," Food Safety News, February 7, 2012, available at https://www.foodsafetynews.com/2012/02/us-presses-taiwan-on-ractopamine-ban/

the EU's setting of maximum residue limits and restrictions on genetically modified organisms (GMOs). In October 2001, the US first expressed concerns about the EC (European Commission) proposals on genetically modified food and feed, and the traceability and labelling of GMOs. 12 other countries supported US concerns regarding the treatment of GMOs by the EU (see STC 106, 110, 117 and 396). Although the proposed regulations were meant to protect human and animal health, consumers, and the environment, they have been considered *de facto* trade-barriers due to lengthy approval processes. Despite the concern being recorded as resolved with the WTO in 2006, the US again expressed trade concerns in June 2016 regarding further delays in the EU's approval process for soybean biotechnological applications (STC 396). As described later in this report, even though some SPS trade concerns get reported as resolved in the WTO's SPS information management system, this does not guarantee that the importing country has withdrawn or revised its SPS policy such that these measures no longer represent a barrier to trade.

Other developing countries such as Brazil, China, and India have also participated more actively in raising/supporting and maintaining SPS trade concerns. Because China maintains zero-tolerance for the presence of ractopamine, salmonella, listeria monocytogenes, and other pathogens in imported raw meat and poultry, many countries have expressed concerns about the unwarranted delay or restrictions of their products exported into the Chinese market. For example, STC 246 reported the trade concern about China's import restrictions on products of animal origin due to dioxin raised by EU; STC 251 discussed the concern about China's zero-tolerance for pathogens on raw meat and poultry products raised by the US.

Also plotted along the secondary horizontal axes in Figure 3.6 and 3.7 are the various MTN product sectors affected by SPS trade concern measures. The top 10 exporting countries raising SPS trade concerns include the U.S., EU, Argentina, Canada, Brazil, China, Australia, Chile, New Zealand and Indonesia. The top 10 importing countries maintaining measures of concern include the EU, U.S., Japan, China, Australia, Brazil, India, South Korea, Canada and Russia. While there is some variation between countries in terms of the product sectors in which SPS trade concern measures are being raised against importing countries applying the measures, or maintained against exporting countries facing these measures, meat (28.6%), fruits and vegetables (21.8%), dairy (13.4%), and cereals & preparations (12.3%) are consistently the most frequently affected product sectors. These four product sectors account for 85% of all SPS specific trade concern measures raised in the WTO's SPS committee meetings. These four product sectors also have a relatively large trade weight in global agri-food trade covering an average of 51% of each of the top 10 exporting and importing countries' agricultural trade.

3.2.2 Trade Data

After carefully examining the global dataset of SPS specific trade concerns, we found that the top 30 agricultural importing and exporting countries consistently and actively participate in raising and maintaining SPS measures of concern. Further, we identified four major product sectors - meat, dairy, fruits & vegetables, and cereals & preparations - that represent over 85% of the full sample of SPS specific trade concerns. In other words, SPS concerns tend to be quite concentrated among 20~30 importing and exporting countries and four product sectors. To ease the computational burden involved in the econometric estimation of SPS trade impacts, in what follows we describe a global dataset of bilateral agricultural trade flows to quantify trade impacts of SPS measures facing the top 30 global agri-food trading countries and four major agricultural product sectors. Table A.2 and A.3 in the Appendix provide the list of the top 30 countries (regions) included in our sample and a mapping of product codes into MTN sectors for which we focused on four (meat, dairy, fruits & vegetables, and cereals & preparations).

Data on the value of bilateral trade at the Standard International Trade Classification (SITC, revision 1) 4-digit level from 1995 to 2016 are collected from the United Nations Commodity Trade Statistics Database (UN Comtrade) database[11]. We used the SITC product codes for two reasons. First, this classification allows us to use a longer time series of bilateral trade data. While the HS classification system was started in 1988, countries, including many developing countries, did not effectively convert their trade statistics to the HS system until the late 1990s. Second, the SITC involves fewer product classifications compared to the HS system. Because we coded each of the 374 SPS specific trade concerns involving the top 30 countries used in our sample individually for each country-pair-by-product, use of the SITC codes expedited this mapping. Third, about a quarter of the SPS specific trade concerns released by the WTO's SPS IMS do not provide specific HS codes for products affected by SPS concern measures. We extracted the relevant product codes according to SPS Committee meeting summary reports. However, in this case, using HS 6- or HS 4-digit product codes may be too specific. To reconcile this issue, we coded the products at the SITC 4-digit level to help identify a broad category of commodities as opposed to a specific product being affected by SPS concern measures[12]. A potential drawback of the SITC product codes is that they are less disaggregated compared to the HS 6- and 4-digit product codes. For example, the four agricultural product sectors considered in this article – meats, dairy, fruits & vegetables, and cereals & preparations – correspond to 86 HS 4-digit (or 303 HS 6-digit) product codes compared to 60 SITC 4-digit product codes.

The bilateral Most-Favored Nation (MFN) tariff and average applied tariffs inclusive of preferential rates within free trade agreements are collected from the International Trade

[11] https://comtrade.un.org/

[12] For instance, beef in the SITC product code consists of "Meat of bovine animals, fresh, chilled, frozen, salted" in SITC code 0111 compared to 6 different HS 6-digit codes breaking down beef into fresh, frozen, carcasses, half carcasses, bone-in or boneless, etc.

Centre-Market Access Map (ITC-MacMap) database[13]. Other economic and trade-related variables (the bilateral distance, common language, common colonial tie, common border, free trade agreements, etc.) are collected from the World Bank[14] and *Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII)[15]. Import demand Elasticities are collected from Soderbery [88] and Grant et al. [46] to match the product and bilateral country pairs included in the study.

When merging SPS trade concern measures with SITC 4-digit bilateral trade data, four additional items need to be mentioned. First, while a majority of the country-pair-by-product triplets were targeted by a single SPS concern measure, the remaining trade triplets overlapped with two or more SPS concern measures that are often different in terms of the type of measures, frequency with which the concern was raised, and/or other characteristics, causing problems merging the trade concerns to a single country-pair-by-product observation[16]. To address this issue, we merged SPS concern measures using the earliest reported concern or the concern with the most prolonged active period. We feel these are the most troublesome SPS concerns raised/supported by the exporting countries that may impact trade.

Second, we screened SPS trade concern measures to eliminate those STCs that involved draft measures (i.e., SPS measures that were in the process of undergoing the 60 day comment period before being implemented). For example, STC 288 discussed the concern raised by the EU and supported by Canada, Iceland, Norway and the US on the draft measures proposed by Ukraine on a wide range of animals and animal product imports. In March 2010, Ukraine withdrew the measures on animals and animal products due to BSE and

[13] http://www.macmap.org/
[14] https://databank.worldbank.org/
[15] http://www.cepii.fr/CEPII/en/
[16] 54.7% of trade triplets were targeted by a single SPS STC, 24.2% of trade triplets were targeted by two distinct STCs, and 18.4% by three or more distinct STCs.

other prior infections after consulting with the concerned members and welcomed further developments of its import system in a transparent manner. Similarly, STC 299 documented the concern raised by China and India and supported by Costa Rica, Jamaica, Mexico, Pakistan and Philippines on the US 2009 Food Safety Enhancement Act that proposed several new measures, including required registration for export food companies, follow-up inspections, compulsory third-party certification for high risk imported products and the expansion of FDA authority. This draft regulation later became law - the Food Safety and Modernization Act - passed by the US Senate in November 2010. However, considering the wide potential product coverage and uncertainty over which product sectors are considered "high risk" or require third party audits, these types of SPS specific trade concern measures were eliminated in this study.

Third, we initially expanded each SPS trade concern measure into a time series using the first and last date when the concern was raised (or the time when the concern was reported as resolved/partially resolved). However, through consultations with the WTO's SPS Committee in Geneva in May of 2018, it was learned that countries rarely report when SPS (and TBT) trade concerns are resolved. Moreover, when countries do report trade concerns as resolved, it is often because the WTO secretariat has urged members to report on the status of their trade concerns[17].

Fourth, an equally important issue is that in synthesizing the minutes attached to each concern, it was realized that trade concerns often started well before the issues were first recorded with the WTO. In other cases, concerns were re-raised and continued after the time when they were recorded as resolved or partially resolved, or animal disease related issues such as AI resurfaced several years later. Therefore, using the recorded dates of specific

[17] Interviews with the WTO's SPS committee in May, 2018 suggest that every few years the committee urges members to update the status of unresolved SPS trade concerns. Our data confirmed this. A large portion of SPS trade concerns were "reported" as resolved/partially resolved in 2004, 2010, 2013, and 2017.

trade concerns is not able to consistently capture the actual interventions or likely impact periods of SPS concern measures, leading to possible measurement errors and inconsistent trade outcomes.

To address these issues, we implemented a data-driven approach to the coding of SPS trade concerns in five steps:

(1) Make use of the WTO's SPS trade concern data as an identification signal indicating which exporters are likely facing SPS issues in specific destination markets for each product.

(2) Evaluate the time series bilateral trade flow data for all affected country-pair-by-product combinations (treatment group) during, before, and after the dates suggested in the language of the recorded SPS committee meeting minutes.

(3) Supplement the information in (1) and (2) with various web-based searches and national sources of SPS specific trade concern measures and consultations with trade policy officials.

(4) Determine the length of time agricultural trade flows were impacted (if any) beyond those recorded in the WTO's SPS committee. If no clear consensus or pattern emerged, SPS trade concerns were coded as recorded based on the language used to describe the situation recorded WTO's SPS committee minutes.

(5) Focus the mapping of SPS trade concern measures on meaningful trade relationships with significant historical trade using a threshold of at least one million dollars of product trade between country-pairs.

To illustrate the potential measurement error between the time when SPS specific trade concern measures are recorded in the WTO's SPS Committee meetings and when trade impacts are being felt by exporters, Figure 3.8 plots EU imports of Brazilian pork over the period 1995-2016 for specific trade concern 275. This specific trade concern was raised by the United States and supported by Brazil and several other exporting countries concerning Taiwan and the EU's restrictions on the use of ractopamine - a feed additive used to promote growth and leanness of pig meat. This concern was first raised in October, 2008 and last raised in 2012. According to the information recorded in the WTO's SPS committee meeting minutes, the SPS treatment period of STC 275 is 5 years (2008-2012). However, further information contained in the committee meeting discussion and online sources of EU and Taiwanese restrictions on ractopamine suggests that these measures have been in place since at least 2006 and continue to impact trade today, despite Codex establishing an official international MRL standard for ractopamine in July 2012. Figure 3.8 illustrates how we re-evaluated the treatment period for this and other specific trade concerns. It is also important to note that STC 275 is an example where trade does not increase despite the concern going unreported since 2012. In the SPS specific trade concern data, we also have patterns where there is a clear increase in trade after a STC ends, such as STC 231: Sri Lankan cinnamon exports to the EU previously impacted by stringent EU standards on sulphur dioxides residue.

This five-step process left us with 202 SPS specific trade concern measures matched to bilateral agricultural trade data from which to conduct a comprehensive empirical analysis. Our data contain 26,348 country-pair-by-product observations affected by SPS trade concern measures over 22 years. It provides a total of 579,656 observations representing bilateral trade between 30 agricultural importing and exporting countries and 60 SITC product codes in four agricultural sectors (meats, dairy, fruits & vegetables, and cereals & preparations). 5 percent of country-pair-by-product trade are in the treatment group, i.e., experienced at least one SPS trade concern measure. Notably, within the treatment group, 49 percent of

SPS trade concerns do not contain a benchmark period, meaning SPS concern measures had been in place well before being recorded at the WTO, and 19 percent of them do not contain a post-resolution period, meaning they continue to be unresolved. Table 3.1 provides summary statistics of the data used in our empirical analysis. Table 3.2 describes the within and between variations of SPS concern measures used in this study.

3.3 Empirical Method

Following Peterson et al. [84], we specify a product-line structural gravity equation to estimate the impact of SPS measures imposed by importing countries that have been revealed as SPS specific trade concerns raised/supported by exporting countries. Let V_{odk} denote the value of exports from origin country o to destination country d in product sector k at time t, the gravity equation can be expressed as

$$V_{odkt} = \frac{Y_{okt}E_{dkt}}{\sum_o Y_{okt}} \left(\frac{T_{odkt}}{\Omega_{okt}P_{dkt}} \right)^{1-\sigma} \tag{3.1}$$

where Y_{okt} is the value of total production of product k for country o at time t; E_{dkt} is the total expenditure on product k by country d at time t; T_{odkt} contain all trade costs needed to get product k from producers in country o to consumers in country d at time t; Ω_{okt} and P_{dkt} are the CES price index used to capture the general equilibrium effects of the inward and outward multilateral resistance terms that arise from change in trade costs at time t.

In the context of agricultural trade, the trade costs are proxied through a multiplicative function of the following factors:

$$T_{odkt} = (1 + tar_{odkt}) \exp \left[\left(\prod_s \theta_s^* L_{od(s)} \right) RTA_{odt}^{\gamma*} SPS_{odkt}^{\lambda*} \right] \tag{3.2}$$

where tar_{odkt} is the applied bilateral tariff rate for the product k exported from origin o to destination d. L_{od} is a vector of bilateral trade promoting or cost variables between o and d, such as common language ($Comlang_{od}$), common colonial tie ($Comcol_{od}$), common border ($Contig_{od}$), or the logarithm of distance ($\ln(Dist_{od})$), reflecting not only transportation and shipment costs but also the cost of coordinating policy with more distant countries (Head and Mayer [49]). RTA_{odt} is a binary variable that equals one when both trading partners belong to the same regional trade agreement. We also introduce a five-year lagged RTA variable, $RTA_{od,t-5}$, to capture the fact that almost all RTAs contain trade liberalization commitments that are "phase-in" over time (Baier and Bergstrand [8], Baier et al. [9], Grant and Boys [42], Grant and Lambert [43]).

The primary variable of interest in this study is the set of SPS trade concern policy variables. To examine the impact of SPS measures imposed by importer d on product k from exporter o, we generate a treatment variable during the period in which the SPS trade concerns were active, $STC_{1,odkt}$, and a post-resolution variable for those concerns that were resolved (either completely or partially), $STC_{2,odkt}$. This allows us to assess the trade effects of SPS measures not only during the active period in which the measures were in place, but also the post-resolution period, and to what extent bilateral trade recovered relative to the pre-SPS specific trade concern period.

Put another way, the SPS specific trade concern data entail three states of the world for each country-pair-by-product triad. Period one captures the years leading up to the SPS specific trade concern. For bilateral trade relationships that began in the first year of our sample (1995) or for concerns that were initiated several years after 1995 but third party sources indicated that the concern measures had been affecting their export industries for many years, there is no period one. Period two is the treatment effect category and corresponds to the years in which the country-pair-by-product relationship experienced an

SPS measure of concern potentially impacting trade. Period three corresponds to the years in which the SPS specific trade concern was resolved. Of course, there are country-pair-by-product relationships that were not impacted by SPS specific trade concerns and these observations are part of our period one control category.

Importantly, the determination of periods one, two, and three is not based on the dates reported by the WTO's SPS Committee for reasons explained earlier. Rather, we use the language and comments put forward by the exporters in describing SPS concern measures documented in the SPS Committee meeting minutes, trends in the underlying trade data for each bilateral-pair-by-product, consultations with policymakers and trade associations, and scrutinizing a number of web-based national sources of information on the SPS concern measure. For some SPS trade concerns, the active period two was never resolved, even if it failed to be raised subsequently as an ongoing concern to the WTO's SPS Committee. In these cases, there is no period three. Examples include some BSE measures (i.e., US concerns over China's SPS measures on BSE that were not resolved until 2017 - beyond the final year in our sample), multiple periods of concern and resolution over China's measures related to US Avian Influenza in poultry (2009 and 2015), and the EU's ban on mangoes and certain vegetables from India which resurfaced after the summer of 2016.

In practice, time-varying country-product-specific fixed effects (α_{okt},α_{dkt}) and time-invariant country-pair-by-product fixed effects (α_{odk}) are utilized as consistent controls for the inward and outward multilateral resistance terms, and time-invariant natural factors impacting bilateral trade costs, respectively (Yotov et al. [100]). As for the dependent variable, because of the unignorable presence of zero trade flows, ordinary least squares estimation fails to produce unbiased and consistent estimates. If an NTM policy results in zero trade, then the omission of such observations eliminates important information regarding trade concerns and will result in underestimation of the true impact of the measures.

To address the issue, we follow Silva and Tenreyro [87] and use the Poisson Pseudo Maximum Likelihood (PPML) estimator that allows for the inclusion of zero trade flows and is robust to different patterns of heteroskedasticity. Even if the conditional variance is not proportional to the conditional mean, the PPML estimation method is still consistent and preferred for the structural gravity model in both partial and general equilibrium (Peterson et al. [84], Yotov et al. [100]).

Substituting equation (3.2) into equation (3.1) and adding a well-behaved error term (ε_{odkt}), the PPML specification of the gravity model is expressed as,

$$\begin{aligned} V_{odkt} &= \exp\Big[\alpha_{okt} + \alpha_{dkt} + \alpha_{odk} + \beta\ln(1 + tar_{odkt}) + \gamma_1 RTA_{od,t} + \gamma_2 RTA_{od,t-5} \\ &\quad + \lambda_1 STC_{1,odkt} + \lambda_2 STC_{2,odkt}\Big]\varepsilon_{odkt} \qquad (3.3) \end{aligned}$$

An important goal of this study is to quantify and compare the trade incidence of animal health, plant health, and food safety related SPS concern measures. A more flexible specification of equation 3.3 disaggregates the SPS STC treatment effect binary variables ($SPS_{1,odkt}$, $SPS_{2,odkt}$) into those related to: (1) SPS measures for animal health reasons: AH_{odkt}, (2) SPS measures for plant health reasons: PH_{odkt}, (3) SPS measures for food safety reasons: FS_{odkt}, respectively. The structural gravity model with disaggregated SPS concern categories is then expressed as,

$$\begin{aligned} V_{odkt} &= \exp\Big[\alpha_{okt} + \alpha_{dkt} + \alpha_{odk} + \beta\ln(1 + tar_{odkt}) + \gamma_1 RTA_{od,t} + \gamma_2 RTA_{od,t-5} \\ &\quad + \sum_{s=1}^{2}\left(\lambda_{s,1} AH_{s,odkt} + \lambda_{s,2} PH_{s,odkt} + \lambda_{s,3} FS_{s,odkt}\right)\Big]\varepsilon_{odkt} \qquad (3.4) \end{aligned}$$

where $AH_{1,odkt}$, $PH_{1,odkt}$ and $FS_{1,odkt}$ denote the SPS treatment effect in periods $s = 1, 2$ (i.e., active and post-resolution) of animal health, plant health and food safety based SPS concern measures, respectively.

Using the estimation results from above, it is possible to estimate the equivalent *ad-valorem* tariff protection of SPS measures of concern. The AVEs of SPS measures adjust the econometric estimates by the elasticity of substitution to put SPS effects on the same scale as tariffs, which serve as a useful metric for input in simulation model assessments and to convey information to policymakers for comparative purposes. The AVEs are also convenient to identify which types of concerns, if resolved, are likely to yield the largest gains for agricultural producers and consumers.

The AVEs of SPS concern measures can be computed as follows. First, given that trade costs are multiplicative, the coefficient λ on any one of the SPS specific trade concern policy indicators in equations 3.3 and 3.4 is a combination of the impact of the policy variable's effect on trade (denoted as δ) and the elasticity of substitution between varieties from different countries (denoted as σ). With $\lambda = \delta(1 - \sigma)$, additional estimates of at least one of these parameters is needed, and without it, policy interpretations of NTMs can be misleading. For example, if the coefficient on SPS variables produces a large negative impact on bilateral trade, a relevant question becomes whether the NTM effect is especially trade-restrictive or whether the elasticity of substitution is large such that even small change in the measure yields large changes (i.e., substitution effects) in trade values.

To overcome this identification issue, a common method is to assume exogenous values of σ estimated in the literature (Grant et al. [46], Kee et al. [63], Soderbery [88]). In this study, we rely on very recent trade elasticities estimated in Soderbery [2015, 2018] because of the broad coverage of country pair and products and the pair-wise consistent estimation methods used in their estimates. Because the elasticity of substitution is sensitive to the type of product (and country) aggregation and pulling estimates from the literature may not match well with our product (and country) aggregation contained in the STC database, we would prefer to estimate the values of σ directly through the coefficient on bilateral tariffs as in equation 3.3 ($\beta = 1 - \sigma$). However, due to limitations on tariff data over the full sample period as well as the aggregation issues when matching tariff rates at the SITC 4-digit level, we elected to use the most recent trade elasticities estimated in the literature (Grant et al. [46], Soderbery [88, 89]).

Evaluating the marginal effect of SPS concern measures and the *ad-valorem* tariff equivalent (at a rate of τ) yields:

$$\frac{\partial V_{odkt}}{\partial tar_{odkt}}|_{tar=\tau} = \exp[\beta \ln(1 + tar_{odkt})] \tag{3.5}$$

$$\frac{\partial V_{odkt}}{\partial SPS_{odkt}}|_{sps=1} = \exp[\lambda] \tag{3.6}$$

The AVE of the concerned SPS measures (AVE^{SPS}) is then the value of τ for which equation (3.5) and (3.6) are equal:

$$\tau = AVE^{SPS} = \exp(\frac{\lambda}{\beta}) - 1 = \exp(\frac{\lambda}{1-\sigma}) - 1 \tag{3.7}$$

3.4 Discussions

In this section, we report the estimated trade impacts of SPS concern measures on the top 30 participating countries and four agricultural product sectors. Firstly, we present the global trade effects of SPS concern measures and the corresponding AVEs using our sample data. Secondly, we present the SPS effects and the corresponding AVEs with a subject-, sector-, and country-pair focus to reflect the heterogeneity among various types of SPS measures as well as products and member countries. Finally, we present six selected case-study of SPS concern measures in particular contexts. A description of these case studies is provided in

Table A.4 in the Appendix. They include: (i) EU aflatoxin limits on groundnuts and cereals; (ii) EU GMOs policies on grain cereals; (iii) BSE restrictions on beef (various countries); (iv) Japan's MRLs restrictions on grain cereals, fruits and vegetables; (v) China, EU, Russia, Taiwan and Thailand's ractopamine restrictions on pork and beef; and (vi) China's ongoing poultry restrictions due to Avian Influenza concerns.

