SANITARY AND PHYTOSANITARY MEASURES AND TECHNICAL BARRIERS TO TRADE AS NON-TARIFF MEASURES TO AGRI-FOOD TRADE IN THE ASIA-PACIFIC

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ABSTRACT: Many free-trade agreements have contributed to abolishing and reducing tariffs across countries; however, concerns regarding trade promotion have shifted from tariff to non-tariff measures (NTMs). This study focuses on sanitary and phytosanitary measures (SPS) and technical barriers to trade (TBT) as NTMs. The literature suggests that the effects of SPS and TBT are likely to be negative; however, some evidence of positive effects has also been found. This empirical study examines the impact of SPS and TBT on agri-food trade in the Asia-Pacific region. The estimation results indicate that SPS and TBT become non-tariff barriers in several agri-food trades in the Asia-Pacific region. In contrast, the results for some commodities appear to suggest that, for these commodities, more transparency encourages trade despite greater bilateral divergence of rules and regulations.

KEYWORDS: Agri-food trade; gravity model; non-tariff measures; harmonization, supply chain.

ACKNOWLEDGEMENT: This study is supported by JSPS KAKENHI Grant (No. 20K06263). Usual disclaimers apply.

1. INTRODUCTION

The Asia-Pacific region consists of countries with various economic statuses, including the United States and Japan, which are developed countries; China, which has achieved emerging development; and a representative country of the Global South, such as India. Traditionally, several economic spheres have been based on free trade agreements within certain regional areas, such as those belonging to the Association of Southeast Asian Nations (ASEAN) and the United States-Mexico-Canada Agreement (USMCA, former NAFTA). In other words, this region epitomizes the global economy, and the agri-food trade among its countries is similar. The United States, Australia, Canada, and Mexico have the most substantial agricultural production, supplying grain and meat to the international markets. Thailand and Indonesia produce and export sugars and vegetable oils worldwide. On the demand side, the United States, China, and Japan are the three largest agri-food-importing countries around the world as well as in the region. Emerging economic growth and trade liberalization caused agri-food trade within the region to escalate from the late 2000s until the mid-2010s and then remain at a high level, except during the Global Financial Crisis.

In the context of Regional Science and International Economics, many empirical trade studies have shown the effects of trade costs on bilateral trade using the gravity model, such as bilateral distance as transportation costs and common languages as transaction costs. Additionally, tariffs have a central location in international trade liberalization negotiation and have been the main policy variable for trade costs. However, over the past two decades, numerous free-trade agreements have contributed to the abolition and reduction of agri-food tariffs. Concerns regarding non-tariff measures (NTMs) have gradually increased in international trade negotiations and studies (Bureau *et al.*, 2019; Gaigné and Gouel, 2022). The Trade Facilitation Agreement (TFA), which came into force in 2017, represents one instance of these shifting gears in trade negotiations. It was the first agreement that World Trade Organization (WTO) members entered in 2014 and targeted comprehensive rules to enhance the transparency of trade regulations and expedite customs proceedings. Moreover, the recently enforced regional trade agreements (RTAs) within the Asia-Pacific region, the Comprehensive and Progressive Agreement for the Trans-Pacific Partnership (CPTPP), and the Regional Comprehensive Economic Partnership Agreement (RCEP) apply new trade facilitation rules beyond those of the TFA.

NTMs include trade regulations and standards that impose imports in each country and incur trade costs (Anderson and van Wincoop, 2004). If they are insufficiently written or unclear, trade costs increase because producers must pay additional professional employee wages and outsourcing fees to search and grasp them. These are non-tariff barriers (NTBs) if imports are imposed by excessive burdens compared with domestic products and serious informal rules. Information on trade measures impinges on whether NTMs would work as NTBs (Thilmany and Barrett, 1997). Higher transparency of RTAs would reduce the costs involved in NTMs (Cadot and Gourdon, 2016). Diminishing trade costs by improving transparency and harmonization might improve trade

(Beghin and Schweizer, 2021). Therefore, transparency and harmonization of trade regulations are necessary to increase agri-food trade.