3.4.1 Global SPS Trade Effects

Table 3.3 presents the estimated trade impacts of SPS measures flagged as specific trade concerns on aggregate, by concern subject and by product sector[18]. The corresponding AVEs of SPS trade concern measures are plotted in Figure 3.9 using the calculation in equation (3.7). The Soderbery [88] estimated trade import elasticities of substitution are listed in the last row of Table 3.3. Soderbery [88] estimated the trade import elasticity of substitution on a country-pair-by-HS4-product level. We retained the country pair dimension but averaged these estimates to the MTN product sector level. We then mapped them to our data for AVE calculations.

The estimated marginal effects of active SPS trade concern measures are striking. At the global level, bilateral agricultural trade exposed to an active SPS trade concern measure decreases members' trade by a remarkable 67.8%, on average (Table 3.3, column (1)). Using Soderbery [88] estimated average elasticity of substitution value of 3.36 for the four product sectors included in the sample, the results suggest an overall AVE tariff of 59% imposed by SPS measures of concern, on average. This AVE tariff is more than 3 times higher than the 18.4% global average applied tariff rate across all agricultural products included in the sample (Figure 3.9). For SPS trade concerns that have been resolved, the effect continues

[18]We do not report the coefficients of other covariates such as RTAs and tariffs to save space. These results were economically plausible and of the correct sign throughout. Full econometric results are available upon request.

to be negative, though much smaller in magnitude, with an AVE tariff of just 6%. Thus, overall, SPS measures that have been flagged as specific trade concerns by exporters impart large reductions in members' agricultural trade during periods in which the trade concern measures are active.

In the lower half of Table 3.3, we decompose the estimated SPS marginal trade effects into four subject categories: animal health, plant health, food safety, and other concerns not elsewhere specified. This decomposition of the SPS trade effect is important because it allows for a determination of which types of SPS measures are most trade restrictive leading to an overall trade reduction of 67.8%. Here, we find that an important reason for the negative and significant trade-reducing effect of SPS measures of concern is due to regulations related to animal health. The trade effect of animal health related trade restrictions is to decrease exporting countries' trade by a striking 83.9% during the active period in which these SPS measures were enforced. This corresponds to an AVE effect of 111%, the largest AVE of any SPS subject category, and nearly five times the average applied tariff level on animal products of 23% (Figure 3.9). Interestingly, we find that the trade effect of animal health based SPS measures that were resolved is smaller but still negative and statistically significant at 39% reduction in animal product trade values (Table 3.3). While smaller, this post-resolution AVE effect suggests that SPS trade impacts related to animal health seem to linger even after concerns are reported as resolved. The effects of plant health and food safety related STCs are relatively smaller, though still sizeable, with estimated trade effects of 61.2% and 60.5%, and AVE tariffs of 47% and 46%, respectively.

Table 3.3 and Figure 3.9 also illustrate the results after estimation of the model for the four product sectors. The results indicate that the estimated trade flow effect of SPS concern measures is the most trade-impeding for meat products, representing an 85.8% trade reduction or an AVE tariff of 106% when SPS trade concern were active. SPS concern measures on meat products, which are often related to animal health and food safety concerns such as animal disease outbreaks and restrictions on beta-agonists, appear to be the most damaging for agricultural exports both in terms of the estimated trade effect and implied AVE.

SPS concern measures applied to cereals & preparations are ranked second in terms of the estimated trade impact with a reduction of 68.8%. However, on an AVE basis, cereal products rank third with an estimated 60% AVE tariff (Table 3.3 column 5 and Figure 3.9). Cereals & preparations are impacted by plant health and food safety concern measures such as quarantine treatments, MRLs, and restrictions related to GMOs.

Dairy products are often affected by animal health and food safety related concerns such as BSE and restrictions on feed and food additives. Here, the estimated impact of SPS concern measures maintained by importing countries is to reduce exporting countries' trade by 67.4% (Table 3.3 column 4). This trade effect represents an AVE tariff of 62% in the period in which SPS concern measures were active using Soderbery [88] estimated elasticity value of 3.39 (Figure 3.9).

Fruits & vegetable products experienced the lowest estimated trade effect and the lowest AVE tariff of SPS measures of concern. Fruits & vegetables are frequently affected by plant health and food safety concerns. Examples include Japan's restrictions on MRLs and US phytosanitary inspection procedures for fruits and vegetables. Here, we find that the impact of these SPS concern measures is to reduce exporters' trade by 50.7%, with an AVE tariff of 33% – the lowest among the four sectors studied (Table 3.3 column 3 and Figure 3.9). Interestingly, fruits & vegetables also have the lowest average applied tariff rate across all 30 countries included in the sample at 13%. With the lowest AVE of SPS concern measures, total protection (46%) defined as the sum of the AVE tariff of SPS measures and the average applied tariff is roughly half the next highest sector (cereals & preparations, 80%), and nearly one-third the overall protection impacting animal products (123%) when SPS trade concern measures are taken into account.

3.4.2 Country Specific SPS Trade Effects

The US, EU, Canada, Brazil, and China are major participants not only in raising/supporting and maintaining SPS trade concern measures but also in terms of their shares in world agricultural imports and exports. US, EU, Canada, Brazil and China participate in about one-third of total SPS specific trade concerns included in our sample involving the top 30 countries and account for a share of 45% of global agricultural imports and 49% of global agricultural exports. Given the importance of these five countries and their often opposing participation in raising versus maintaining SPS measures of concern, two relevant and interesting policy questions are: (i) By how much do SPS measures maintained by the US, EU and China affect exporters' agricultural trade? And (ii) what is the impact of SPS concern measures on the US, EU Brazil, and Canadian exports of agricultural exports? We report the estimated results in Table 3.4 and the corresponding AVE tariffs in Figures 3.10 and 3.11.

Comparing the estimated results of US, EU and China's agricultural imports (columns 1-3 in Table 3.4 and Figure 3.10), we find an asymmetric pattern of SPS trade impacts. On average, SPS concern measures maintained by China appear to be the most trade restrictive, reducing exporters' trade by a striking 96.5%, on average. China's SPS trade effect corresponds to an AVE tariff of 131% during the period in which animal health, plant health, or food safety based concern measures were active. This sizable effect is over 8 times higher than China's average applied tariff on agricultural products of approximately 12%. For those concerns that achieved resolution, the effect declines by about a quarter but remains negative, implying an AVE tariff of 38% (Table 3.4). We also find that the trade effect and AVE tariff of China's SPS measures that have been flagged as specific trade concerns are very similar in magnitude across different concern types, with food safety based SPS measures estimated to be the most prohibitive both in the active (an AVE effect of 182%) and post-resolution (an AVE effect of 50%) periods.

On the other hand, the trade effect of SPS concern measures maintained by the EU is estimated to be 76%, or an AVE tariff of 92% in the active period – about 5 times higher than EU's average applied agricultural tariff of 18%. The most prohibitive SPS measures maintained by the EU are related to animal health restrictions (affecting meat and dairy imports), causing an estimated trade decline of 90%, or an AVE tariff of 186%. EU's animal health related SPS measures are followed by food safety related SPS measures at an estimated trade reduction of 76% or an AVE tariff of 89%, and plant health related SPS measures at an estimated trade reduction of 62%, or an AVE tariff of 55%.

By contrast, the trade effects of SPS concern measures maintained by the US are significantly smaller in magnitude, representing an average trade reduction of 51.7%, or an AVE tariff of 42% - less than a half (third) the AVE tariff of SPS concern measures imposed by the EU (China). In particular, the trade effect of food safety based SPS measures imposed by the US is estimated to be the lowest among the three destinations, with a trade-reducing effect of 44.1%, or an AVE tariff of just 32%. The effects of US animal and plant health based SPS measures are roughly double the magnitude of US food safety SPS concern measures. In summary, our results indicate that global agricultural exporters appear to face more stringent SPS regulations in the EU and Chinese markets compared to the US market. Depending on the product and concern type, the effect of SPS concern measures varies in scope, ranging from an AVE tariff of 32% to 186%. These results are consistent with Arita et al. [6] who quantified selected SPS/TBT measures affecting US-EU agricultural trade and also found larger AVE effects of these NTMs in the latter compared to the former.

Turning attention to exporting countries, we examine the impacts of SPS concern measures facing four of the largest agricultural exporting countries: the US, EU, Canada and Brazil. The estimated marginal trade effects are reported in columns 4-7 in Table 3.4 and the corresponding AVEs are plotted in Figure 3.11. On the export side, the trade effects of SPS STCs are somewhat similar in trend. The marginal effects of SPS measures perceived as trade concerns by US and Canadian exporters are slightly higher than those for EU and Brazilian exporters. Averaging over the four estimates and we get an estimated effect of 86% trade reduction, or an AVE tariff of 116%. Perhaps more interestingly, we find that US exports face SPS measures that are two and three times more restrictive than the SPS measures the US maintains on its imports. Conversely, exports of EU agricultural products are less constrained by SPS measures maintained by other nations than those imposed by the EU on its imports. This discrepancy is quite significant in the estimates of animal health and food safety based SPS measures. Canadian exports of agri-food products are relatively more constrained by food safety based SPS measures imposed by its trading partners with an AVE tariff of 183% facing its exports. Brazil, on the other hand, faces more restrictive animal health based SPS measures imposed by importing countries with an AVE tariff of 178%.

3.4.3 Case-Study of Selected SPS Trade Effects

While the global and country-specific effects of SPS concern measures on agricultural trade are informative, the results may not be fully generalized to specific SPS measures of concern. To enhance understanding of specific SPS cases that have been discussed extensively in the WTO's SPS Committee and highlight their trade effects, we selected six case studies of SPS concern measures for further examination. The estimation results are reported in Table 3.5 and AVE tariffs are plotted in Figure 3.12. The six case studies are as follows and summarized in depth in Table A.4 in the Appendix:

(1) Stringent maximum limits on aflatoxins in foodstuffs maintained by the EU;

(2) Regulations on genetically modified organisms maintained by the EU;

(3) Import restrictions due to BSE outbreaks;

(4) Pesticide MRL enforcement system implemented by Japan;

(5) Restrictions on the use of ractopamine in pork for imports in China, Taiwan, Thailand, Russia, and EU; and

(6) China's restrictions on US poultry exports due to Avian Influenza.

EU Aflatoxin Standards

Aflatoxins are harmful substances produced by various fungi that are widely spread in nature. They can be found in cereals, oilseeds, and ground and tree nuts, and can lead to serious risks to humans and livestock (Kumar et al. [66]). Because aflatoxins are considered to be genotoxic and carcinogenic, the EU introduced regulations for these toxins in 1998, at levels considered to be as low as reasonably achievable (EFSA 2007). However, concerns were expressed by 22 countries arguing that the EC (European Community) proposal did not seem to be based on a proper risk assessment and would impose severe restrictions on trade. For example, in June of 2002, Bolivia noted that "although larger Bolivian exporters were able to meet the EC requirements at considerable costs and difficulties, smaller exporters could not fulfil the EC's requirements [on aflatoxin]"[19].

[19] Retrieved from: http://spsims.wto.org/en/SpecificTradeConcerns/View/128

The concern was subsequently raised 13 times after the initial round and reported resolved in March 2004. The results in Table 3.5 suggest that stricter EU aflatoxins on Bolivian and other Southern American and Asian developing country exporters reduced EU imports of these products by 37.4%. The average AVE tariff of the EU's aflatoxin maximum limits is 21.9% while the corresponding average applied tariff rate the EU applies at the border is just 2.4%.

EU GMO Policies

Acceptance of genetically modified organisms (GMOs) has been one of the most contentious SPS (and TBT approval and labelling) issues in global agricultural trade. The EU continues to maintain a *de facto* moratorium on the use and cultivation of GMOs for use in food and animal feed. U.S. GMO standards, in contrast, are typically more focused on the nature and end use of the final products rather than the process in which they are produced. A number of countries including Argentina, Australia, Canada and the U.S. have expressed concerns over the EU's GMO approval process and traceability and labeling requirements, arguing that EU regulations are not commensurate with the risks and lacked scientific justification[20].

The results in Table 3.5 and Figure 3.12 show that EU GMO regulations are indeed a barrier to trade, reducing exports by 68.5% on average. This effect translates into an AVE tariff of 56% on agricultural products exported to the EU markets, which is almost five times the level of EU applied tariffs on GMO products.

[20] Retrieved from: http://spsims.wto.org/en/SpecificTradeConcerns/View/135 and two additional SPS STCs.

Restrictions on Beef Trade due to BSE

The discovery of Bovine Spongiform Encephalopathy (BSE, or mad cow disease) in the state of Washington in December 2003 prompted a large international policy response and immediate restrictions on U.S. beef exports to nearly every major destination market[21]. While Mexico and Canada re-opened their markets to U.S. beef relatively quickly, following the BSE outbreak, other markets including many top export destinations in Asia remained closed for a much longer period of time. For example, Japan and South Korea suspended all imports of U.S. beef through 2005/2006, after which both countries eased restrictions on U.S. beef by allowing imports of beef from cattle aged less than 21 and 30 months, respectively. China banned imports of U.S. beef until September 2016, when China announced that it would begin allowing imports of U.S. beef aged less than 30 months, provided U.S. exporters comply with China's traceability and quarantine rules.

Trade restrictions due to BSE continue to linger in some Asian markets. Moreover, the BSE-related SPS trade concern (STC 193) was the most frequently raised concern for exporters, the most recent of which occurred in November, 2018. The effect of SPS restrictions due to BSE reduced exporting countries' beef trade by 68.4%, on average (Table 3.5). Converting this to an AVE results in BSE restrictions being equivalent to a 58.3% tariff (Figure 3.12) – the third highest AVE tariff out of the six SPS case-studies considered. When added to existing applied tariffs faced by the U.S., Canada, and EU exporters, our estimates suggest that total protection during the period when BSE SPS measures were in place was equivalent to a 75.3% tariff.

[21]Retrieved from: http://spsims.wto.org/en/SpecificTradeConcerns/View/239

Positive List System for MRLs in Japan

In May 2006, Japan introduced its Positive List System for MRLs of agricultural and veterinary chemicals in food. After implementation of this SPS policy, foods containing residues exceeding Japan's MRLs, or 0.01 ppm in cases where no MRLs were established, were prohibited from entry into Japan[22]. China and many other WTO members expressed concerns about Japan's ”uniform standards” of 0.01 ppm for several products. China contended that these new MRL standards were not based on scientific evidence and created serious obstacles to their food exports to Japan[23]. Our results show that Japan's positive list for MRLs reduced exporters trade by 45.5% (Table 3.5) and is equivalent to a 26.3% tariff. Given Japan's relatively high tariff rates on certain product lines including rice, this is one case in which the AVE of the SPS specific trade concern is less than the average applied tariff rate.

Restrictions on the use of Ractopamine

Ractopamine is a controversial veterinary drug (beta agonist) used in the production of swine, turkeys and cattle to promote the growth of lean meat. After years of scientific debate, the Codex Alimentarius Commission adopted an MRL standard for ractopamine in July 2012. Nevertheless, some meat importing countries including China, Taiwan, Thailand, Russia, and the EU continue to maintain a policy of zero tolerance for ractopamine in meat products[24]. Our analysis suggests that restrictions on the use of ractopamine represents a significant barrier to trade, reducing pork exporters' trade by nearly 85% (Table 3.5). Moreover, the AVE of this concern is equivalent to an 88.9% tariff, and is the second most restrictive individual SPS specific trade concern policy among the six selected STC cases.

[22] See USDA/FAS GAIN Report (2006) available at: https://apps.fas.usda.gov/gainfiles/200602/146176749.doc

[23] Retrieved from: http://spsims.wto.org/en/SpecificTradeConcerns/View/92 and two additional SPS STCs.

[24] Retrieved from: http://spsims.wto.org/en/SpecificTradeConcerns/View/275

The AVE tariff is also 4 times higher than the average applied tariff rate (22.6%) on pork trade (Figure 3.12).

China's SPS restrictions on poultry related to Avian Influenza

Finally, in Table 4 and Figure 12 we consider the SPS specific trade concern raised by the U.S. and EU against China's import restrictions of poultry related to Highly Pathogenic Avian Influenza (HPAI)[25]. As a major producer and consumer of poultry products, China imposed restrictions on imports of poultry meat from the U.S. and EU, despite recommendations by the OIE and regionalization efforts. The results reported in Table 3.5 and Figure 3.12 suggest that China's AI restrictions is among the most prohibitive SPS policy measures of the six case studies evaluated. China's AI restrictions have led to estimated export losses of 91.6% and is equivalent to a very high AVE tariff of 120.3%.

3.5 Conclusions

Using a theoretically consistent gravity model of product line agricultural trade flows, this study examines the SPS measures that have been raised as specific trade concerns in the WTO's SPS committee over the 1995-2016 period. Because the universe of SPS and TBT notifications of non-tariff measures is diverse and large with over 54,000 total measures (SPS and TBT) notified to the WTO through 2017, a broad- based approach that attempts to quantify their trade impact may lead to ambiguous trade outcomes. Alternatively, we use a data-driven approach to identify country-pair-by-product trade relationships that have been flagged in the WTO's SPS committee as having been impacted by SPS measures maintained by importing countries. We focus our analysis on the top 30 agricultural trading countries

[25]Retrieved from: http://spsims.wto.org/en/SpecificTradeConcerns/View/258

covering all products within the meat, dairy, fruits vegetables, and cereals preparations sectors.

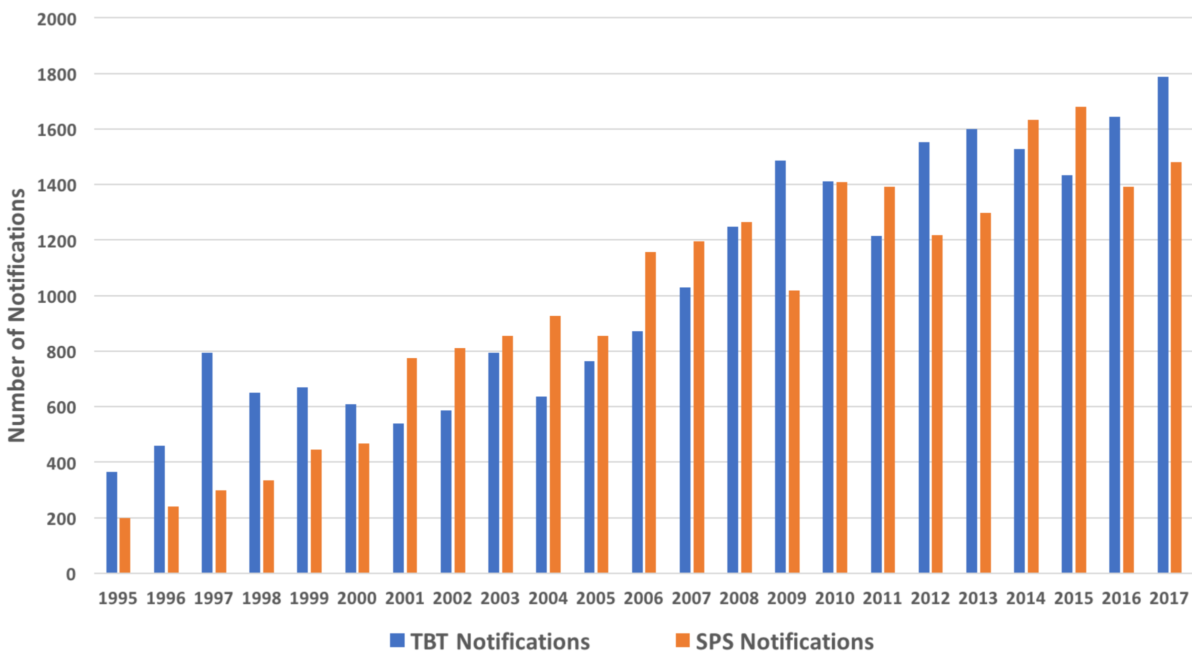
We estimated and compared the SPS trade effect globally, by animal health, plant health an food safety measures, by sector and specific exporting and importing country markets, and for six specific SPS case-studies. Our results show that, on average, trade losses due to SPS measures that have been flagged as trade concerns ranges from 50.8% to 81.5% for the four major product sectors considered during the period in which the SPS trade concerns were active. However, while the SPS trade effect is almost universally negative for trade concern measures, the extent to which trade declines varies considerably across product sectors. Meat and dairy exports which are often affected by animal health-related trade concern measures experienced trade reductions of 86% and 73%, respectively, during years in which SPS trade concern measures were active on these product sectors. Fruit vegetable and cereals preparation exports affected by plant health and food safety SPS measures also experienced negative trade flow reductions; however the magnitude of the trade decrease was less than those for meat and dairy sectors.

We also investigated the trade impact of SPS concern measures for U.S. and EU as importers maintaining measures against exporting countries and as exporters facing SPS measures maintained by other destination markets. In terms of U.S. and EU agricultural exports, we find that both countries experience significant trade reductions due to SPS measures with estimated AVE tariffs of 120% and 104%, respectively. In terms of U.S. and EU SPS measures of concern maintained in their respective imports, a much more contrasting picture merged. Here, the AVE tariff of SPS STCs maintained by the U.S. is estimated to be 41%, less than half the 94% AVE tariff imposed by EU SPS measures.

Finally, we reported SPS trade impact results for six specific trade concern cases that have been discussed extensively in the WTO's SPS committee meetings to provide a more nuanced view of their trade effects. The results show that China's restrictions on AI and ractopamine restrictions imposed by the EU, Russia, China, Taiwan and Thailand are the most prohibitive SPS policies facing exporters among all cases considered.

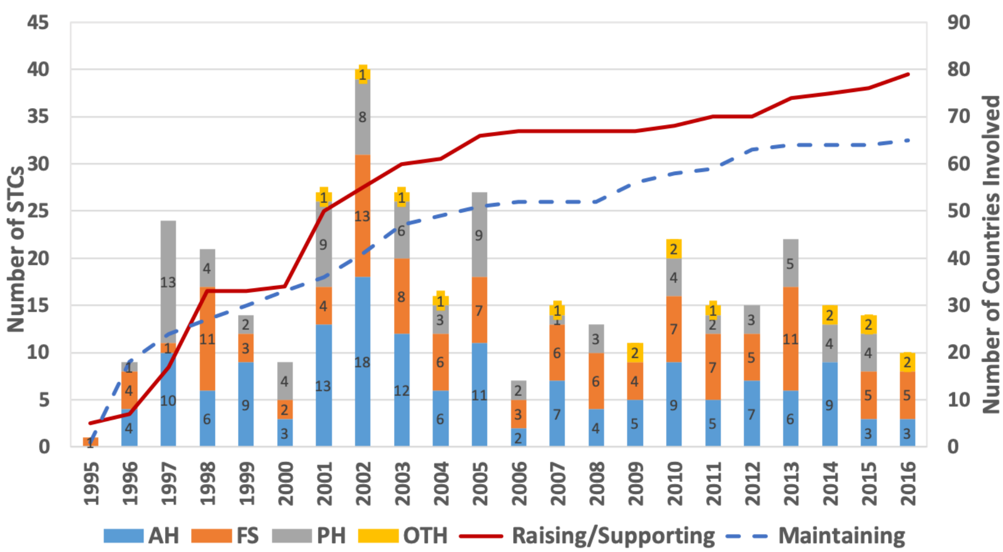
To conclude, this study finds a larger average AVE tariff of SPS measures of 59% and a wider range of 33% and 106% by focusing on the problematic trade compared to previous studies (Arita et al. [6], Disdier et al. [31, 32], Ghodsi et al. [40], Kee et al. [63]). In short, SPS measures maintained by importing countries that have been flagged as specific tade concerns present serious and oftentimes damaging trade impacts for agricultural exporting countries. Even though SPS (and TBT) measures have been widely investigated by researchers in the academic literature, the ability of researchers to identify and quantify the significance and magnitude of the more troubling obstacles facing agricultural exports have not been fully understood owing to the sheer number of measures making up the WTO's notifications-based data of SPS and TBT measures. Our findings in this study thus provide important policy information for trade negotiators and trade policy simulation forecasts seeking to harmonize regulatory barriers, as well as for welfare analysis.

Figure 3.1: Trends in notification of SPS and TBT measures to the WTO, 1995-2017



Source: Authors' calculation from WTO's SPS Information Management System.

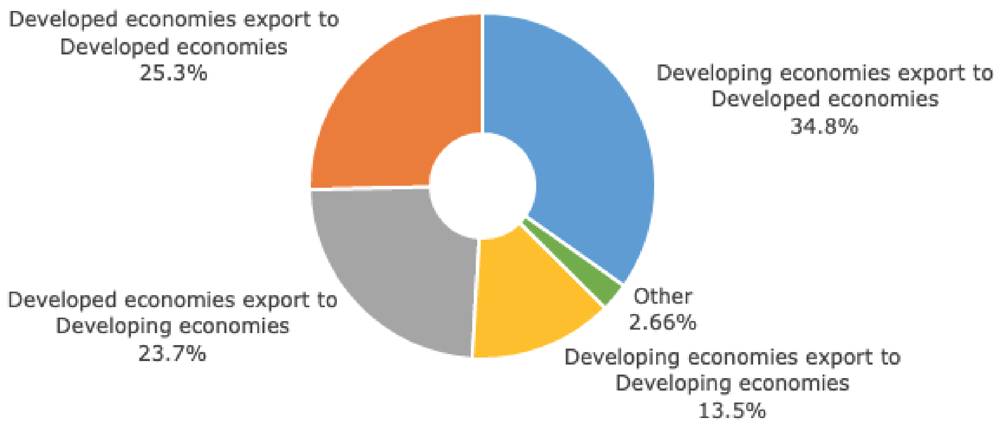
Figure 3.2: Time series of SPS STCs by subjects and cumulative number of countries involved, 1995-2016



Note: AH, PH, FS, and OTH denote the SPS STCs related to animal health, plant health, food safety, and other issues, respectively. Raising/Supporting (red solid line) and Maintaining (blue dashed line) refer to the cumulative count of countries involved.

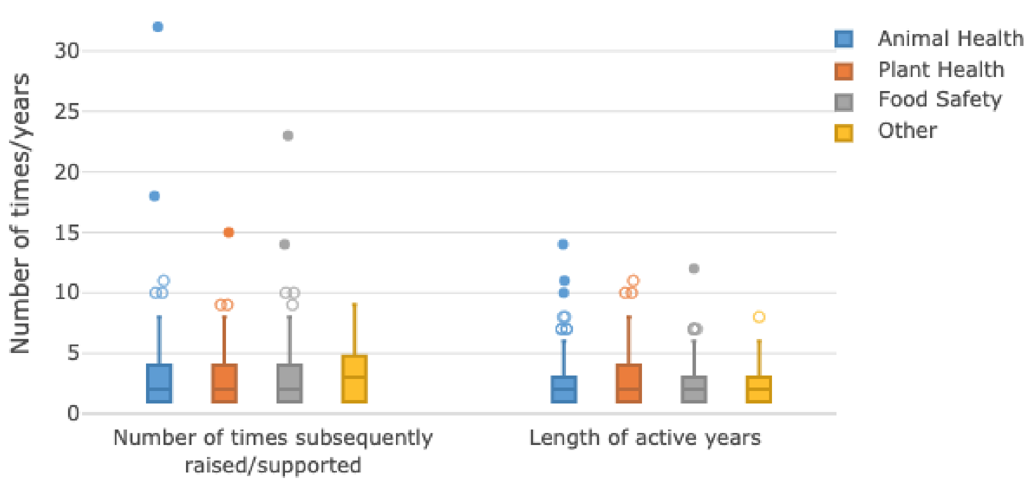
Source: Authors' calculation.

Figure 3.3: Share of SPS STCs by country development levels



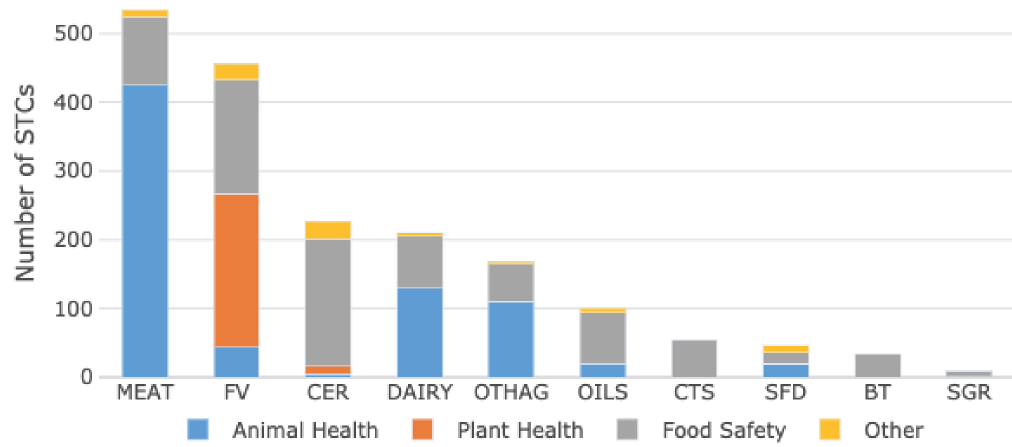
Note: The "Other" category includes developed and developing countries export products to least developed countries, and least developed countries export products to developed and developing countries.
Source: Authors' calculation.

Figure 3.4: Distribution of SPS STCs by number of times subsequently raised and length of active years, 1995-2016



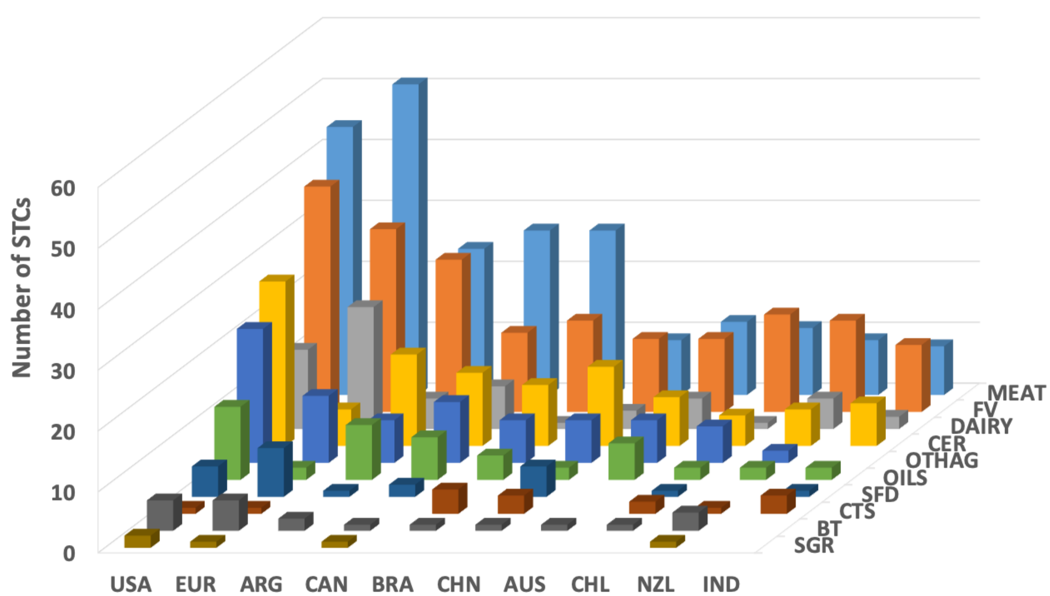
Note: Outliers that are more than 3 times the interquartile range (IQR) above the 3rd quantile or below the 1st quantile are represented by a filled circle. Suspected outliers that are more than 1.5 times IQR but less than 3 times IQR above the 3rd quantile or below the 1st quantile are represented by an open circle.
Source: Authors' calculation.

Figure 3.5: Tabulation of SPS STCs by MTN sectors and subjects, 1995-2016



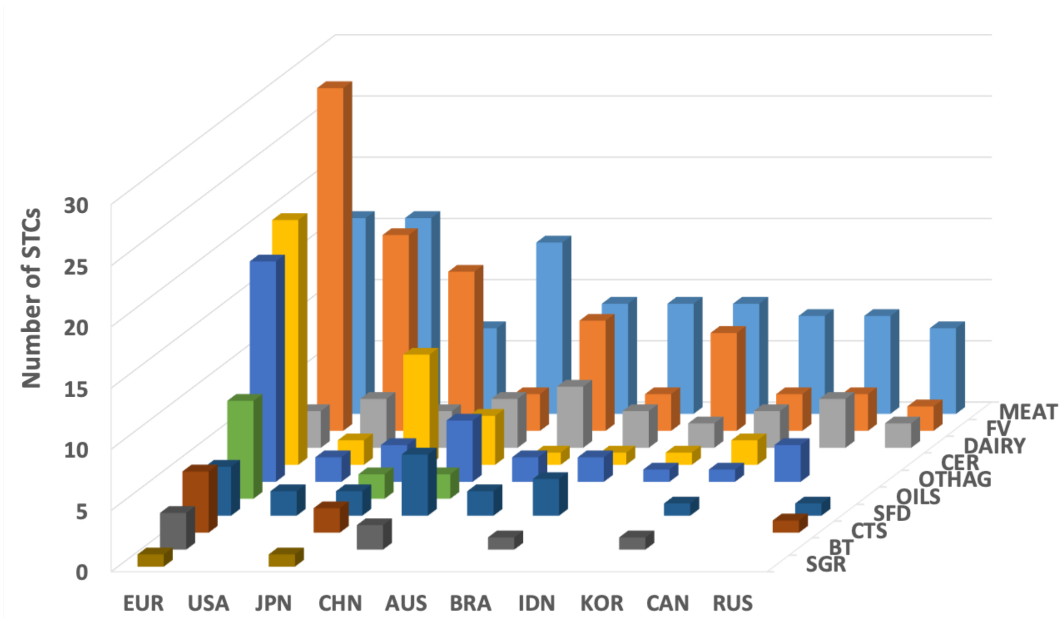
Note: MEAT = animal products; FV = fruits & vegetables; DAIRY = dairy products; CER = cereals & preparations; OILS = oilseeds, fats & oils; SFD = fish & fish products; CTS = coffee, tea, mate & spices; BT = beverages & tobacco; SGR = sugars & confectionery; OTHAG = other agricultural products.
Source: Authors' calculation.

Figure 3.6: Top 10 countries raising/supporting SPS STCs by MTN sectors, 1995-2016



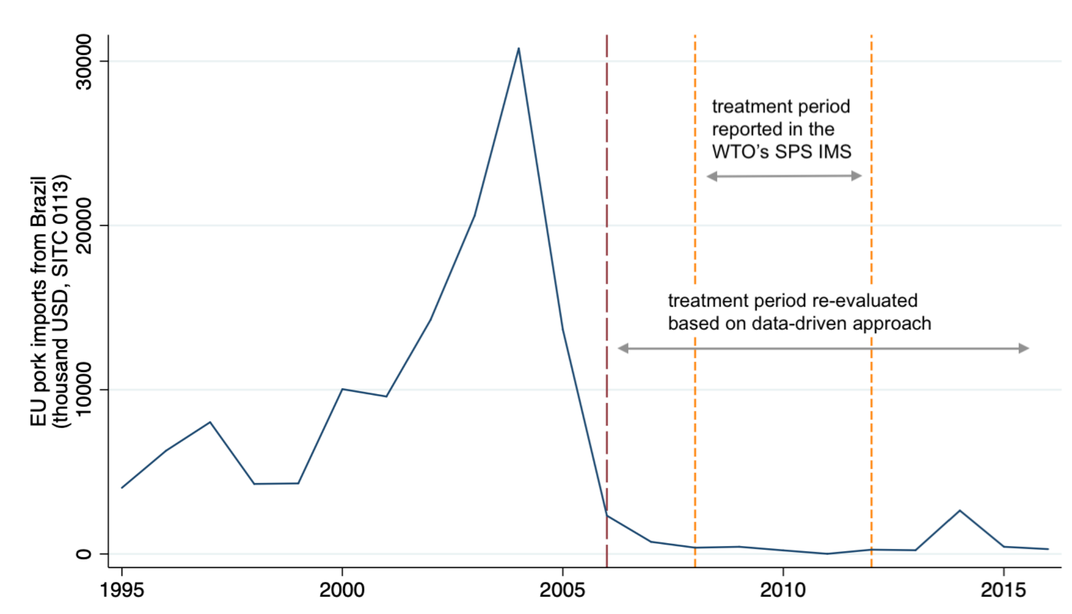
Source: Authors' calculation.

Figure 3.7: Top 10 countries maintaining SPS STCs by MTN sectors, 1995-2016



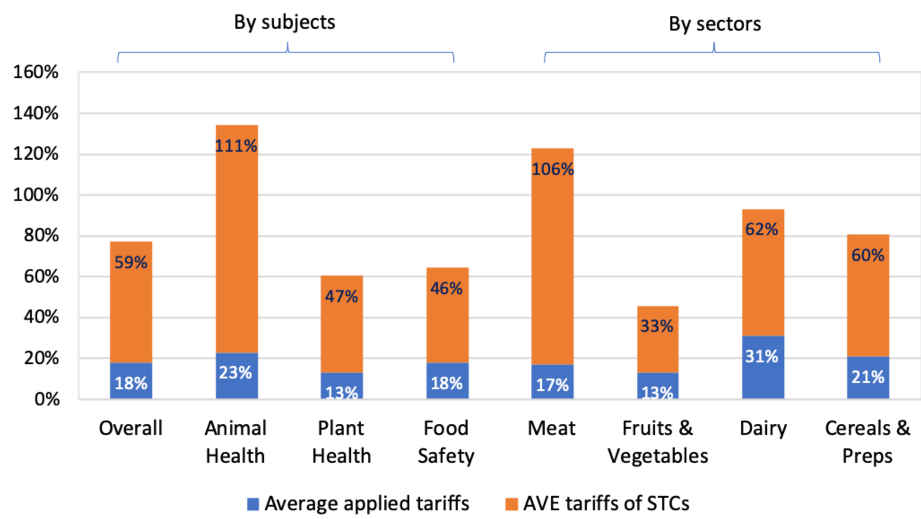
Source: Authors' calculation.

Figure 3.8: EU imports of Brazilian pork, an example of the adjusted treatment period of STC 275



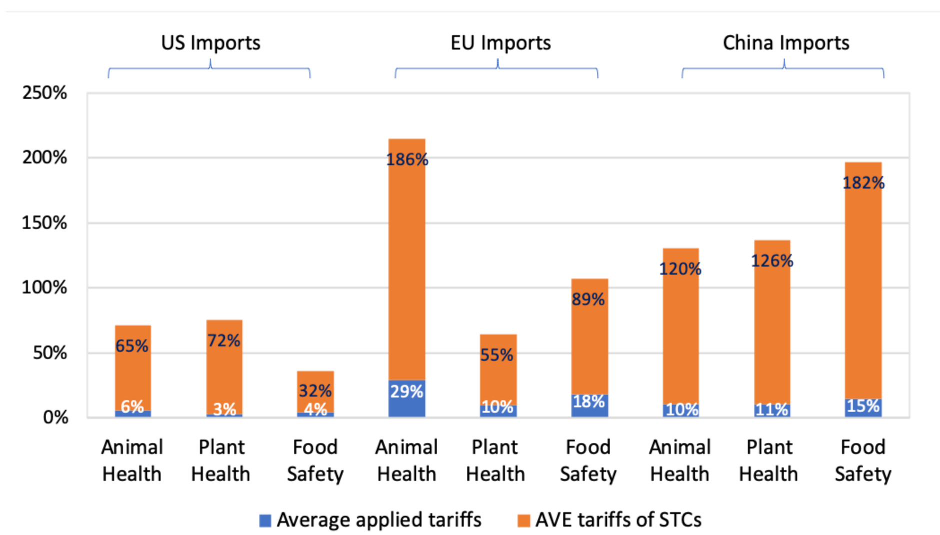
Note: short dashed line denotes the documented initial and last dates of raising STC 275 in the WTO's SPS committee meetings, long dashed line denotes the initial and last dates of STC 275 re-evaluated in the study. Source: Authors' calculation.

Figure 3.9: Estimated *ad valorem* tariff equivalents of SPS STCs by subjects



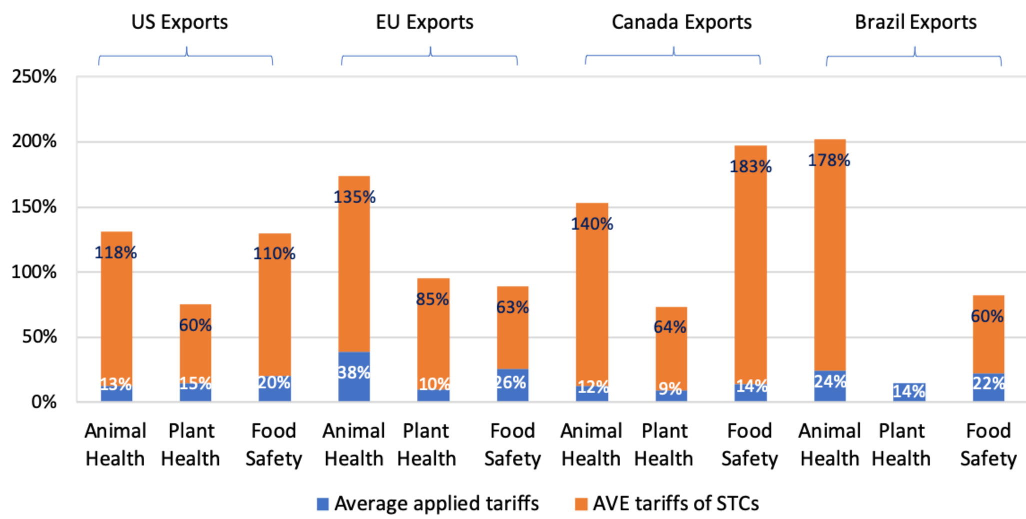
Source: Authors' calculation.

Figure 3.10: Estimated *ad valorem* tariff equivalents by major importers



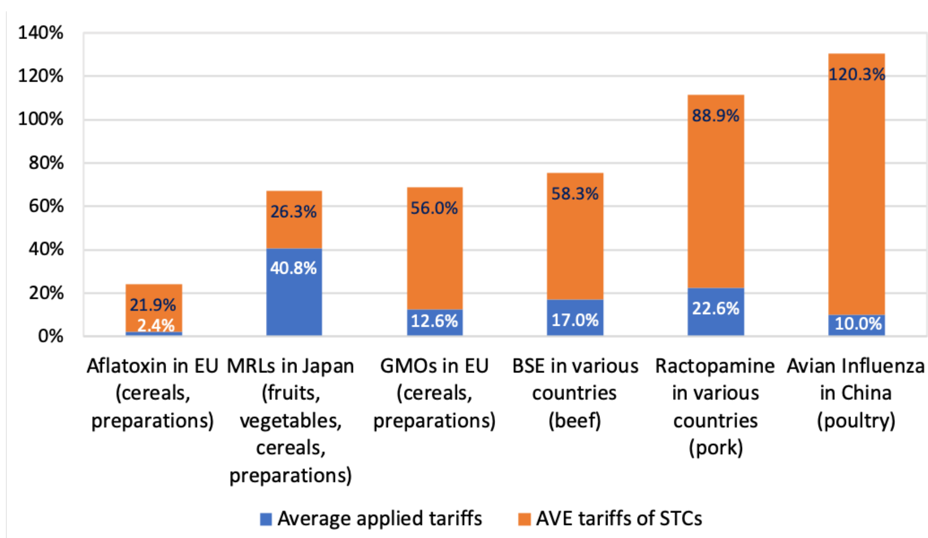
Source: Authors' calculation.