Regarding NTMs, this study focuses on sanitary and phytosanitary measures (SPS) and technical barriers to trade (TBT). They are official border rules necessary to protect domestic agriculture and public health against diseases and pests and to conserve the domestic ecosystem. These agri-food coverages are more expansive than those of other manufactured goods (Gaigné and Gouel, 2022), and they have a considerable influence on agri-food trade (Beghin *et al.*, 2015). Quarantine and biosecurity measures are sometimes supposed to become seeds of bilateral political issues, such as China applying them against imports of several agricultural products, such as beef and seafood from Australia in 2020 and pineapples from Taiwan in 2021. Disdier *et al.* (2008) indicate the negative impacts of SPS and TBT on agri-food imports by Organisation for Economic Co-operation and Development (OECD) members. However, there is considerable room in terms of the effects of regulatory harmonization—in other words, the impacts of regulatory divergence between exporting and importing countries. Producers in the home country usually produce goods under domestic sanitary and food safety regulations and standards. If these complied domestic rules and standards are the same as, or similar to, those of a partner country, producers have already observed regulations in the importing country; this means that they need to pay fewer or no additional requirements. Winchester *et al.* (2012) show that regulatory heterogeneity in maximum residue limits (MRLs) negatively influences food trade. De Frahan and Mark (2006) show that harmonizing food standards in the EU encourages intra-regional agri-food trade. Therefore, this study focuses on the effect of bilateral regulatory divergence of SPS and TBT on agri-food trade in the Asia-Pacific region as an aspect of harmonization in trade facilitation to address transparency and harmonization in trade regulations.

Although we do not have a specific way to set variables for NTMs in quantitative analysis, it is necessary to reflect the concept of additional fixed costs implied by Melitz (2003). This study employs the "Additional Compliance Requirement Indicator (ACRI)" suggested by Obashi (2020) and Nabeshima and Obashi (2021). This indicator represents the divergence of regulations between exporting and importing countries; in other words, it shows the degree to which additional requirements lead to additional fixed costs for exporters. In addition, the indicator can be measured using the data in the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS) that has recently been enriched. This database includes data on trade policy instruments, including quotas and price controls, as well as regulatory technical measures, such as SPS and TBT. It covers NTMs data for more than 85% of world trade and for more than 100 countries (UNCTAD, 2018). To elucidate the impact of SPS and TBT on trade, the number of notifications to the WTO has been used in many studies (Fontagné *et al.*, 2015; Kou and Kusakari, 2019). However, Obashi (2020) points out that it is not sufficient to capture bilateral NTMs because of its 30 percent coverage. Moreover, Santeramo and Lamonaca (2019) conducted a meta-analysis of the impact of NTMs on agri-food and highlighted that differences in NTM types and proxy variables in a quantitative analysis yielded different results. Hence, this study adopts the ACRI measured using more systematic bilateral data on NTMs provided by TRAINS to show the impacts of SPS and TBT on agri-food trade.

Moreover, the agri-food trade in this study is confined to edible products to examine the relationship between NTMs and product types. SPS and TBT have the same objective of protecting domestic human health and animal or plant life from risks; however, they cover different risk sources. SPS covers the risks of entry of pests, diseases, and disease-carrying organisms, and TBT covers the hazards caused by product characteristics and production processes. These different coverages may lead to different impacts of SPS and TBT by product type, such as primary or processed agri-foods. Hence, SPS might affect the trade of primary agri-food more than processed agri-food as it makes a judgement decision on pests and disease-carrying or causing organisms. TBT might have the opposite effect as it requires the declaration of production processes and assessment of producers. In addition, long distances in the supply chain make it more difficult for production information to reach consumers despite increasing concerns about food safety. Hence, TBT might have a greater influence on products supplied to households than on those supplied to industries because it oversees the standards for product processes. Therefore, in this study, edible agri-food trade in the Asia-Pacific region is subdivided into two processing stages—primary and processed agri-foods—and two destinations in the supply chain—supply to industries as intermediates and household demand as final consumption goods.

The remainder of this paper is organized as follows. Section 2 offers a brief overview of the agri-food trade and the ACRI as an index of SPS and TBT in the Asia-Pacific region. Section 3 presents the gravity equations, methodology, and data for the estimation. Section 4 presents the estimation results of the Poisson pseudo-maximum-likelihood (PPML) method for the impact of SPS and TBT on agri-food trade in the Asia-Pacific region. Finally, Section 5 concludes and discusses the study's limitations and potential extensions.

2. THE REGULATORY DIVERGENCE OF SPS AND TBT IN THE ASIA-PACIFIC

This section describes the "Additional Compliance Requirements Index (ACRI)" proposed by Obashi (2020) and Nabeshima and Obashi (2021) to reflect the status of SPS and TBT in the Asia-Pacific region.[1] This index focuses on the necessity of additional costs incurred from additional regulations compared with domestic compliance and importer border regulations.[2]

The first step is to measure the cosine similarity ($Cos(\theta)_{ijh,t} = \frac{\sum_{k=1}^{K} F_{ihk,t} F_{ijhk,t}}{\sqrt{\sum_{k=1}^{K}\left(F_{ihk,t}\right)^2}\sqrt{\sum_{k=1}^{K} F_{ijhk,t}^2}}$) to determine the degrees of divergence in bilateral regulations. $F_{ihk,t}$ is the number of measures in border measure category k for good h in the home country i in year t. $F_{ijhk,t}$ is the summation of measures in border measure category k for good h in the countries of origin (exporter) i and destination (importer) j in year t.[3] k denotes categories of border regulations in SPS and TBT in the *TRAINS*, seven categories in SPS ($k = 1, \dots, 7$), and seven categories in TBT ($k = 1, \dots, 7$).[4] A good h is a six-digit code of the Harmonized

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[1] The ACRI in Obashi (2020) and Nabeshima and Obashi (2021) cover SPS, TBT, and pre-ship investigation (PSI) at a stretch to measure ACRI as NTMs of technical measures. However, in this study, it measures the respective ACRI for SPS and TBT.