Figure 3.11: Estimated *ad valorem* tariff equivalents by major exporters



Source: Authors' calculation.

Figure 3.12: Estimated *ad valorem* tariff equivalents of selected SPS case studies



Source: Authors' calculation.

Table 3.1: Summary statistics of variables

	Mean	Std. Dev.	Min	Max
Trade value ($million),$V_{odkt}$	6.367	56.798	0	5504.550
Distance (thousand miles),$Log(Dist_{od})$	8.838	0.820	5.371	9.901
Regional trade agreements, RTA_{odt}	0.243	0.429	0	1
Common language, $Comlang_{od}$	0.236	0.425	0	1
Common border, $Contig_{od}$	0.074	0.261	0	1
Common colony, $Comcol_{od}$	0.098	0.298	0	1
Importer's GDP ($million), $Log(GDP_{dt})$	6.328	1.738	1.845	9.853
Exporter's GDP ($million), $Log(GDP_{ot})$	6.406	1.722	1.845	9.853
Applied tariff rates, Tar_{odkt}	0.184	0.508	0.000	26.692
Trade elasticities, σ_{odk}	3.434	1.357	1.100	12.932
SPS trade concerns, active, $STC_{1,odkt}$	0.025	0.156	0	1
SPS trade concerns, post-resolution, $STC_{2,odkt}$	0.017	0.130	0	1
AH STCs, active, $AH_{1,odkt}$	0.008	0.090	0	1
AH STCs, post-resolution, $AH_{2,odkt}$	0.005	0.068	0	1
PH STCs, active, $PH_{1,odkt}$	0.005	0.068	0	1
PH STCs, post-resolution, $PH_{2,odkt}$	0.004	0.061	0	1
FS STCs, active, $FS_{1,odkt}$	0.011	0.104	0	1
FS STCs, post-resolution, $FS_{2,odkt}$	0.008	0.090	0	1
OTH STCs, active, $OTH_{1,odkt}$	0.001	0.037	0	1
OTH STCs, post-resolution, $OTH_{2,odkt}$	0.001	0.027	0	1

Table 3.2: Description of SPS specific trade concern variables

		Mean	Std. Dev.	Min	Max
STCs, active	overall	0.025	0.156	0.000	1.000
	between		0.121	0.000	1.000
	within		0.099	-0.929	0.980
STCs, post-resolution	overall	0.017	0.130	0.000	1.000
	between		0.092	0.000	0.955
	within		0.092	-0.937	0.972
AH STCs, active	overall	0.008	0.090	0.000	1.000
	between		0.072	0.000	1.000
	within		0.055	-0.946	0.963
AH STCs, post-resolution	overall	0.005	0.068	0.000	1.000
	between		0.046	0.000	0.864
	within		0.050	-0.859	0.959
PH STCs, active	overall	0.005	0.068	0.000	1.000
	between		0.052	0.000	0.955
	within		0.043	-0.950	0.959
PH STCs, post-resolution	overall	0.004	0.061	0.000	1.000
	between		0.045	0.000	0.955
	within		0.041	-0.951	0.958
FS STCs, active	overall	0.011	0.104	0.000	1.000
	between		0.079	0.000	1.000
	within		0.067	-0.944	0.965
FS STCs, post-resolution	overall	0.008	0.090	0.000	1.000
	between		0.064	0.000	0.909
	within		0.062	-0.901	0.963
OTH STCs, active	overall	0.001	0.037	0.000	1.000
	between		0.028	0.000	0.909
	within		0.024	-0.908	0.910
OTH STCs, post-resolution	overall	0.001	0.027	0.000	1.000
	between		0.019	0.000	0.864
	within		0.019	-0.863	0.910

Table 3.3: Estimated trade effects of SPS trade concerns by subjects and sectors

	ALL	Meat Products	Fruits & Vegetables	Dairy Products	Cereals & Preparations
	Effect in aggregate				
STC, active	-0.678***	-0.816***	-0.507***	-0.674***	-0.688***
	(0.023)	(0.030)	(0.041)	(0.041)	(0.046)
STC, post-resolved	-0.139**	-0.297***	-0.096	-0.206**	0.107
	(0.061)	-(0.109)	-(0.078)	-(0.090)	-(0.217)
	Effect by subjects				
Animal Health, active	-0.839***	-0.858***		-0.733***	
	(0.027)	(0.028)		0.054	
Animal Health, post-resolved	-0.388***	-0.448***		0.041	
	(0.104)	(0.105)		0.206	
Plant Health, active	-0.612***		-0.629***		-0.503***
	(0.057)		(0.061)		(0.192)
Plant Health, post-resolved	-0.137		-0.268**		1.199
	(0.116)		(0.112)		(0.762)
Food Safety, active	-0.605***	-0.715***	-0.401***	-0.635***	-0.695***
	(0.034)	(0.061)	(0.052)	0.059	(0.048)
Food Safety, post-resolved	-0.016	0.115	0.034	-0.330***	0.018
	(0.084)	(0.254)	(0.104)	0.079	(0.203)
Other, active	-0.734***		-0.678***		
	(0.045)		(0.109)		
Other, post-resolved	0.093		-0.084		
	(0.208)		(0.217)		
Importer-product-time FE	Y	Y	Y	Y	Y
Exporter-product-time FE	Y	Y	Y	Y	Y
Importer-exporter-product FE	Y	Y	Y	Y	Y
Observations	555,258	109,058	230,701	74,005	141,494
σ	3.364	3.452	3.348	3.387	3.332

Note: All regressions are estimated using PPML, controlling for time-varying importer-product, time-varying exporter-product, and time-invariant importer-exporter-product fixed effects. Results are reported in terms of marginal effects ($\exp(\hat{\lambda}) - 1$). σ are used for conversion of AVE effects and are summarized from the Soderbery (2015, 2018) trade import elasticity of substitution estimates. Standard errors in parentheses. Asterisks ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Table 3.4: Estimated trade effects of SPS trade concerns by major countries

	Imports			Exports			
	US	EU	China	US	EU	Canada	Brazil
				Effect in aggregate			
STC, active	-0.517***	-0.764***	-0.965***	-0.852***	-0.832***	-0.902***	-0.841***
	(0.118)	(0.049)	(0.015)	(0.036)	(0.028)	(0.028)	(0.066)
STC, post-resolved	0.019	-0.174	-0.726***	-0.405***	-0.11	-0.521***	-0.168
	(0.311)	(0.226)	(0.110)	(0.132)	(0.215)	(0.116)	(0.261)
				Effect by subjects			
Animal Health, active	-0.645***	-0.903***	-0.921***	-0.866***	-0.890***	-0.893***	-0.955***
	(0.154)	(0.057)	(0.069)	(0.088)	(0.023)	(0.042)	(0.024)
Animal Health, post-resolved	-0.610***	0.459	-0.066	-0.531***	-0.478***	-0.515***	-0.244*
	(0.118)	(0.504)	(0.886)	(0.134)	(0.105)	(0.091)	(0.129)
Plant Health, active	-0.676***	-0.619***	-0.927***	-0.701***	-0.797***	-0.718***	0.16
	(0.096)	(0.081)	(0.005)	(0.044)	(0.060)	(0.091)	(0.129)
Plant Health, post-resolved	-0.276*	-0.320**		-0.342***	-0.379***	-0.536***	1.518***
	(0.150)	(0.133)		(0.107)	(0.118)	(0.173)	(0.342)
Food Safety, active	-0.441***	-0.758***	-0.964***	-0.853***	-0.717***	-0.929***	-0.760***
	(0.147)	(0.060)	(0.016)	(0.023)	(0.091)	(0.173)	(0.342)
Food Safety, post-resolved	0.516	-0.195	-0.727***	-0.196	0.72	-0.521***	-0.164
	(0.409)	(0.272)	(0.110)	(0.180)	(0.707)	(0.149)	(0.477)
Other, active	-0.702***	-0.848***	-0.496***	-0.759***	-0.887***	-0.880***	
	(0.018)	(0.028)	(0.106)	(0.153)	(0.028)	(0.022)	
Other, post-resolved		-0.502***		-0.318	-0.389***	-0.386**	
		-(0.110)		(0.364)	(0.071)	(0.155)	
Importer-product-time FE	Y	Y	Y	Y	Y	Y	Y
Exporter-product-time FE	Y	Y	Y	Y	Y	Y	Y
Importer-exporter-product FE	Y	Y	Y	Y	Y	Y	Y
Observations	30,646	33,418	24,728	34,650	34,628	29,854	25,058
σ	2.993	3.176	3.679	3.486	3.504	3.552	3.526

Note: All regressions are estimated using PPML, controlling for time-varying importer-product, time-varying exporter-product, and time-invariant importer-exporter-product fixed effects. Results are reported in terms of marginal effects $(\exp(\hat{\lambda}) - 1)$. σ are used for conversion of AVE effects and are summarized from the Soderbery (2015, 2018) trade import elasticity of substitution estimates. Standard errors in parentheses. Asterisks ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Table 3.5: Estimated trade effects of selected SPS trade concerns

	Aflatoxin (EU)	GMOs (EU)	BSE (Various countries)	MRLs (Japan)	Ractopamine (China, EU, Russia, Taiwan, Thailand)	Avian Influenza (China)
	Marginal effect					
Active STCs	-0.374***	-0.685***	-0.684***	-0.455***	-0.847***	-0.916***
	(0.091)	(0.035)	(0.039)	(0.052)	(0.049)	(0.023)
	AVE effect					
Active STCs	0.219***	0.560***	0.583***	0.263***	0.889***	1.203***
	(0.075)	(0.067)	(0.077)	(0.047)	(0.203)	(0.190)
Importer-product-time FE	Y	Y	Y	Y	Y	Y
Exporter-product-time FE	Y	Y	Y	Y	Y	Y
Importer-exporter-product FE	Y	Y	Y	Y	Y	Y
Observations	20,510	91,938	20,034	112,125	6,604	2,872
σ	3.381	3.551	4.135	3.403	3.420	3.741

Note: All regressions are estimated using PPML, controlling for time-varying importer-product, time-varying exporter-product, and time-invariant importer-exporter-product fixed effects. Results are reported in terms of marginal effects $(\exp(\hat{\lambda}) - 1)$ and AVE effects $(\exp(\frac{\hat{\lambda}}{1-\sigma}) - 1)$. σ are used for conversion of AVE effects and are summarized from the Soderbery (2015, 2018) trade import elasticity of substitution estimates. Standard errors in parentheses. Asterisks ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Chapter 4

SPS Measures and the Hazard Rate of US Agri-food Exports: A Discrete-time Approach

4.1 Introduction

International trade in agricultural products is vital to the prosperity of agriculture and food industries and likewise, to the well-being of food consumers. Producers gain access to foreign markets and, if there are economies of scale, enlarged markets allow firms to move down their long-run average cost curves and expand their sales. Consumers benefit from lower prices and a greater variety and more consistent supplies of goods throughout the year. To promote these gains from trade, the General Agreement on Tariffs and Trade (GATT) and its successor, the World Trade Organization (WTO), have contributed to the expansion of world trade over the past six decades through successive rounds of tariff reductions.

However, understanding the structure of tariffs and preferences within the WTO and free trade agreements (FTAs), while important, is only part of the story. In addition to tariffs, complex non-tariff issues remain. Among the non-tariff measures (NTMs) affecting agricultural trade, sanitary and phytosanitary (SPS) regulations and technical barrier to trade (TBT) occupy a special place in terms of prevalence, economic significance, and negotiating options for reform. First, SPS and TBT measures are pervasive because of the diverse needs and perceptions about the protection of plant and animal health, food safety, and consumer information about product and quality standards among countries. Second, the WTO agreement on the application of SPS agreement permits WTO member countries to adopt their own health and safety regulations provided these measures are based on a scientific risk assessment, not discriminatory between countries with similar conditions, and are minimally trade-distorting to prevent their disingenuous use as instruments of disguised protectionism (Josling et al. [62]). Third, SPS measures are the most frequently encountered NTMs in agricultural trade according to data collected by official sources such as the Trade Analysis and Information System (TRAINS) of the United Nations Conference on Trade and Development (UNCTAD) and the WTO's Integrated Trade Intelligence Portal (I-TIP). They are also considered among the most reverent impediments to exports, according to a small sample of NTM business surveys conducted by the World Bank and International Trade Centre (Internationl Trade Centre [57], World Bank [96]).

Extensive research has been conducted to investigate the trade effects of NTMs including SPS and TBT measures and many find that the impacts of these measures are more likely to be trade-distorting depending on the trading countries and products impacted, and the type of SPS measures involved (Arita et al. [6], Deardorff and Stern [27], Disdier et al. [31], Fernandes et al. [37], Ferrantino [38], Grant et al. [45], Kee et al. [63, 65], Li and Beghin [69], Nicita and Gourdon [79], Peterson et al. [84]). Most of the above-mentioned studies focus on the impact of SPS measures on trade values and/or quantities, with a particular interest in the intensive and extensive margins. Moreover, they mainly rely on the notification-based information retrieved from the TRAINS and I-TIP databases, such as the tabulation of measures involved, frequency indices, coverage ratio, the ad valorem equivalent tariff, and the trade restrictiveness index, to predict what trade would be in the absence of the measures. While examining the impacts of SPS and TBT measures on the magnitude of trade is important, much less is known about the role of these measures in affecting export survival and duration and why some country-product pairs stop trading. A growing literature on trade survival analysis has shown that trade relationships often short-lived with multiple entries and exits in a market leading to multiple periods of exporting (Besedeš and Prusa [13, 14, 15, 16], Hess and Persson [52, 53], Nguyen [78], Nitsch [80], Peterson et al. [85]). They also find that product standards, country sizes, firm features, and networks of exporters in the importing market significantly affect foreign market access.

The objective of this paper is to provide an empirical investigation of US agricultural trade duration and quantify the extent to which SPS measures affect the duration and hazard rate (probability of exit) of US agricultural exports. Because of the explosion of free trade agreements in world trade since 1995, the focus of agricultural trade policies has increasingly shifted from the traditional tariffs, tariff-rate quotas and export subsidies toward more obscure NTMs including SPS and TBT measures (Aisbett and Pearson [1], Beverelli et al. [17], Moore and Zanardi [75], Orefice [83]). Trade costs related to NTMs are particularly burdensome for small- and medium-size enterprises that may not have the resources to comply (Cadot and Gourdon [18]). Identifying the hazardous impact of SPS measures on agricultural trade duration becomes especially crucial in terms of the implication to the agricultural firm decision-making as well as the government policy-making.

Unlike tariffs that are more easily observed and quantified, SPS measures are not always transparent and quantification of their impacts on trade can be tricky due to the diverse and heterogeneous array of policies and regulatory standards. In addition, self-notified SPS measures which require the importing authorities to self-report any changes in their SPS regulations can be troublesome due to potential moral hazard problems. These measures also omit the bilateral-pair-by-product dimension, making it difficult to match with a bilateral trade dataset. In this study, we use the WTO's SPS Information Management System (SPS IMS) database compiled by Grant and Arita [41] to address the issues mentioned above. This database records the SPS measures maintained by importers that have been reported as specific trade concerns (STCs) by exporters at the WTO's SPS Committee meetings. It contains a rich set of information that lends itself to merge with the bilateral trade for empirical analyses. Information complied includes the year a SPS specific trade concern was raised and resolved, countries raising/supporting and maintaining the concern, specific products affected, the number of times the concern was subsequently raised, the duration of the concern, and the subject of the concern. We update the database through 2017 and use it as an alternative means from which to identify SPS measures that have been revealed as trade concerns in our analysis.

The remainder of the article is organized as follows. Section two develops the empirical methodology. Section three describes the data and summary statistics. It then follows with a discussion of the results. The conclusions and policy implications are given in the end.

4.2 Empirical Model

Traditional research on trade policy analysis aims to investigate its impacts on the intensive and extensive margins of trade and predict the potential trade losses/gains in the absence of specific trade policy. In this study, we turn our attention to the impacts of SPS measures on the hazard rate of US agricultural and food exports. In particular, we aim to examine whether SPS measures perceived as specific trade obstacles have influenced the failure of US agri-food export relationships.

Trade duration analysis complements the conventional structural gravity estimation of trade intensive and extensive margins by focusing on the factors affecting the length of spells of trade relationships between trading partners (Besedeš and Prusa [13, 14, 15, 16], Cox [23], Hess and Persson [52, 53], Nguyen [78], Nitsch [80], Peterson et al. [85]). By definition, a trade relationship is noted as a specific country exporting a specific product to a specific importing country, or an importer-exporter-product combination. A spell of trade is defined as the period of time with uninterrupted trade for any given importer-exporter-product combination. The duration of each spell is then defined as the number of consecutive years with positive trade flows. Following Hess and Persson [53] and Peterson et al. [85], this study employs a discrete-time hazard model with a panel probit random effects approach to assess to what extent SPS measures have affected the hazard rate of US agri-food exports[1].

Let T_i be a non-negative random variable that measures the survival time of the ith trade relationship, i.e., an exporting country o – the US in our study – exports an agricultural commodity k to an importing country d, also noted as an exporter-importer-product triplet, odk. The conditional probability that the ith trade relationship ends at time $t+1$ conditional on the relationship surviving up to the time t, also termed as the discrete-time hazard rate, h_i, is specified as

$$h_{it} \quad = \quad P(T_i \leq t+1 | T_i \geq t) = \Phi(\mathbf{x}_{it}\beta + \gamma_t) \tag{4.1}$$

where $\mathbf{x}_{it}$ is a set of time-varying explanatory variables, β is the set of estimated coefficients (standardized by the variance of $\sigma^2 = 1$), γ_t is a set of dummy variables identifying the duration of each spell of service in order to allow the hazard rate to vary over time, and $\Phi(\cdot)$ is an appropriate distribution function that ensures $0 \leq h_{it} \leq 1$.

[1]Hess and Persson [53] argue that it is inappropriate to analyze trade duration with continuous-time Cox models because of the presence of multi-tied duration times, unobserved heterogeneity, and the assumption of restrictive proportional hazards. They propose several discrete-time models and find empirical support for their models against the Cox models.

Let y_{it} be a dummy variable that equals one if the ith trade spell was observed to end in the tth time interval, and zero otherwise, the log-likelihood function for the discrete-time duration model is then defined as follows,

$$\ln L = \sum_{i=1}^{N}\sum_{t=1}^{T}\left[y_{it}\ln(h_{it}) + (1-y_{it})\ln(1-h_{it})\right]. \tag{4.2}$$

Since this expression approximates a standard log-likelihood function for a binary panel regression model with the dependent variable, y_{it}, the limited dependent variable estimators can be used depending on the assumed distribution of the hazard rate function. In our study, we follow Hess and Persson [53] to choose a panel probit estimator assuming a normal distribution of the conditional hazard rate. Unobserved heterogeneity is often brought up due to the importance of considering the multitude of factors influencing trade relationships in terms of the specific exporting, importing countries, and commodities. One approach to deal with unobserved heterogeneity is to introduce the fixed-effect estimator. However, due to the incidental parameters problem (Lancaster [68]) in the panel probit fixed-effect estimator, we turn to use a random-effect probit estimator to account for unobserved heterogeneity and test for the assumption of random-effect probit against the standard probit estimator. It is also beneficial in terms of explicitly estimating unobserved heterogeneity in the discrete-time hazard specification. As a robustness check, we apply a panel logit model and a cloglog model and compare the results across estimation methods discussed below. To ensure conditional independence between spells, we also control for the multiple spells from the same ith trade relationship.

Empirically, our discrete-time hazard function for US agri-food exports is specified as the following,

$$
\begin{aligned}
y_{odkt} &= \beta_1 DUR_{odkt} + \beta_2 LEFT_{odk} + \beta_3 DUR_{odkt} * LEFT_{odk} + \sum_{s=2}^{4} \gamma_s SPL_{odk,s} \\
&\quad + \beta_4 \ln(VI_{odkt}) + \beta_5 \ln(GDP_{ot}) + \beta_6 \ln(GDP_{dt}) + \beta_7 ER_{odkt} \\
&\quad + \beta_8 MX_{okt} + \beta_9 MI_{dkt} + \beta_{10} TAR_{odkt} + \sum_{m=1} \delta_m GRAV_{od(t)} \\
&\quad + \alpha SPS_{odkt} + \lambda_o + \lambda_d + \lambda_k + \lambda_t + \varepsilon_{odkt}
\end{aligned}
\tag{4.3}
$$

where DUR_{odkt} is the number of years for which the current trade spell of service has lasted; $LEFT_{odkt}$ is equal to one if the observed trade spell is left-censored defined as a trade relationship that was active before and up to 1995; $SPL_{odk,s}$ is a set of dummy variables equal to one if the current trade relationship is the second, third, fourth spell or more in the sample; VI_{odkt} is the initial trade value of the trade spell; GDP_{ot} and GDP_{dt} are the real gross domestic products (GDP) in the exporting country o and destination country d; ER_{odkt} is the change in real effective exchange rates (with the basis of US currency in 2010); MX_{okt} is the (logarithmic) count of the number of exporting countries shipping each product to the import market each year; MI_{dkt} is the import market concentration for each product each year using Herfindahl-Hirschman Index (HHI); TAR_{odkt} is the applied bilateral tariff rate; $GRAV_{od(t)}$ is a set of variables controlling for the conventional gravity model components, including whether the trading partners share a common regional trade agreement (RTA_{odt}), a common official language ($Comlang_{od}$), a common colonial tie ($Colony_{od}$), and distance ($Dist_{od}$); $\lambda_o, \lambda_d, \lambda_k$ and λ_t are used to control for the time-invariant country-, product- and time-specific fixed effects; and ε_{odkt} is a well-behaved normal-distributed error term.

Importantly, SPS_{odkt} denotes SPS measures maintained by importers that have been raised as specific trade concerns by exporters - and the crucial interest in our analysis. To estimate both the overall and heterogeneous impacts of the concerned SPS measures on the conditional probability of exit of US agri-food exports, we consider a diverse set of variables representing SPS trade concern measures. These include a binary variable that is equal to one: (1) if (at least) one SPS concern has been raised for the affected product exported to the destination market (STC_{odkt}); (2) if the concerned SPS measure has been implemented ($IMPL_{odkt}$); (3) if the SPS concern escalated to a WTO formal dispute case ($DISP_{odkt}$); and a set of binary variables indicating: (4) whether the SPS concern has been resolved (RSD_{odkt}), partially resolved (PR_{odkt}), or not resolved (NR_{odkt}), (5) whether the SPS concern has been raised more or less than 6 times ($TM_{1(2),odkt}$); (6) whether the SPS concern has remained active more or less than 5 years ($YR_{1(2),odkt}$); (7) whether the SPS concern is/was related to animal health (AH_{odkt}), plant health (PH_{odkt}), food safety (FS_{odkt}), or other SPS measures (OTH_{odkt}); (8) whether the SPS concern is/was raised indicating a ban or prohibition, (BAN_{odkt}), more moderate language such as restriction or delay, (RST_{odkt}), or a softer tone descrbing the SPS measure such as draft measure or new regulations, (OLG_{odkt}).

Using these various specifications of SPS trade concern measures, we examine the extent to which these concern measures affect US agri-food export duration and survival. In what follows, we discuss the data used in this study and the data transformation for duration and survival analysis.

4.3 Data

Annual bilateral trade data for all US agricultural and food products at the Harmonized System of Classification (hereafter HS) 6-digit level from 1995 to 2016 are collected from United Nations ComTrade Database[2]. We also include data from 1988-1994 in order to address

[2] https://comtrade.un.org/

the left-censoring issue discussed shortly. SPS Specific Trade Concerns Database are taken from Grant and Arita [41] and updated using the WTO's SPS Information Management System from 1995-2016[3]. Data for other economic and trade cost variables are collected from the World Bank[4], United States Department of Agricultural-Economic Research Service (USDA-ERS), Centre d'Etudes Prospectives et d'Informations Internationals (CEPII)[5], and International Trade Centre-Trade Map and Market Access Map (MAcMap)[6]. Table 4.1 provides summary statistics of the data used in our analysis.

Up to December 2018, the WTO's SPS Committee has recorded 452 SPS specific trade concerns. 141 of these concerns are raised (66%) and supported (34%) by the US. According to the four subjects of concerns used by the WTO, 42%, 40% and 11% of SPS measures concern animal health, food safety, and plant health SPS issues, respectively, and 7% of trade concerns are classified as "other" concerns no elsewhere identified. Of these SPS trade concern measures raised/supported by the US, 89% are based on concerns related to SPS measures that are active and implemented by maintaining countries, 47% are reported as resolved (completely or partially) within our sample period, and 8% have escalated to formal dispute settlement cases at the WTO. The average number of times the US has subsequently raised/supported SPS trade concern measures is 3~4, and the average duration of the SPS trade concerns is about 2~three years. There are, however, concerns that have lasted much longer. For example, STC 193 dealing with continued BSE restrictions in importing countries has been subsequently raised 36 times, leading to a concern duration of 14 years. The major US agricultural sectors covered by SPS concern measures imposed by importing countries are meat & animal products (MEAT, 32%), fruits, plants & vegetables (FV, 21%), cereals & preparations (CER, 13%), dairy products (DAIRY, 10%), other agri-food products (OTHAG,

[3]http://spsims.wto.org/
[4]https://databank.worldbank.org/
[5]http://www.cepii.fr/CEPII/en/
[6]http://www.macmap.org/

13%), and an aggregate of 11% for oilseeds, fats & oils, fish & fish products, beverages & tobaccos, sugars & confectionery, and coffee, tea, mate & spices.

Moving from the broad view of SPS concern measures to the bilateral-pair-by-product perspective, Figure 4.1 and 4.2 display the top 10 importing countries maintaining SPS trade concern measures against US exports by subject and resolution status. Unsurprisingly, a large proportion of SPS concern measures are imposed by the EU – mostly related to animal health and food safety measures. 59% of the US-EU concerns on SPS measures have yet to be resolved. These SPS concern measures include, but are not limited to, import restrictions due to Transmissible Spongiform Encephalopathies/Bovine Spongiform Encephalopathy (TSE/BSE), maximum residue limits (MRLs), and genetically modified organisms (GMOs) traceability and labeling requirements. Japan and China rank second and third as the top destination markets maintaining SPS measures that have been flagged as problematic by the US, and only a few of them have been resolved (completely or partially) to date. For Japan, most SPS concern measures are related to plant health and food safety issues, including restrictions on plant quarantine rules, pesticides, veterinary drugs, and feed additive. For China, many SPS concern measures are related to animal health and food safety issues, including restrictions on the use of ractopamine, pathogens, lengthy bans due to BSE, avian influenza, and GMOs regulations. Other countries like Ukraine, South Korea, Indonesia, and India have also maintained SPS measures for which the US has raised an issue.

In the context of survival analysis, we define a trade relationship as a specific importer-exporter-product combination. We include all US agri-food exports that have experienced at least one specific trade concern measure maintained by trading partners during the 1995-2016 sample period. In total, our data contain 57 importing countries and 547 agricultural products at the HS 6-digit level, making a total of 5,882 bilateral trade relationships and

13,409 spells of service.

Notably, trade relationships may exhibit numerous spells of service since either trading partner can terminate the trade relationship and re-establish it in a later period. This explains why the number of trade spells generally exceeds the number of trade relationships. We use Figures A.7 and A.8 in the Appendix to explain trade duration and spells of service in more detail. For example, South Korea had continuously imported US apples from 1995 to 2000, indicating that the KOR-USA-apple trade relationship had a duration of 6 years in its first spell of service during the sample period. After a two-year break, it re-established the trade relationship from 2002 to 2011, leading to a duration of 10 years in its second spell of service. Again, four years later, South Korea rebuilt the trade relationship in 2015 forming its third spell of service. In another example, Japan had continuously imported beef from the US until 2003, after which Japan stopped its import from the US due to Bovine Spongiform Encephalopathy (BSE) detected in the US in December 2003. In 2006/2007, Japan re-established its trade relationship of beef imports from the US and has continued the trade relationship to date. In this case, the JPN-USA-beef trade relationship has two spells of service over the sample period.

Moreover, it is possible that some trade relationships were established before the first year of the sample period (i.e., before 1995), known as left-censored trade spells; and other trade relationships may continue after the last year of the sample period (i.e., after 2016), known as right-censored trade spells. Figures A.7 and A.8 can also be used to demonstrate the left- and right-censoring issues that are often encountered in survival analysis. Although the first spell of service of the KOR-USA-apple trade relationship shown in Figure A.8 lasted for 6 years, the actual beginning time of this spell of service was 1992, making the first spell of service left-censored. Similarly, while the last spell of service of the JPN-USA-beef trade relationship shown in Figure A.7 ended in 2016, trade continues to date, making the last spell of service right-censored. Besedeš and Prusa [14] and Hess and Persson [53] note that while right-censoring does not lead to estimation problems, it is not the case for left-censored observations. To partially mitigate left-censured observations, we collect trade data seven years prior to the begining of our smaple (i.e., from 1988-1994) and control for the duration of left-censored trade spells. In this way, trade spells that have longer than 22 years of length indicate that they have started before 1995. The maximum 29 years of a spell of service represents an uninterrupted trade relationship established since 1988. We also include an interaction term to differentiate the effect of duration length of left-censored observations from non-left-censored relationships.

Figure 4.3 displays the entry and exit trends of US trade relationships over the 1995-2016 period. Initially, there were 3,240 trade relationships entered, irrespective of whether they were just started in 1995 or had survived up to 1995. The total number of trade relationships peaked at 3,359 in 1998, after which it began to decline, possibly due to the outbreaks of many food safety issues such as BSE, bird flu, etc. A second spike happened in 2008 in which the total number of trade relationships reached 3,325, owning to the largest new market entrances that year. The total number of trade relationships gradually declined in recent years. Through 2016, there were 2,223 trade relationships remaining in the sample.

Figure 4.4 summarizes the distribution of trade spells and the duration of US agri-food exports in our sample. The top panel of Figure 4.4 shows that about 44% of trade relationships have a single spell of service, 87% have three spells of service or less, and 4 trade relationships have the maximum 8 spells of service. The bottom panel of Figure 4.4 shows that 20% of trade spells have a single year duration, over half of them survived 5 years or less, and less than 2% survived for the full sample period. Different from previous studies that find that trade spells last for a median duration of 1~3 years, we find a relatively longer median duration of US agri-food exports of 5 years. Nevertheless, despite the differences of country and product coverage, the summary statistics here reflect only a part of US agri-food exports that have at least experienced one SPS specific trade concern[7].

With detailed information in the SPS STCs database, we extend each concern bilaterally (in terms of the importer-exporter-product dimension at the HS 6-digit product level) according to the time each concern was first raised until the time when it was reported as resolved/partially resolved, or the last time when it was subsequently raised, whichever is applicable. We then use the extended SPS concern measures to match the bilateral trade data for empirical analyses. However, before presenting the model results, three caveats are worth noting when performing the data mapping. First, our hypothesis is that the SPS measures maintained by importing countries that have been flagged as trade obstacles by US agri-food exporters are likely to affect the survival and duration of trade relationships. Due to the possibility that the trade relationships could terminate before the time when the SPS trade concerns were first raised, ignoring it would lead to underestimation of the actual SPS impacts on trade duration and survival using SPS STCs database. Hence, to reconcile this issue, we use a one-year lag of SPS concern measures to pick up this potential delay in the SPS hazard effect. Second, after extending each SPS trade concern bilaterally, we noticed that some trade relationships overlapped with multiple SPS concern measures that are quite different in terms of concern type, frequency, and severity. In this case, we choose to map the bilateral trade with SPS concern measures using the longest-standing concern. We argue that these SPS concern measures are likely to be the most important among exporting countries having been raised first.

[7] We also examined the trend of US agri-food exporting markets and tabulation of spells and duration of US agri-food exports in 1995-2016 using the global data set and find that the general conclusions still hold.

4.4 Results Discussion

In this section, we report the estimated results of the effects of SPS trade concern measures on the hazard rate of US agri-food exports during the sample period in 1995-2016. We begin by presenting the non-parametric Kaplan Meier (KM) survival estimates of US agri-food exports according to different values of economic variables and SPS STCs to gain some preliminary insights. We then move to the discussion of the parametric model results specified in eq. (4.3) in order to examine the SPS impacts on the hazard rate of US agri-food exports controlling for the effects of other covariates.

Figure 4.5 depicts the Kaplan Meier (KM) survival estimates of US agri-food exports by various economic factors. Without exception, the survival probabilities are shown to be negatively correlated with the duration of trade relationships, meaning that the survival probability of trade relationships is decreasing as trade relationships live for longer periods. Trade relationships with importer's GDP per capita higher than $50,000 USD are likely to have the lowest survival percentage compared to those with lower GDP per capita (the upper left panel) as trade activities continue, which is somewhat counter-intuitive. One possible explanation is that bilateral trade among the highest per capita income countries tends to have more disruptions due to tighter animal, plant, and food safety standards. Moreover, it is also important to recall that middle-low income countries are not well represented in the sample due to the lower rates with which they participate in SPS specific trade concerns. Trade relationships with changes in real effective exchange rates higher than 15 also tend to have the lowest survival rate compared to those with lower changes in real effective exchange rates (the upper right panel). It is as expected as positive changes in RER imply a depreciation of the foreign currency, or appreciation of US currency. As a result, US agri-food products exported to foreign markets become more expensive and more likely to drop or even terminate.

Trade relationships with importer market HHI higher than 0.5 tend to fail at higher probabilities than those with lower HHI (the bottom left panel in Figure 4.5). In particular, trade relationships with importer markets of HHI lower than 0.2 tend to have the highest chance of survival at any time after the first year. It implies that market competition in the destination countries seems to help boost the survival rate of trade relationships studied in the sample, while high market concentration (i.e., low competition) tends to harm trade survivals to some degree. This point of view is further supported by the result shown in the bottom right panel in which trade relationships with more than 60 exporting competitors tend to survive better than those with fewer competitors in the destination markets. The log-rank tests for the null hypotheses assumed in each of the four panels in Figure 4.5 are performed and rejected at the 5 percent significance level.

Figure 4.6 provides a look at the KM survival estimates of US agri-food exports conditional on various specifications of SPS concern measures. Compared to the baseline trade relationships, US agri-food exports that have experienced at least one SPS concern measure are prone to have a lower survival rate, as is shown in panel (a). The differences in survival probabilities increase as trade relationships continue up to five years and then gradually decrease as they survive longer. This underscores the finding that SPS measures that have been revealed as trade obstacles tend to affect the survival of trade relationships. Further in panel (b) we look at SPS concern measures that have escalated to WTO dispute settlement proceeding. Here, we find that the difference in survival probabilities becomes more striking as trade continues; trade relationships that elevated to formal disputes tend to fail earlier and survive for a shorter period. The bottom left panel (c) in Figure 4.6 implies that trade relationships with unresolved SPS concern measures generally have a lower survival rate than those with partially or completely resolved STCs. Furthermore, the bottom right panel (d) shows that trade relationships that suffered from plant health based SPS concern measures are inclined to survive at a lower probability than those impacted by other types of SPS concern measures. To sum up, these survival graphs in Figure 4.5 and 4.6 underscore the importance of developing parametric methods that allow us to control for relevant covariates to isolate the impact of SPS measures on US agri-food exports.

Using the discrete-time hazard model, our estimation results are provided in Table 4.2. Columns (1) through (8) display the estimation results using different specifications of SPS concern measures defined in the previous section. Overall, our findings are consistent with those from the previous survival studies. Export duration tends to negatively affect (therefore, decrease) the hazard rate of US agri-food exports, meaning that the longer periods trade relationships remain at a lower probability of failure. As expected, the duration effect is more negative for left-censored spells, indicating that left-censored trade relationships are much less likely to fail than those non-left-censored ones. Compared to trade relationships with a single trade spell, more numerous spells of service seem to have no significant impact on the probability of failure except for the trade relationships with at least four or more trade spells.

In terms of the macroeconomic variables, trade relationship that have larger initial trade values, larger economic size of importing countries, and more origin countries from which imports are sourced, lowers the hazard rate of exporting by an estimated average of 4.2%, 3.2%, and 2.8%, respectively. Conversely, the more concentrated the importing market is, the lower the hazard rate. Interestingly, this finding overturns what we found in the KM estimates, which could be due to multiple confounding factors omitted in the non-parametric analysis. With a single exporting country (the US), the economic size of the exporting country is close to a proxy of the time trend in the study. Thus, the larger economic size of the US implies longer survival time among trade relationships, leading to a higher chance of export failure. Lastly, we control for bilateral applied tariffs and find that trade relationships facing higher tariffs likely face a higher probability of failure by an estimated average of 3.6%.

Regarding the gravity variables, the results show that trade relationships that share a common language and/or border seem to have a lower probability of failure. The insignificance of the estimated effect of common RTA could be due to multi-collinear issues between RTA and other covariates such as common border. Estimates of distance seem counter-intuitive, which could be due to the multicollinearity between these gravity variables.

Most importantly, Table 4.2 presents the estimated coefficients of various specifications of SPS concern measures on the hazard rate of US agri-food exports but without controlling for importer and time dummy variables. We denote the model results here as baseline estimates. The estimates of SPS concern measures are all positive and statistically significant at 1 percent level, meaning that having experienced at least one specific trade concern related to SPS measures imposed by the importing country(ies) increases the conditional probability of exit of US agri-food exports, with the estimated average marginal effects ranging from 1.86% to 5.63% depending on the specific SPS variables used. For instance, using the overall SPS concern measures in Column (1), the estimated average marginal effect is 3.5%, and the average predicted hazard rate of trade relationships targeted by SPS concern measures increases from a sample average of 21.8% to 25.26%. For SPS concern mesures that are implemented (as opposed to draft mesures), the results in Column (2) are very close to those in Column (1), with an estimated marginal increase of 2.5% on the hazard rate of exporting. Column (3) uses SPS concern measures that have escalated to formal disputes in the WTO's dispute settlement meetings. Here, the results indicate a more substantial effect on the conditional probability of trade termination. SPS measures that failed to be resolved through bilateral discussions in the SPS committee meetings and ended up in dispute settlement increased the probabilty of US export failure by 5.6%.

Further, Column (4) utilizes the specifications of SPS concern measures by resolution status and finds that resolution does not seem to benefit the survival of trade, which could be due to the inconsistent timing when the concerns were truly resolved versus when they were recorded in the WTO's SPS information management system. Columns (5) and (6) discuss how the duration of SPS concerns being raised impacts the hazard rate of US agri-food exports. SPS concerns that have been subsequently raised more than 6 times have little effect on the hazard rate of exporting. However, SPS concern measures that have remained for a period longer than 5 years tend to increase the hazard rate. Column (7) differentiates SPS concern measures by subjects and finds that plant health based and other unspecified concerns increase the probability of exit of US agri-food exports. Finally, Column (8) investigates how the documented language used by raising/supporting country (the US) may have different impacts on the hazard rate of exporting. We find that SPS concern measures in which the exporter complains about their products being ”banned” or ”prohibited” in the importing country maintaining the measure lead to higher hazard rates compared to trade concerns that use moderated or soft language to describe the impacts of SPS measures such as ”restrictions” or ”delays” or ”proposed measures” and ”new regulations”.

While these initial results are revealing, they may not capture the true impact of SPS concern measures without controlling for importer- and time-specific characteristics.In Table 4.3, we re-estimate the models controlling for importer and time dummy variables. Admittedly, we find some discrepancies between the two sets of estimation results. After taking into account the time-invariant characteristics of importing countries and the time trend, the economic size and market concentration of importers turn out to be insignificant in affecting the probability of exit of US agri-food exports in our case. Changes in the real effective exchange rates become significantly positive – which is in concordance with our preliminary KM estimates. In addition, after cleaning out the time-invariant gravity components, the effect of RTAs in a 5-year lag term becomes negative and significant. Entering into a regional trade agreement appears to an important factor in reducing the hazard rate of trade relationships. That is, RTAs have a stabilizing effect on the duration of US agricultural trade.

We find that SPS concern measures seem to have little impacts on the hazard rate of US agri-food exports once we control for importer and time ”fixed effects”, though, with exceptions for SPS measures that have been implemented and those that have been complained using moderated languages. Can we conclude, however, that SPS concern measures do not have an economically significant effect on the probability of exit? Perhaps in aggregate but not at the sector level. To economize on space and to emphasize the fact that a majority of SPS concern measures were(are) targeting meat and fruit & vegetable products, we re-estimate the model for US exports of meats and fruits & vegetables, separately. The results are reported in Tables 4.4 and 4.5 for each sector, respectively. The results indicate that after controlling for importer and time ”fixed effects”, SPS concern measures imposed on US meat exports have average marginal effects on the hazard rate of US exports ranging from 2.46% to 15.25%. Similarly, SPS concern measures imposed on US fruit & vegetable exports increased the hazard rate of trade relationships with the estimated average marginal effects ranged in 2.13%~5.3%. We find that other survival, economic, and gravity variables all remain consistent with the previous explanations in terms of the impacts on the hazard rate of trade relationships compared to those in the baseline models.

Finally, as a sensitivity analysis, we re-estimate the baseline, fixed effects, and sectoral models using a panel logit (both random effects and fixed effects) and cloglog estimation methods. Our conclusions remain consistent across model specifications despite slight differences in the estimated magnitude, as is shown in Table A.5. We also estimate these models using an alternative threshold of trade values defining export failure with trade value thresholds of \$10 thousand, \$50 thousand, or \$100 thousand, and a different sample period by redefining the trade duration and spells of service in the 2001-2016 period. Again, our results remained consistent across these additional specifications and are available from the authors upon request. To summarize, after controlling for importer- and time-specific "fixed effects", SPS concern measures tend to have positive and significant impacts on the hazard rate of US agri-food exports, especially for US exports of meat and fruit & vegetable products.

4.5 Conclusions

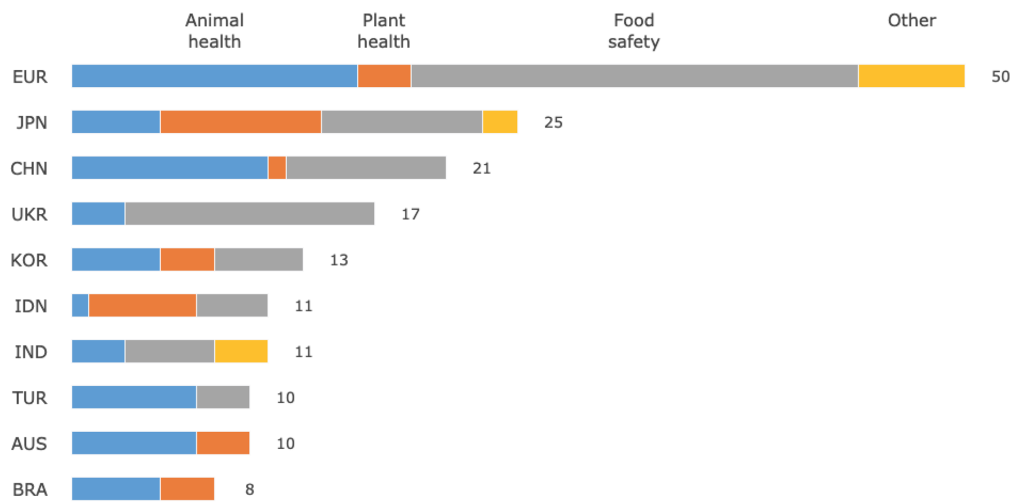
This study examines the impact of SPS measures that have been flagged as specific trade obstacles on the hazard rate of US agricultural and food exports using the SPS specific trade concerns database from the WTO's SPS Information Management System from 1995 to 2016. Because of the pervasiveness of non-tariff measures in agri-food trade and the growing literature that has emerged around it, this study adds new insights about their heterogeneous impacts on the survival of trade relationships.