[2] The ACRI shows the regulatory divergence between an origin country and a destination country. However, the variable indicating regulatory heterogeneity in Winchester *et al.* (2012) does not simply show only the bilateral divergence but the relative relation between the bilateral differences against the international range in each regulation.

[3] Although Obashi (2020) and Nabeshima and Obashi (2021) express country i as the origin and country j as the destination, this study denotes them oppositely because they need to be expressed consistently with the gravity equation, denoted later.

[4] SPS belongs to Chapter A and TBT belongs to Chapter B in the classification of TRAINS (UNCTAD, 2018). SPS has seven categories: A1 Prohibitions/restrictions; A2 Tolerance limits for residues and restricted use of substances; A3 Labelling, marking, packaging requirements; A4 Hygienic requirements; A5 Treatment for the elimination of pests and diseases; A6 Requirements on production/post-production processes; and A8 Conformity assessment. A7 is an unused category. TBT has seven categories: B1 Prohibitions/restrictions; B2 Tolerance limits for residues and restricted use of substances; B3 Labeling, marking, packaging requirements; B4 Production or post-production requirements; B6 Product identity requirement; B7 Product quality or performance requirement; and B8 Conformity assessment. B5 is an unused category.

Commodity Description and Coding System (HS) belonging to 111, 112, 121, and 122 in the broad economic categories (BEC). This cosine similarity is available to range from greater than 0 to less than 1 ($Cos(\theta)_{ijh} \in (0,1]$); closer to 1 means that the bilateral regulation is more similar, and closer to 0 means lower similarity.

The second step is to subtract the cosine similarity from one to show that higher figures are many additional obligations in importers' border regulations. In addition, the ACRI is set to 0 if there is no regulation in a foreign country; conversely, it is set to 1 if only the home country has regulations. As a result, $ACRI_{ijh,t}$ of good h between countries i and j in year t is between 0 and 1, inclusive. Closer to 1 means the exporter has more regulations to comply with at the destination; closer to 0 means the opposite. In other words, a high ACRI means a higher divergence of regulations for agri-foods between bilateral countries, or relatively more regulations.

Figure 1 shows the means of the ACRIs of SPS and TBT in the Asia-Pacific 22 countries and regions from 2010 to 2020. The ACRI of SPS was higher than that of TBT at the beginning; an almost consistent increase in the ACRI of TBT exceeded SPS in 2016. The expansion of the TBT divergence is consistent with the expanding applicable scope of TBT in Gaigné and Gouel (2022).

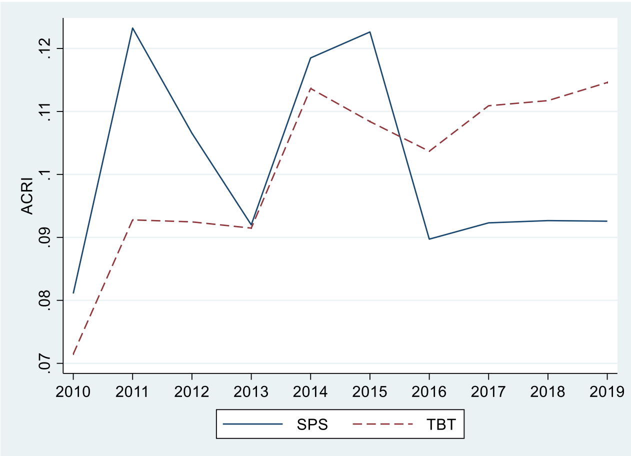

Figure 1. ACRI in Agri-Food Trade in the Asia-Pacific Region. Source: Author's measures using data of *TRAINS* in UNCTAD. Note: Twenty-two countries and regions are covered because of the available data: Japan, China, Hong Kong, South Korea, Vietnam, the Philippines, Malaysia, Singapore, Thailand, Indonesia, Brunei, Myanmar, Cambodia, Laos, India, the United States, Canada, Mexico, Peru, Chile, Australia, and New Zealand.