The sample data show that 20% of trade relationships survive a single year, over half of them survived five years or less, and less than 2% of them survived the full sample period. Moreover, about 44% of trade relationships have a single spell of service, and 87% of them have three spells of service or less. Our results are broadly consistent with previous studies in terms of the coefficient sign and magnitude of most economic and gravity-based variables. Export duration, left-censored trade spells, and multiple spells of service decrease the hazard rate of US agri-food exports. Similarly, larger initial trade values, economic size of importing countries, higher competition in terms of the number of suppliers in importing markets, and whether the US shares a mutual RTA with the importing coumntry all lower the hazard rate. Bilateral tariffs, however, increase the hazard rate of trade relationships.

Results in this paper support the view that SPS trade concern measures have a small but statistically significant impact on the conditional probability of exit of US agri-food exports. SPS concern measures that have been subsequently raised multiple times, have not been fully resolved, or have escalated to formal WTO dispute settlement, impose a more significant hazardous impact on US agri-food export duration. SPS concern measures that use language such as ”bans” or ”prohibitions” when describing importing countries’ measures lead to higher export hazard rates. More broadly, SPS concern measures tend to raise the hazard rate of US agri-food exports between 2.1% and 15.3%, causing the predicted average conditional hazard rate to increase from 21.8% up to a range of 23.56% to 27.89%. Finally, we find that SPS concern measures have heterogeneous impacts across agricultural product sectors and are particularly detrimental to export survival in animal products and fruits and vegetables.

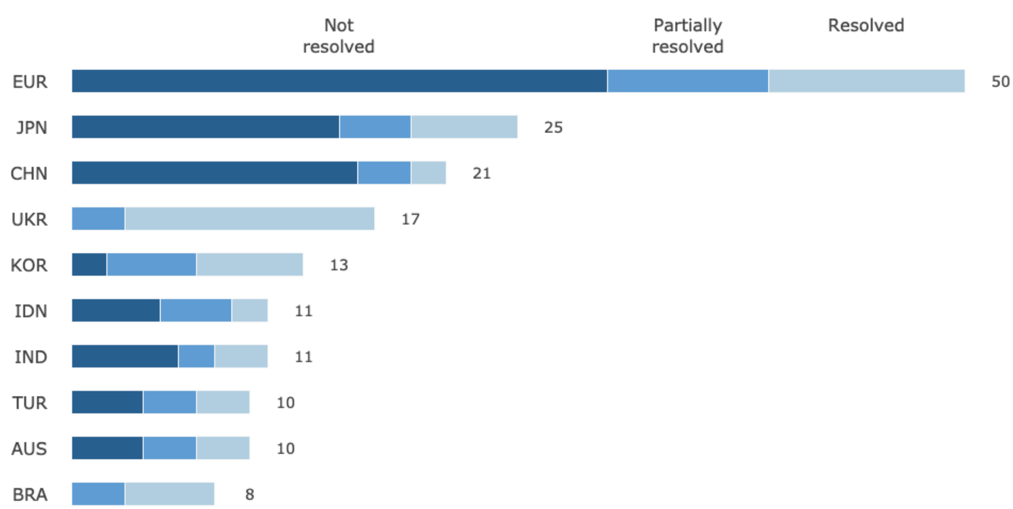
In summary, this study evaluated an alternative channel by which SPS measures can impact agricultural and food trade: export failure. SPS measures that have been revealed as specific trade concerns impose not only a barrier for trade establishment (entries) but also for trade survival (exits). Our results provide important policy implications for US agricultural policymakers about the hazard rate of exporting when negotiating SPS reforms with importing countries or maintaining the viability of existing trade relationships. These results are also robust to different specifications of SPS STCs variables, thresholds of trade values that define an ”export failure” and estimation methods.

Figure 4.1: Tabulation of SPS STCs by subjects, 1995-2016



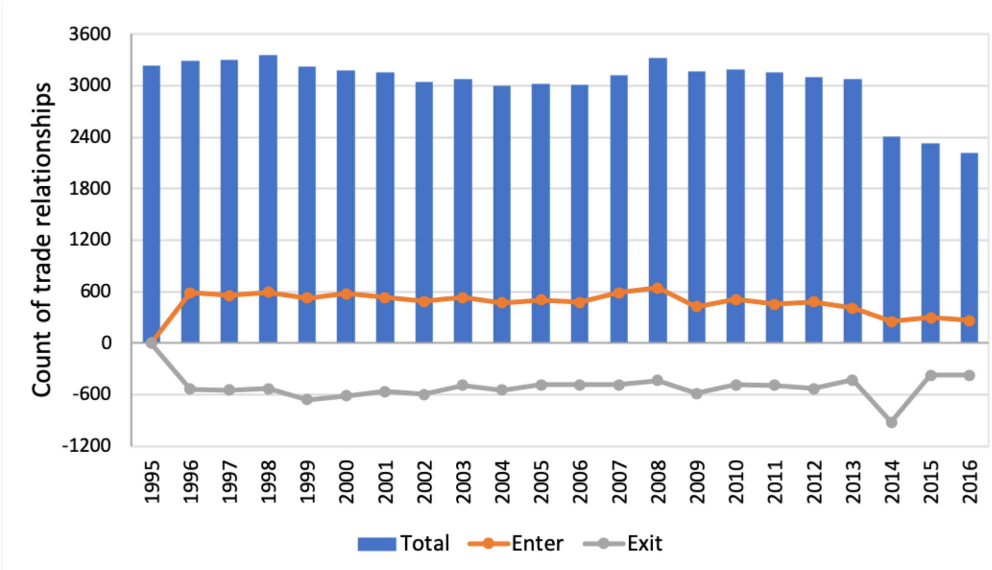
Source: Authors' calculation.

Figure 4.2: Tabulation of SPS STCs by resolution status, 1995-2016



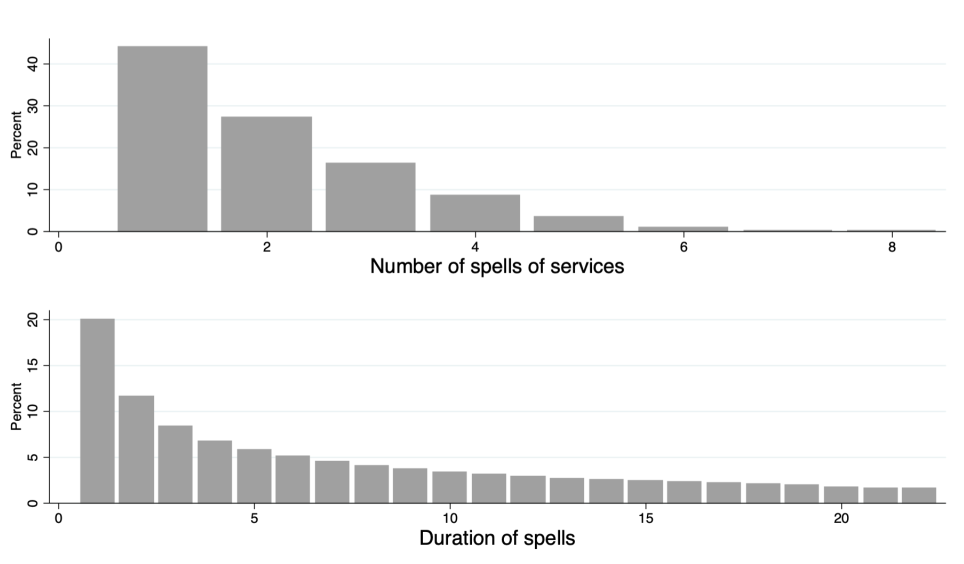
Source: Authors' calculation.

Figure 4.3: Trend of US agri-food exporting markets, 1995-2016



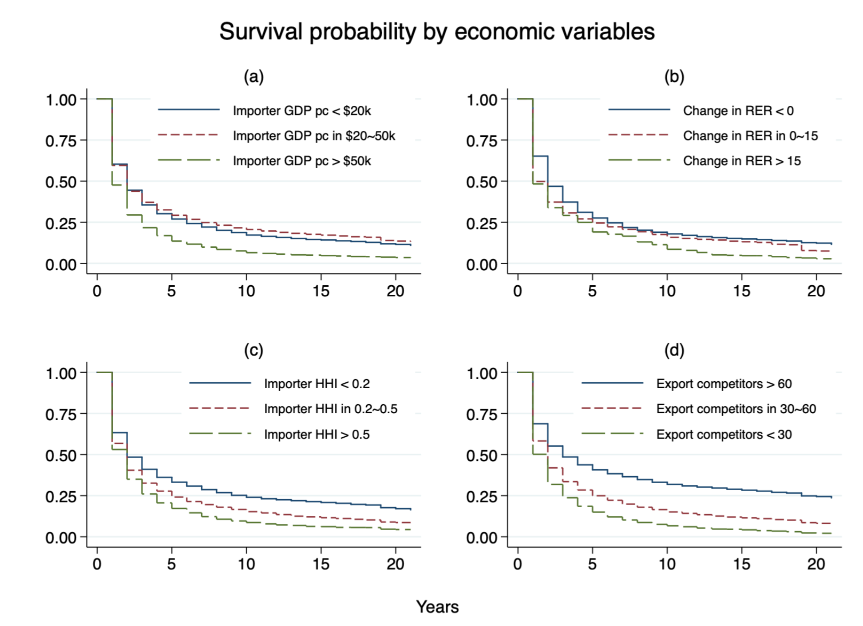
Note: A trade relationship is defined as an exporting country exports a product to an importing country, or an importer-exporter-product triplet at the HS 6-digit product level. Source: Authors' calculation.

Figure 4.4: Distribution of spells and duration of US agri-food exports, 1995-2016



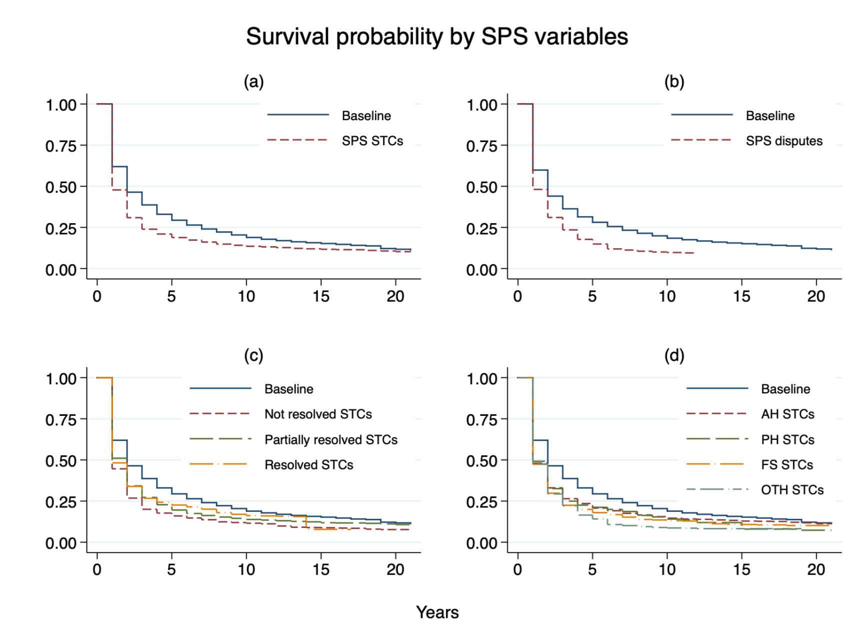
Note: A spell of service is defined as the period of time with uninterrupted exports of a product to an importing country. The duration of each spell is then defined as the number of consecutive years with positive trade flows. Source: Authors' calculation.

Figure 4.5: Kaplan Meier survival estimates of US agri-food exports, 1995-2016



Source: Authors' calculation.

Figure 4.6: Kaplan Meier survival estimates of US agri-food exports, 1995-2016



Source: Authors' calculation.

Table 4.1: Summary statistics of variables

	Mean	Std. Dev.	Min	Max
Trade relationship end, y_{odkt}	0.200	0.400	0	1
Survival variables				
Spell duration, DUR_{odkt}	9.385	7.589	1	29
Number of spells, SPL_{odkt}	1.893	1.211	1	9
Left-censored, $LEFT_{odkt}$	0.512	0.500	0	1
Gravity variables				
Regional trade agreements, RTA_{odt}	0.042	0.200	0	1
Common language, $Comlang_{od}$	0.170	0.375	0	1
Common colony, $Comcol_{od}$	0.190	0.392	0	1
Common border, $Contig_{od}$	0.010	0.100	0	1
Distance (thousand miles), $\ln(Dist_{od})$	2.008	0.398	-0.601	2.784
Macroeconomic variables				
Initial trade value ($thousand), $\ln(VI_{odkt})$	5.770	2.275	2.303	15.105
Importer GDP ($million), $\ln(GDP_{dt})$	6.388	1.494	0.075	9.324
Exporter GDP ($million), $\ln(GDP_{ot})$	9.425	0.262	8.944	9.829
Change in real exchange rate, ER_{odt}	0.659	9.767	-33.464	147.353
Count export suppliers, MX_{okt}	57.108	23.743	1	121
Import market HHI, MI_{dkt}	0.245	0.178	0.036	1
Bilateral tariff rates, TAR_{odkt}	0.186	0.405	0	8.683
SPS STCs variables				
Overall, STC_{odkt}	0.248	0.432	0	1
Implemented, $IMPL_{odkt}$	0.229	0.420	0	1
Dispute, $DISP_{odkt}$	0.066	0.249	0	1
Number of time raised, TM_{odkt}	2.089	6.079	0	32
Number of years remained, YR_{odkt}	1.412	3.097	0	14
Status: Not resolved, NR_{odkt}	0.114	0.318	0	1
Status: Partially resolved, PR_{odkt}	0.098	0.297	0	1
Status: Resolved, RSD_{odkt}	0.037	0.188	0	1
Subject: Animal health, AH_{odkt}	0.075	0.263	0	1
Subject: Plant health, PH_{odkt}	0.027	0.162	0	1
Subject: Food safety, FS_{odkt}	0.094	0.292	0	1
Subject: Other, OTH_{odkt}	0.053	0.223	0	1
Language used: Ban, BAN_{odkt}	0.064	0.245	0	1
Language used: Restrictions, RST_{odkt}	0.103	0.304	0	1
Language used: Other, OLG_{odkt}	0.081	0.273	0	1

Table 4.2: Estimation results for the hazard rates of U.S. agri-food exports (baseline)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Survival variables								
Duration	-0.018***	-0.017***	-0.018***	-0.018***	-0.018***	-0.017***	-0.018***	-0.018***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Left-censored	-1.973***	-1.974***	-1.972***	-1.973***	-1.974***	-1.973***	-1.975***	-1.974***
	(0.069)	(0.069)	(0.069)	(0.069)	(0.069)	(0.069)	(0.069)	(0.069)
Dur * Left-censored	0.098***	0.098***	0.099***	0.098***	0.098***	0.098***	0.099***	0.099***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Spell 2	-0.020	-0.019	-0.017	-0.020	-0.020	-0.019	-0.020	-0.019
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Spell 3	0.006	0.006	0.009	0.005	0.006	0.007	0.006	0.008
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Spell 4	-0.106***	-0.107***	-0.106***	-0.107***	-0.106***	-0.106***	-0.107***	-0.105***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Macroeconomic variables								
Initial trade value (ln)	-0.181***	-0.181***	-0.179***	-0.181***	-0.181***	-0.181***	-0.180***	-0.180***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Importer GDP (ln)	-0.137***	-0.138***	-0.136***	-0.137***	-0.136***	-0.138***	-0.137***	-0.138***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)
Exporter GDP (ln)	1.672***	1.648***	1.684***	1.686***	1.674***	1.680***	1.703***	1.713***
	(0.068)	(0.069)	(0.069)	(0.068)	(0.068)	(0.069)	(0.069)	(0.069)
Real exchange rate (△%)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Count export suppliers (ln)	-0.813***	-0.816***	-0.806***	-0.813***	-0.812***	-0.813***	-0.808***	-0.811***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Import market HHI	-0.119**	-0.115**	-0.123**	-0.121**	-0.124**	-0.117**	-0.129**	-0.114**
	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)
Tariffs (ln)	0.156***	0.163***	0.168***	0.155***	0.157***	0.155***	0.161***	0.157***
	(0.050)	(0.050)	(0.049)	(0.050)	(0.049)	(0.050)	(0.049)	(0.050)
Gravity variables								
RTA	-0.056	-0.057	-0.056	-0.052	-0.050	-0.062	-0.047	-0.067
	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
RTA, 5-year lag	-0.053	-0.053	-0.055	-0.051	-0.050	-0.054	-0.048	-0.054
	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)	(0.071)
Common language	-0.098***	-0.097***	-0.099***	-0.097***	-0.097***	-0.099***	-0.096***	-0.102***
	(0.031)	(0.031)	(0.030)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Common colony	-0.044	-0.044	-0.051	-0.043	-0.045	-0.043	-0.046	-0.043
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Common border	-0.836***	-0.858***	-0.760***	-0.842***	-0.830***	-0.826***	-0.813***	-0.809***
	(0.167)	(0.167)	(0.167)	(0.167)	(0.167)	(0.167)	(0.167)	(0.167)
Distance (ln)	-0.260***	-0.262***	-0.216***	-0.262***	-0.253***	-0.260***	-0.245***	-0.254***
	(0.034)	(0.034)	(0.034)	(0.034)	(0.035)	(0.034)	(0.035)	(0.034)
SPS STCs variables								

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Table 4.2 – continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
STCs	0.147***							
	(0.019)							
Implemented		0.106***						
		(0.021)						
Dispute			0.232***					
			(0.032)					
Not resolved				0.159***				
				(0.023)				
Partially resolved				0.144***				
				(0.028)				
Resolved				0.205***				
				(0.043)				
Raised <= 6 times					0.157***			
					(0.020)			
Raised > 6 times					0.108***			
					(0.037)			
Raised <= 5 years						0.133***		
						(0.022)		
Raised > 5 years						0.171***		
						(0.027)		
Animal health based							0.080**	
							(0.032)	
Plant health based							0.216***	
							(0.044)	
Food safety based							0.166***	
							(0.027)	
Other based							0.223***	
							(0.035)	
Strong language used								0.235***
								(0.033)
Moderate language used								0.178***
								(0.029)
Soft language used								0.108***
								(0.025)
No. of parameters	20	20	20	20	20	20	20	20
No. of observations	50169	50169	50169	50169	50169	50169	50169	50169
Log-likelihood	-20445.733	-20463.328	-20450.896	-20439.406	-20444.963	-20444.996	-20434.324	-20434.568
ρ	0.188	0.190	0.186	0.189	0.187	0.189	0.186	0.187
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Note: Estimates are derived from random-effect panel probit model without controlling for importer and time dummy variables. The parameter ρ denotes the fraction of the error variance that is due to unobserved importer-product factors. The tests of the null hypothesis of $\rho = 0$ are rejected at 5 percent level. Standard errors in parentheses. The asterisks denote the significance level, *** p<0.01, ** p<0.05, * p<0.1.

Table 4.3: Estimation results for the hazard rates of U.S. agri-food exports (controlling for importer and time dummy variables)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Survival variables								
Duration	-0.068***	-0.068***	-0.068***	-0.068***	-0.068***	-0.068***	-0.068***	-0.068***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Left-censored	-0.908***	-0.906***	-0.908***	-0.910***	-0.907***	-0.908***	-0.909***	-0.905***
	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)
Dur * Left-censored	0.060***	0.060***	0.060***	0.060***	0.060***	0.060***	0.060***	0.059***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Spell 2	-0.094***	-0.094***	-0.094***	-0.094***	-0.093***	-0.094***	-0.094***	-0.094***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Spell 3	-0.058*	-0.058*	-0.058*	-0.059*	-0.058	-0.058*	-0.059*	-0.058*
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Spell 4	-0.174***	-0.175***	-0.175***	-0.175***	-0.174***	-0.175***	-0.175***	-0.174***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Macroeconomic variables								
Initial trade value (ln)	-0.202***	-0.201***	-0.202***	-0.201***	-0.202***	-0.202***	-0.202***	-0.202***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Importer GDP (ln)	-0.004	-0.013	0.003	-0.004	-0.006	-0.004	-0.004	-0.011
	(0.048)	(0.048)	(0.047)	(0.048)	(0.048)	(0.048)	(0.048)	(0.048)
Real exchange rate (△%)	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Count export suppliers (ln)	-0.596***	-0.596***	-0.595***	-0.596***	-0.596***	-0.596***	-0.597***	-0.598***
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Import market HHI	0.028	0.029	0.028	0.025	0.031	0.028	0.024	0.031
	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)	(0.056)
Tariffs (ln)	0.158***	0.157***	0.160***	0.160***	0.158***	0.158***	0.159***	0.160***
	(0.054)	(0.054)	(0.054)	(0.054)	(0.055)	(0.054)	(0.054)	(0.055)
Gravity variables								
RTA	0.018	0.017	0.018	0.019	0.016	0.019	0.025	0.016
	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)
RTA, 5-year lag	-0.194**	-0.192**	-0.198**	-0.193**	-0.195**	-0.195**	-0.190**	-0.184**
	(0.093)	(0.093)	(0.093)	(0.093)	(0.093)	(0.093)	(0.093)	(0.093)
SPS STCs variables								
STCs	0.021							
	(0.021)							
Implemented		0.041*						
		(0.022)						
Dispute			0.013					
			(0.034)					
Not resolved				0.037				
				(0.027)				
Partially resolved				0.003				

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Table 4.3 – continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				(0.031)				
Resolved				0.006				
				(0.045)				
Raised <= 6 times					0.016			
					(0.023)			
Raised > 6 times					0.040			
					(0.041)			
Raised <= 5 years						0.023		
						(0.025)		
Raised > 5 years						0.017		
						(0.029)		
Animal health based							-0.000	
							(0.034)	
Plant health based							0.056	
							(0.049)	
Food safety based							0.040	
							(0.031)	
Other based							-0.002	
							(0.037)	
Strong language used								0.008
								(0.035)
Moderate language used								0.073**
								(0.032)
Soft language used								-0.015
								(0.029)
Importer FE	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
No. of parameters	87	87	87	87	87	87	87	87
No. of observations	47924	47924	47924	47924	47924	47924	47924	47924
Log-likelihood	-16165.571	-16164.354	-16165.981	-16165.063	-16165.413	-16165.556	-16164.623	-16163.108
ρ	0.125	0.124	0.125	0.124	0.125	0.125	0.124	0.125
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Note: Estimates are derived from random-effect panel probit model controlling for importer and time dummy variables. The parameter ρ denotes the fraction of the error variance that is due to unobserved importer-product factors. The tests of the null hypothesis of $\rho = 0$ are rejected at 5 percent level. Standard errors in parentheses. The asterisks denote the significance level, *** p<0.01, ** p<0.05, * p<0.1.

Table 4.4: Estimation results for duration model of U.S. meat exports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Survival variables								
Duration	-0.066***	-0.065***	-0.066***	-0.061***	-0.062***	-0.065***	-0.064***	-0.066***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Left-censored	-0.740***	-0.733***	-0.754***	-0.753***	-0.740***	-0.736***	-0.749***	-0.748***
	(0.188)	(0.189)	(0.188)	(0.191)	(0.190)	(0.189)	(0.189)	(0.189)
Dur * Left-censored	0.052***	0.052***	0.054***	0.051***	0.052***	0.052***	0.052***	0.053***
	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)	(0.014)	(0.014)	(0.013)
Spell 2	-0.231***	-0.236***	-0.222***	-0.230***	-0.225***	-0.230***	-0.230***	-0.234***
	(0.082)	(0.082)	(0.082)	(0.084)	(0.083)	(0.082)	(0.082)	(0.082)
Spell 3	-0.157	-0.159	-0.149	-0.146	-0.141	-0.154	-0.155	-0.160*
	(0.096)	(0.097)	(0.096)	(0.098)	(0.098)	(0.097)	(0.097)	(0.096)
Spell 4	-0.305***	-0.305***	-0.305***	-0.299***	-0.288***	-0.304***	-0.311***	-0.303***
	(0.107)	(0.107)	(0.107)	(0.109)	(0.109)	(0.107)	(0.108)	(0.107)
Macroeconomic variables								
Initial trade value (ln)	-0.214***	-0.214***	-0.213***	-0.217***	-0.217***	-0.215***	-0.215***	-0.214***
	(0.018)	(0.018)	(0.017)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Importer GDP (ln)	0.336***	0.338***	0.371***	0.342***	0.362***	0.331***	0.326***	0.325***
	(0.102)	(0.102)	(0.101)	(0.103)	(0.103)	(0.102)	(0.103)	(0.102)
Real exchange rate (△%)	0.010***	0.010***	0.011***	0.010***	0.010***	0.010***	0.010***	0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Count export suppliers (ln)	-0.533***	-0.537***	-0.522***	-0.579***	-0.561***	-0.536***	-0.537***	-0.537***
	(0.065)	(0.065)	(0.065)	(0.067)	(0.066)	(0.065)	(0.065)	(0.065)
Import market HHI	-0.007	-0.008	-0.003	-0.022	-0.012	-0.008	-0.003	-0.013
	(0.132)	(0.132)	(0.132)	(0.134)	(0.133)	(0.132)	(0.132)	(0.131)
Tariffs (ln)	-0.024	-0.041	-0.020	-0.035	-0.064	-0.031	-0.009	-0.008
	(0.128)	(0.129)	(0.128)	(0.132)	(0.131)	(0.129)	(0.131)	(0.128)
Gravity variables								
RTA	-0.034	-0.040	-0.013	-0.072	-0.088	-0.037	-0.024	-0.050
	(0.187)	(0.188)	(0.190)	(0.190)	(0.189)	(0.188)	(0.188)	(0.188)
RTA, 5-year lag	-0.850***	-0.850***	-0.840***	-0.830***	-0.839***	-0.849***	-0.851***	-0.848***
	(0.212)	(0.212)	(0.212)	(0.213)	(0.213)	(0.212)	(0.212)	(0.212)
SPS STCs variables								
STCs	0.134**							
	(0.054)							
Implemented		0.175***						
		(0.056)						
Dispute			0.112					
			(0.456)					
Not resolved				0.197***				
				(0.069)				
Partially resolved				0.665***				
				(0.148)				

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Table 4.4 – continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Resolved				-0.120				
				(0.082)				
Raised <= 6 times					0.053			
					(0.058)			
Raised > 6 times					0.640***			
					(0.137)			
Raised <= 5 years						0.112*		
						(0.061)		
Raised > 5 years						0.185**		
						(0.085)		
Animal health based							0.129*	
							(0.071)	
Food safety based							0.173**	
							(0.071)	
Other based							-0.272	
							(0.232)	
Strong language used								0.035
								(0.127)
Moderate language used								0.217***
								(0.068)
Soft language used								0.049
								(0.079)
Importer FE	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
No. of parameters	83	83	83	85	84	84	85	85
No. of observations	6049	6049	6049	6049	6049	6049	6049	6049
Log-likelihood	-2394.621	-2392.806	-2397.698	-2381.026	-2386.144	-2394.325	-2392.911	-2392.605
ρ	0.104	0.106	0.104	0.119	0.116	0.106	0.106	0.102
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Note: Estimates are derived from random-effect panel probit model controlling for importer and time dummy variables. The parameter ρ denotes the fraction of the error variance that is due to unobserved importer-product factors. The tests of the null hypothesis of $\rho = 0$ are rejected at 5 percent level. Standard errors in parentheses. The asterisks denote the significance level, *** p<0.01, ** p<0.05, * p<0.1.

Table 4.5: Estimation results for duration model of U.S. fruit & vegetable exports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Survival variables								
Duration	-0.061***	-0.061***	-0.060***	-0.060***	-0.061***	-0.061***	-0.061***	-0.061***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Left-censored	-1.110***	-1.108***	-1.098***	-1.109***	-1.111***	-1.110***	-1.107***	-1.114***
	(0.131)	(0.131)	(0.131)	(0.131)	(0.131)	(0.131)	(0.131)	(0.131)
Dur * Left-censored	0.069***	0.069***	0.068***	0.069***	0.069***	0.069***	0.069***	0.070***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Spell 2	-0.038	-0.038	-0.038	-0.038	-0.038	-0.038	-0.037	-0.038
	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Spell 3	-0.030	-0.030	-0.029	-0.032	-0.030	-0.031	-0.030	-0.032
	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)
Spell 4	-0.146**	-0.146**	-0.144**	-0.147**	-0.147**	-0.146**	-0.145**	-0.147**
	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)
Macroeconomic variables								
Initial trade value (ln)	-0.267***	-0.267***	-0.266***	-0.267***	-0.267***	-0.267***	-0.267***	-0.267***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Importer GDP (ln)	-0.341***	-0.332***	-0.259***	-0.323***	-0.349***	-0.342***	-0.351***	-0.348***
	(0.102)	(0.103)	(0.099)	(0.103)	(0.103)	(0.102)	(0.104)	(0.102)
Real exchange rate ($\triangle$%)	0.005*	0.005*	0.005*	0.004	0.004*	0.004	0.004	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Count export suppliers (ln)	-0.544***	-0.543***	-0.544***	-0.545***	-0.543***	-0.544***	-0.546***	-0.543***
	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)
Import market HHI	-0.021	-0.018	-0.020	-0.020	-0.021	-0.021	-0.023	-0.023
	(0.085)	(0.085)	(0.085)	(0.085)	(0.085)	(0.085)	(0.085)	(0.085)
Tariffs (ln)	0.284**	0.284**	0.290**	0.280**	0.283**	0.283**	0.283**	0.286**
	(0.132)	(0.132)	(0.132)	(0.132)	(0.132)	(0.132)	(0.132)	(0.132)
Gravity variables								
RTA	-0.189	-0.187	-0.212*	-0.137	-0.186	-0.188	-0.171	-0.174
	(0.125)	(0.125)	(0.126)	(0.130)	(0.125)	(0.125)	(0.126)	(0.127)
RTA, 5-year lag	-0.006	-0.011	-0.063	0.036	-0.003	-0.011	0.024	0.033
	(0.176)	(0.176)	(0.174)	(0.178)	(0.176)	(0.176)	(0.179)	(0.181)
SPS STCs variables								
STCs	0.133***							
	(0.049)							
Implemented		0.115**						
		(0.049)						
Dispute			0.035					
			(0.058)					
Not resolved				0.117**				
				(0.059)				
Partially resolved				0.109*				
				(0.063)				

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Table 4.5 – continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Resolved				0.266**				
				(0.103)				
Raised <= 6 times					0.128***			
					(0.050)			
Raised > 6 times					0.204			
					(0.132)			
Raised <= 5 years						0.142**		
						(0.055)		
Raised > 5 years						0.120*		
						(0.063)		
Plant health based							0.186**	
							(0.072)	
Food safety based							0.138**	
							(0.065)	
Other based							0.091	
							(0.067)	
Strong language used								0.115*
								(0.063)
Moderate language used								0.207**
								(0.094)
Soft language used								0.122*
								(0.063)
Importer FE	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
No. of parameters	64	64	64	66	65	65	66	66
No. of observations	16212	16212	16212	16212	16212	16212	16211	16212
Log-likelihood	-5624.955	-5625.902	-5628.466	-5623.867	-5624.788	-5624.897	-5623.862	-5624.531
ρ	0.11	0.11	0.111	0.11	0.11	0.11	0.109	0.109
p-value	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Note: Estimates are derived from random-effect panel probit model controlling for importer and time dummy variables. The parameter ρ denotes the fraction of the error variance that is due to unobserved importer-product factors. The tests of the null hypothesis of $\rho = 0$ are rejected at 5 percent level. Standard errors in parentheses. The asterisks denote the significance level, *** p<0.01, ** p<0.05, * p<0.1.

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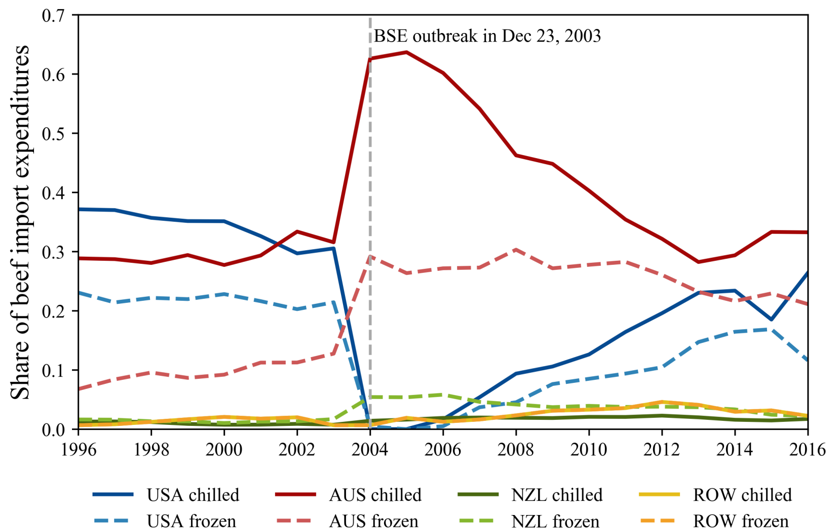
Appendix A

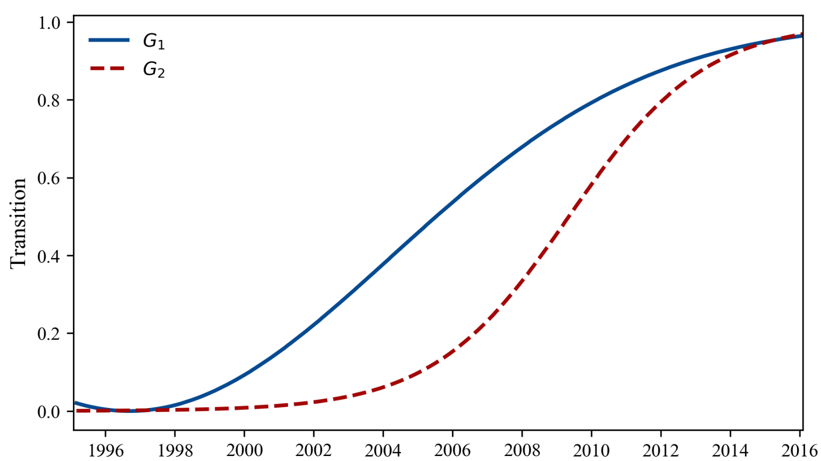
Appendix

Figure A.1: Annual Japanese fresh/chilled and frozen beef import shares by different origins, 1996-2016



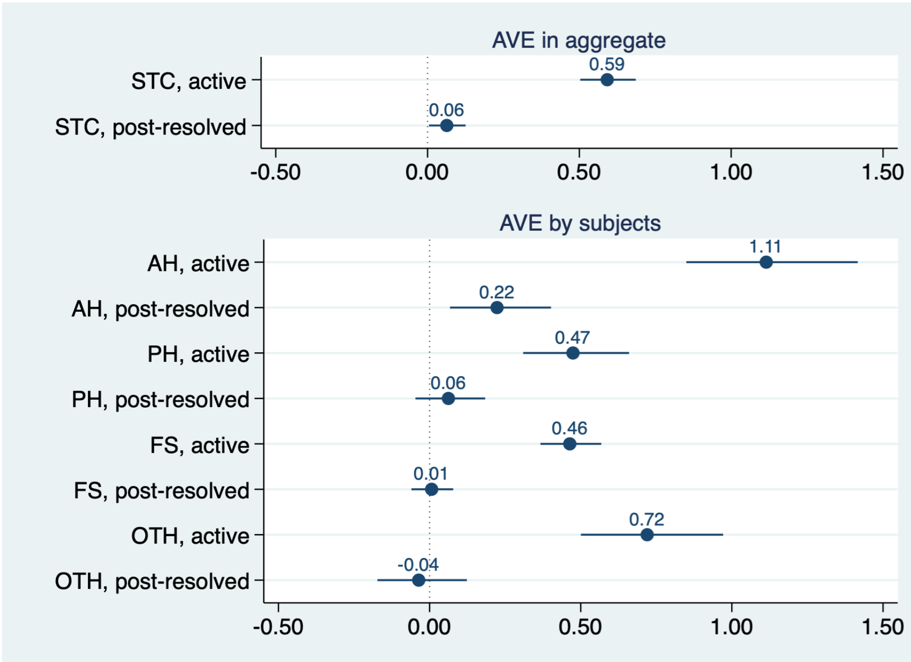
Source: Authors' calculation based on data from Global Trade Atlas.

Figure A.2: Estimated transition functions in the Japanese beef import demand model



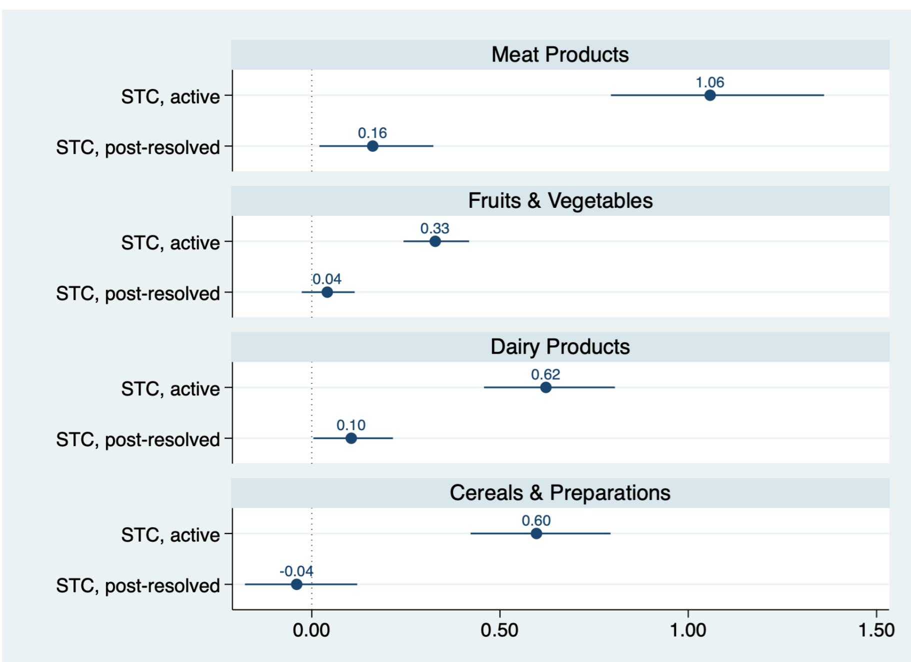
Note: Two smooth transition functions are used in the three-regime SDAIDS model estimation. The first is the exponential smooth transition function (labeled as G_1) with $\lambda_1 = \exp(-1.117) = 0.327$ and $c_1 = 0.077$. The second is the logistic smooth transition function (labeled as G_2) with $\lambda_2 = \exp(1.131) = 3.099$ and $c_2 = 0.68$. All four parameters are significant at 1% level.

Figure A.3: Estimated *ad valorem* tariff equivalents of SPS STCs by subjects



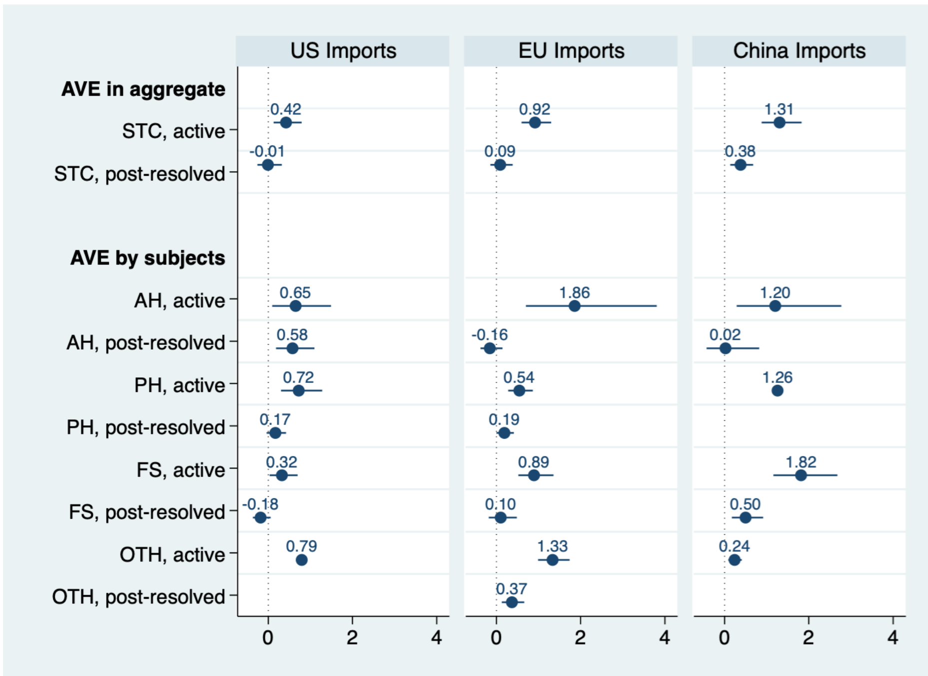
Source: Authors' calculation.

Figure A.4: Estimated *ad valorem* tariff equivalents of SPS STCs by sectors



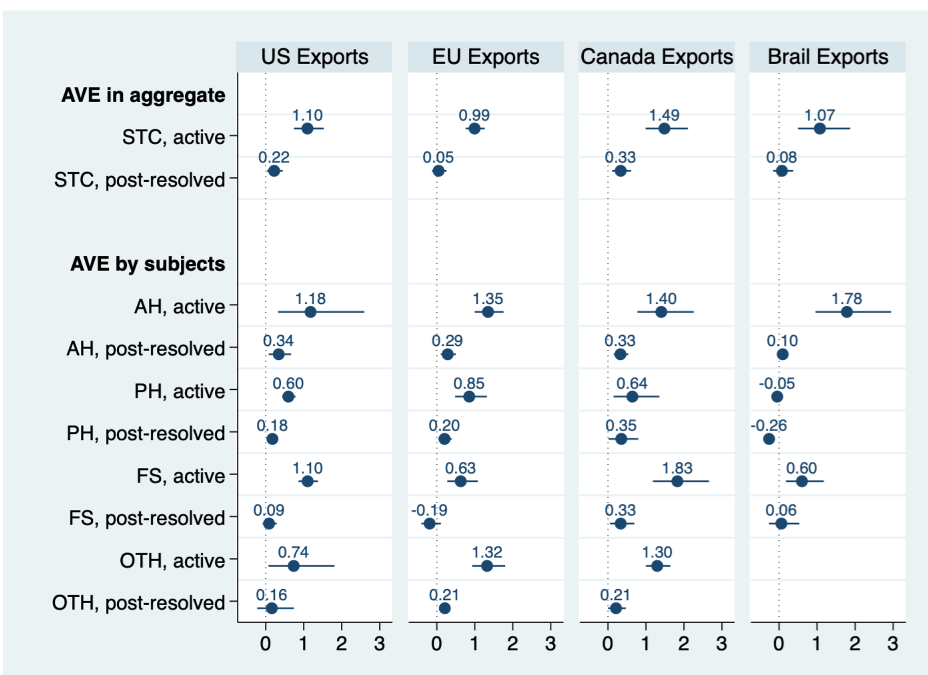
Source: Authors' calculation.

Figure A.5: Estimated *ad valorem* tariff equivalents of SPS STCs by major importers



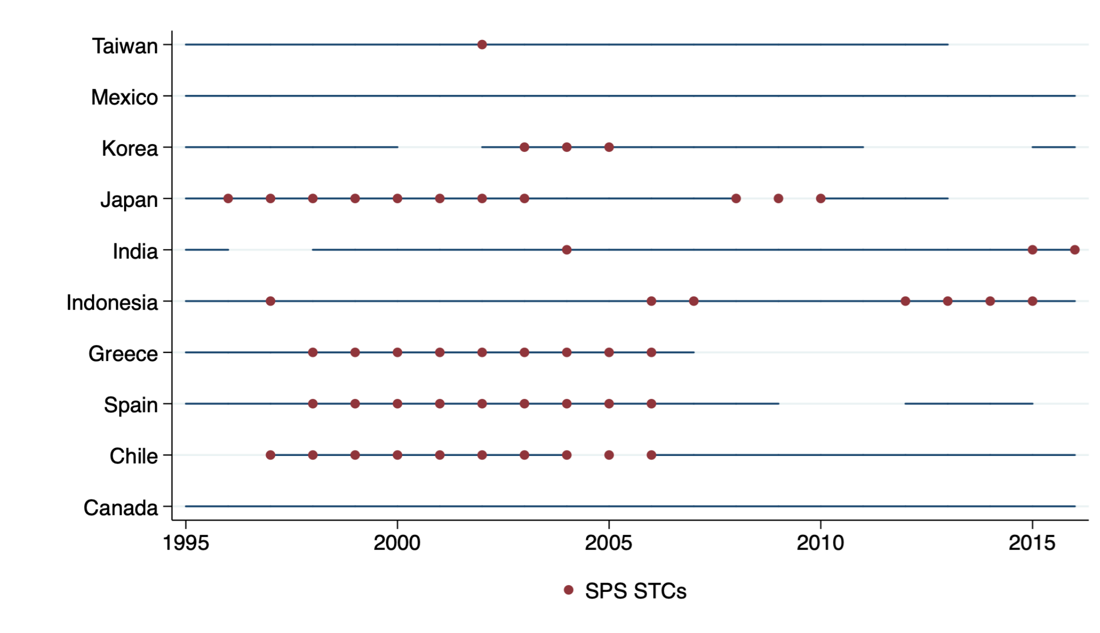
Source: Authors' calculation.

Figure A.6: Estimated *ad valorem* tariff equivalents of SPS STCs by major exporters



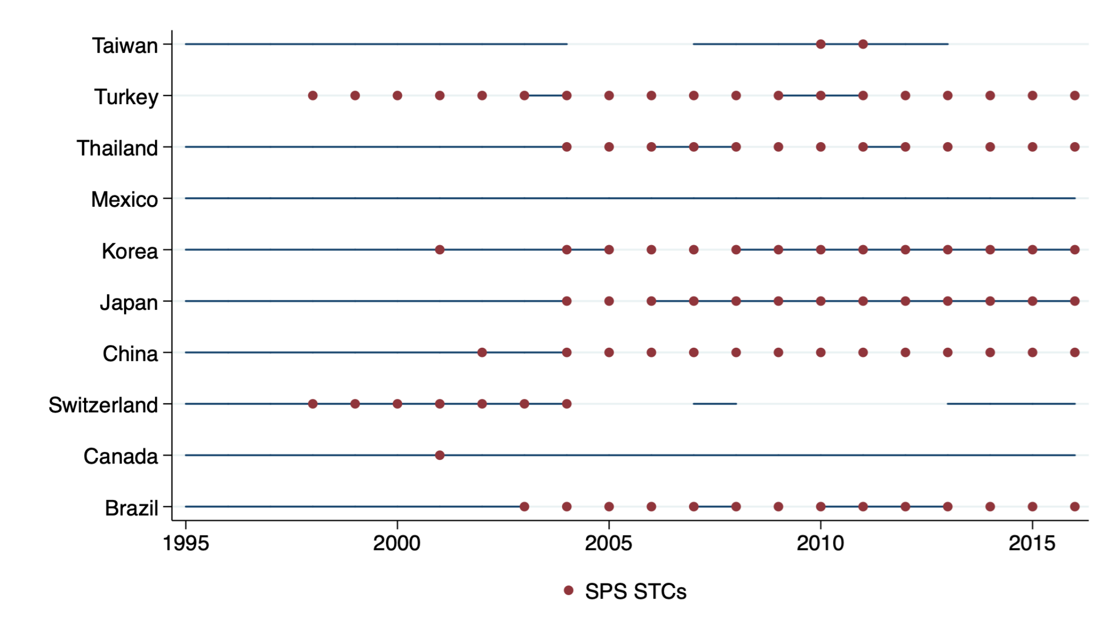
Source: Authors' calculation.

Figure A.7: Trade spells of US apple exports (HS 080810), 1995-2016



Note: *Lines* denote spells of consecutive years of positive trade. *Red marks* denote the incidence of SPS specific trade concern in that year. Source: Authors' calculation.

Figure A.8: Trade spells of US beef exports (HS 020220), 1995-2016



Note: *Lines* denote spells of consecutive years of positive trade. *Red marks* denote the incidence of SPS specific trade concern in that year. Source: Authors' calculation.

Table A.1: The estimated coefficients for the Japanese beef import demand model

Coefficients from expenditure regression

	Coef.	Std. Err.
Constant	0.046***	(0.014)
ln (GDP)	2.622***	(0.677)
BSE ban	-0.453***	(0.053)
Japanese domestic beef retailer price	-0.908**	(0.431)
Japanese consumer price index	3.316**	(1.437)
Japanese real effective exchange rate	0.451***	(0.112)
ln (price of U.S. chilled beef)	0.595***	(0.131)
ln (price of Australia chilled beef)	0.095	(0.213)
ln (price of New Zealand chilled beef)	-0.277	(0.170)
ln (price of Rest-of-world chilled beef)	0.078*	(0.045)
ln (price of U.S. frozen beef)	0.101	(0.085)
ln (price of Australia frozen beef)	-0.256*	(0.135)
ln (price of New Zealand frozen beef)	0.521***	(0.101)
ln (price of Rest-of-world frozen beef)	-0.025	(0.024)

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Coefficients from demand system regression

	USA chilled beef	AUS chilled beef	NZL chilled beef	ROW chilled beef	USA frozen beef	AUS frozen beef	NZL frozen beef	ROW frozen beef
α^1	0.433***	0.253***	0.011***	-0.007***	0.195***	0.077***	0.036***	0.001
	(0.026)	(0.026)	(0.002)	(0.003)	(0.022)	(0.020)	(0.008)	(0.004)
α^2	-0.414***	0.895***	0.008*	0.035***	-0.133*	0.511***	0.057***	0.040***
	(0.149)	(0.124)	(0.004)	(0.009)	(0.074)	(0.082)	(0.016)	(0.010)
α^3	0.318***	0.232***	0.027***	0.007***	0.145***	0.196***	0.034***	0.040***
	(0.033)	(0.031)	(0.002)	(0.003)	(0.026)	(0.024)	(0.008)	(0.006)
β^1	-0.015*	-0.006	0.002***	0.006***	0.011	0.002	-0.005*	0.006***
	(0.008)	(0.009)	(0.001)	(0.001)	(0.008)	(0.008)	(0.003)	(0.002)
β^2	0.122***	-0.076***	-0.015***	-0.003	0.136***	-0.119***	-0.035***	-0.009**
	(0.032)	(0.028)	(0.004)	(0.003)	(0.024)	(0.020)	(0.009)	(0.004)
β^3	0.046***	-0.025**	0.004***	-0.003***	-0.014	-0.005	0.002	-0.004
	(0.013)	(0.013)	(0.001)	(0.001)	(0.013)	(0.011)	(0.004)	(0.003)
$\gamma^1_{\text{USA chilled}}$	-0.130**	0.116*	-0.003	0.016**	-0.024	0.042	-0.022	0.004
	(0.063)	(0.060)	(0.006)	(0.007)	(0.035)	(0.037)	(0.018)	(0.006)
$\gamma^1_{\text{AUS chilled}}$		-0.122**	0.018***	-0.012*	0.007	-0.038	0.037**	-0.006
		(0.058)	(0.007)	(0.006)	(0.033)	(0.035)	(0.018)	(0.006)
$\gamma^1_{\text{NZL chilled}}$			-0.013***	-0.002*	0.012***	0.001	-0.015***	0.002***
			(0.004)	(0.001)	(0.004)	(0.005)	(0.003)	(0.000)
$\gamma^1_{\text{ROW chilled}}$				-0.002	0.005	-0.005	-0.000	0.000
				0.002	(0.004)	(0.005)	(0.003)	(0.001)
$\gamma^1_{\text{USA frozen}}$					0.134***	-0.100**	-0.029**	-0.005
					(0.041)	(0.039)	(0.014)	(0.006)
$\gamma^1_{\text{AUS frozen}}$						0.06	0.038**	0.001
						(0.043)	(0.016)	(0.006)
$\gamma^1_{\text{NZL frozen}}$							-0.012	0.002
							(0.012)	(0.002)
$\gamma^1_{\text{ROW frozen}}$								0.002
								(0.002)

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Coefficients from demand system regression (cont')

	USA chilled beef	AUS chilled beef	NZL chilled beef	ROW chilled beef	USA frozen beef	AUS frozen beef	NZL frozen beef	ROW frozen beef
$\gamma^2_{\text{USA chilled}}$	-0.586**	0.538**	0.035	0.013	-0.851***	0.632***	0.138*	0.081
	(0.294)	(0.261)	(0.034)	(0.021)	(0.266)	(0.201)	(0.075)	(0.033)
$\gamma^2_{\text{AUS chilled}}$		-0.412*	-0.124**	-0.001	0.790***	-0.549***	-0.178**	-0.064**
		(0.222)	(0.052)	(0.020)	(0.245)	(0.175)	(0.083)	(0.030)
$\gamma^2_{\text{NZL chilled}}$			0.086***	0.003	0.040**	-0.046**	0.017	-0.011***
			(0.027)	0.005	(0.017)	(0.022)	(0.013)	(0.004)
$\gamma^2_{\text{ROW chilled}}$				-0.015	0.021	-0.038**	0.022	-0.006
				(0.008)	(0.013)	(0.019)	(0.014)	(0.004)
$\gamma^2_{\text{USA frozen}}$					-0.529**	0.392**	0.129**	0.008
					(0.212)	(0.166)	(0.055)	(0.020)
$\gamma^2_{\text{AUS frozen}}$						-0.07	-0.318***	-0.005
						(0.117)	(0.095)	(0.020)
$\gamma^2_{\text{NZL frozen}}$							0.194***	-0.006
							(0.060)	(0.010)
$\gamma^2_{\text{ROW frozen}}$								0.003
								(0.010)
$\gamma^3_{\text{USA chilled}}$	0.087	-0.085	-0.003	0.001	0.051	-0.061	0.01	0.000
	(0.056)	(0.056)	(0.006)	(0.006)	(0.041)	(0.038)	(0.019)	(0.008)
$\gamma^3_{\text{AUS chilled}}$		0.066	0.019**	-0.000	-0.054	0.042	0.014	-0.001
		(0.055)	(0.008)	(0.006)	(0.040)	(0.037)	(0.019)	(0.009)
$\gamma^3_{\text{NZL chilled}}$			-0.015	-0.001	0.012***	0.008*	-0.022***	0.001
			(0.010)	0.001	(0.004)	(0.005)	(0.003)	(0.000)
$\gamma^3_{\text{ROW chilled}}$				0.001	-0.009***	0.011	-0.002	-0.000
				(0.002)	(0.004)	(0.005)	(0.003)	(0.001)
$\gamma^3_{\text{USA frozen}}$					-0.022	-0.028	0.023*	0.027***
					(0.034)	(0.033)	(0.013)	(0.007)
$\gamma^3_{\text{AUS frozen}}$						0.058	-0.011	-0.018
						(0.038)	(0.018)	(0.007)
$\gamma^3_{\text{NZL frozen}}$							-0.004	-0.009**
							(0.014)	(0.003)
$\gamma^3_{\text{ROW frozen}}$								-0.000
								(0.003)

$\lambda_1 = \exp(\lambda_1^*) = \exp(-1.117)$, $c_1 = 0.077$, $\lambda_2 = \exp(\lambda_2^*) = \exp(1.131)$, $c_2 = 0.680$

Note: Estimates are derived from the three-regime smooth transition SDAIDS model with time-varying α,β and γ. Standard errors in parentheses. The asterisks denote the significance level, *** p<0.01, ** p<0.05, * p<0.1.

Table A.2: List of countries (and/or regions) analyzed in the empirical analysis

Country	**ISO3 Code**	**Development Level**
Argentina	ARG	Developing
Australia	AUS	Developed
Brazil	BRA	Developing
Canada	CAN	Developed
Chile	CHL	Developing
China	CHN	Developing
Colombia	COL	Developing
Costa Rica	CRI	Developing
Ecuador	ECU	Developing
Indonesia	IDN	Developing
India	IND	Developing
Japan	JPN	Developed
Mexico	MEX	Developing
Malaysia	MYS	Developing
New Zealand	NZL	Developed
Philippines	PHL	Developing
Paraguay	PRY	Developing
Russian Federation	RUS	Developing
South Africa	ZAF	Developing
South Korea	KOR	Developed
Switzerland	CHE	Developed
Taiwan, China	TWN	Developing
Thailand	THA	Developing
Turkey	TUR	Developing
Ukraine	UKR	Developing
Uruguay	URY	Developing
United States	USA	Developed
Venezuela	VEN	Developing
Vietnam	VNM	Developing
European Union (28)	EUR	Developed

Source: World Economic Situation Prospects, United Nations (UN [93]).

Table A.3: MTN sectors mapping to HS and SITC product codes

MTN Category	**Abbreviation**	**HS Code (Revision 2007)**	**SITC Code (Revision 1)**
Animal Products	*MEAT*	01, 02, 1601-1602	001, 011-013
Dairy Products	*DAIRY*	0401-0406	022-024
Fruits, Vegetables & Plants	*FV*	0601-0603, 07, 08, 1105-1106, 2001-2008, 1211, 13, 14	051-055
Coffee, Tea, Mate & Spices	*CTS*	0901-0903, 18 (except 1802), 2101	071-075
Cereals & Preparations	*CER*	0407-0410, 10, 1101-1104, 1107-1109, 19, 2102-2106, 2209	025, 041-048, 0554
Oilseeds, Fats & Oils	*OILS*	1201-1208, 15 (except 1504), 2304-2306, 3823	0813, 0913-0914, 221, 4113, 421-422, 431
Sugars & Confectionary	*SGR*	17	061-062, 5129
Beverages & Tobacco	*BT*	2009, 2201-2208, 24	111-112, 121- 122
Fish & Fish Products	*SFD*	03, 1504, 1603-1605, 230120	031-032, 0814, 4111
Other Agricultural products	*OTHAG*	0904-0910, 05, 0604, 1209-1210, 1212-1214, 1802, 230110, 2302-2303, 2307-2309, 290543-290545, 3301, 3501-3505, 380910, 382460, 4101-4103, 4301, 5001-5003, 5301-5302	0811-0812, 0990, 211-212, 262, 265, 291, 292

Note: Mapping to HS Codes is cited from World Tariff Profiles (ITC and UNCTAD [59]). Mapping to SITC Codes (Revision 1) is completed by the authors.

Table A.4: List of selected case-study SPS specific trade concerns

Topics	Maintained by	Raised/supported by	Products covered	Keywords
Aflatoxin (STC 39, 168, 198)	European Union	Argentina; Australia; Bolivia; Brazil; China; The Gambia; India; Indonesia; Malaysia; Philippines; Senegal; Thailand; Canada; Colombia; Mexico; Pakistan; Paraguay; Peru; Philippines; South Africa; Turkey; United States; Uruguay	Milk, peanuts, other nuts, dried fruits, corn, cereals, other food preparations	Food safety
GMOs (STC 106, 110, 117, 396)	European Union	Argentina; Australia; Canada; Egypt; Israel; Jordan; Singapore; Chinese Taipei; Paraguay; Philippines; United States	Cereals, grains, food preparations, other animal feeds	Food safety; Other concerns
BSE (STC 4, 96, 193)	Argentina; Australia; Brazil; Chile; China; Japan; Singapore; South Korea; Thailand; Turkey; Ukraine; European Union; United States	Canada; Switzerland; European Union; United States; Uruguay	Beef	Animal health
MRLs (STC 212, 267, 283)	Japan	China; Australia; Brazil; Philippines; Ecuador; New Zealand; United States	Fruits, vegetables	Food safety
Ractopamine (STC 275)	China; Chinese Taipei; Thailand; European Union; Russian Federation	United States; Brazil; Canada; Costa Rica; Ecuador; Peru	Pork	Food safety
AI (STC 196, 259, 406)	China	United States; European Union; Canada	Poultry	Food safety

Source: http://spsims.wto.org/

Table A.5: Compare estimation results from various duration models of U.S. agri-food exports

	Base Model			With Importer, Time, and Sector Dummies		
	Probit (1)	Logit (2)	Cloglog (3)	Probit (4)	Logit (5)	Cloglog (6)
Survival variables						
Duration	-0.018***	-0.033***	-0.090***	-0.067***	-0.122***	-0.148***
	(0.004)	(0.007)	(0.004)	(0.004)	(0.008)	(0.005)
Left-censored	-1.973***	-4.207***	-4.161***	-0.889***	-1.641***	-1.564***
	(0.069)	(0.144)	(0.124)	(0.073)	(0.144)	(0.125)
Dur * Left-censored	0.098***	0.203***	0.235***	0.059***	0.104***	0.123***
	(0.004)	(0.008)	(0.006)	(0.005)	(0.010)	(0.008)
Spell 2	-0.020	-0.044	-0.005	-0.105***	-0.184***	-0.117***
	(0.031)	(0.055)	(0.035)	(0.031)	(0.055)	(0.038)
Spell 3	0.006	0.004	0.052	-0.073**	-0.127**	-0.048
	(0.035)	(0.061)	(0.038)	(0.035)	(0.062)	(0.041)
Spell 4	-0.106***	-0.195***	-0.002	-0.186***	-0.327***	-0.133***
	(0.039)	(0.068)	(0.039)	(0.039)	(0.068)	(0.043)
Macroeconomic variables						
Initial trade value (ln)	-0.181***	-0.320***	-0.195***	-0.202***	-0.375***	-0.269***
	(0.007)	(0.012)	(0.007)	(0.007)	(0.013)	(0.008)
Importer GDP (ln)	-0.137***	-0.224***	-0.096***	0.007	0.024	0.066
	(0.009)	(0.016)	(0.008)	(0.049)	(0.088)	(0.067)
Exporter GDP (ln)	1.672***	2.883***	1.925***			
	(0.068)	(0.120)	(0.077)			
Real exchange rate (△%)	0.001	-0.000	0.001	0.009***	0.016***	0.012***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Count export suppliers (ln)	-0.813***	-1.347***	-0.626***	-0.606***	-1.031***	-0.599***
	(0.031)	(0.054)	(0.022)	(0.028)	(0.051)	(0.028)
Import market HHI	-0.119**	-0.215**	-0.092	-0.057	-0.123	-0.086
	(0.056)	(0.096)	(0.057)	(0.058)	(0.102)	(0.066)
Tariffs (ln)	0.156***	0.269***	0.151***	0.073	0.110	0.075
	(0.050)	(0.087)	(0.052)	(0.058)	(0.105)	(0.072)
Gravity variables						
RTA	-0.056	-0.098	-0.084	-0.011	-0.003	0.069
	(0.053)	(0.092)	(0.064)	(0.076)	(0.136)	(0.106)
RTA, 5-year lag	-0.053	-0.105	-0.023	-0.202**	-0.364**	-0.263**
	(0.071)	(0.123)	(0.090)	(0.093)	(0.166)	(0.128)
Common language	-0.098***	-0.157***	-0.084***			
	(0.031)	(0.053)	(0.030)			
Common colony	-0.044	-0.071	-0.043			
	(0.033)	(0.057)	(0.032)			
Common border	-0.836***	-1.392***	-0.712***			
	(0.167)	(0.295)	(0.185)			

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Table A.5 – continued from previous page

	Base Model			With Importer, Time, and Sector Dummies		
	Probit (1)	Logit (2)	Cloglog (3)	Probit (4)	Logit (5)	Cloglog (6)
Distance (ln)	-0.260***	-0.446***	-0.244***			
	(0.034)	(0.059)	(0.033)			
SPS STCs variables						
STCs	0.147***	0.266***	0.192***			
	(0.019)	(0.033)	(0.023)			
STCs * MEAT (baseline)				0.129***	0.212**	0.134**
				(0.048)	(0.085)	(0.060)
STCs * FV				-0.094	-0.148	-0.050
				(0.058)	(0.102)	(0.074)
STCs * DAIRY				-0.375***	-0.620***	-0.437***
				(0.096)	(0.171)	(0.123)
STCs * CER				-0.198***	-0.319**	-0.195**
				(0.069)	(0.124)	(0.090)
STCs * OILS				-0.078	-0.123	-0.060
				(0.093)	(0.165)	(0.123)
STCs * CTS				0.675	1.228	0.914
				(0.601)	(1.261)	(1.168)
STCs * SFD				-0.073	-0.093	-0.022
				(0.105)	(0.185)	(0.138)
STCs * SGR				-0.399	-0.732	-0.582
				(0.280)	(0.512)	(0.437)
STCs * BT				-0.277**	-0.512**	-0.475**
				(0.121)	(0.225)	(0.188)
STCs * OTHAG				-0.256***	-0.435***	-0.301***
				(0.082)	(0.149)	(0.115)
Sector FE				Y	Y	Y
Importer FE				Y	Y	Y
Time FE				Y	Y	Y
No. of parameters	20	20	20	105	105	105
No. of observations	50169	50169	50169	47699	47699	47924
Log-likelihood	-20445.733	-20409.480	-20525.093	-16050.808	-16048.587	-16177.086
ρ	0.188	0.165		0.117	0.110	
p-value	[0.00]	[0.00]		[0.00]	[0.00]	

Note: Estimates are derived from various estimation methods and specifications. The parameter ρ denotes the fraction of the error variance that is due to unobserved importer-product factors. The tests of the null hypothesis of $\rho = 0$ are rejected at 5 percent level. Standard errors in parentheses. The asterisks denote the significance level, *** p<0.01, ** p<0.05, * p<0.1.