Figure 2 shows four panels of the ACRI: (a) primary, (b) processed agri-food, (c) intermediate demand, and (d) final goods. Compared to panels (a) and (b), the ACRIs of SPS and TBT for primary agri-food trade are higher than those of processed agri-food trade. This indicates that the divergence of SPS and TBT from export countries' regulations for primary agri-food imports is more prominent than that for processed agri-foods. For the ACRI for primary agri-foods in panel (a), TBT exceeded SPS since 2016, although it was higher than TBT at the beginning. For the ACRI for processed agri-foods in panel (b), the two indexes were at the same level until 2011, and then TBT exceeded SPS. For the ACRI for final goods in panel (d), SPS and TBT were almost at the same levels, but TBT exceeded SPS, similar to others. In contrast, for the ACRI for intermediate demand in panel (c), SPS is at higher levels than TBT, unlike others.

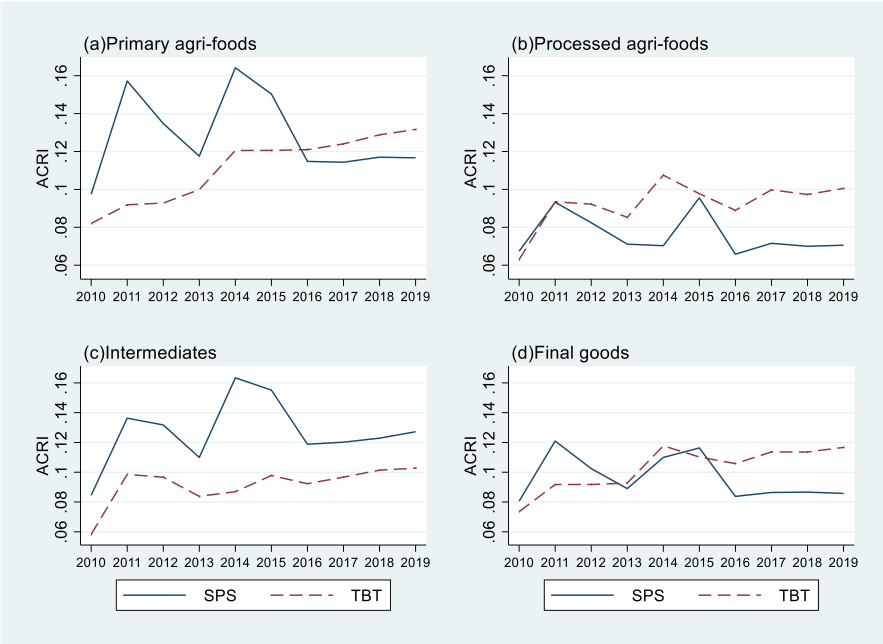

Figure 2. ACRI by Processing Stages and Demand Destinations. Source: Author's measures using data of *TRAINS* in UNCTAD.

As seen above, for NTMs in the Asia-Pacific region, the bilateral divergence of TBT has increased, and the level exceeds SPS after 2016;

however, the levels and trends by processing stages and demand destinations are not uniform.

3. METHODS AND DATA

Traditionally, the gravity equation has been applied to explain bilateral trade. This study also assumes the following equation to evaluate the impact on agri-food trade in the Asia-Pacific region:

$$EX_{ij,t}^{m} = A\frac{GDP_{i,t}^{\theta_1}GDP_{j,t}^{\theta_2}}{TTC_{ij,t}^{\eta}} \quad (1)$$

where $EX_{ij,t}^{m}$ is the bilateral exports of edible agri-food by item m from country i to j in year t. The exports comprise 18 items based on the Standard International Trade Classification (SITC) and 34 items classified by product types and supply destinations ($m = 1, \dots, 52$, Table 2 shows details.). $GDP_{i,t}$ and $GDP_{j,t}$ are the economic sizes of both countries, and $TTC_{ij,t}$ is the trade cost from country i to j in year t, including the transportation and transaction costs incurred from i to j. In this study, the trade costs consist of the bilateral distance ($DIST_{ij}$), contiguity (COG_{ij}), common language (LNG_{ij}), historical relations (COL_{ij}), regional trade agreements ($RTA_{ij,t}$), and bilateral additional compliance requirements of SPS and TBT ($ACRI_{ij,t}^{SPS}$ and $ACRI_{ij,t}^{TBT}$); $TTC_{ij,t}^{\eta} = exp\left[\beta_1 lnDIST_{ij} + \beta_2 COG_{ij} + \beta_3 COL_{ij} + \beta_4 RTA_{ij,t} + \beta_5 ACRI_{ij,t}^{SPS} + \beta_6 ACRI_{ij,t}^{TBT}\right]$

. $\beta_m (m = 1, \dots, 6)$ are the unknown parameters.

Some studies have indicated several problems in estimating the traditional gravity equation, whereas others have suggested improvements. Anderson and van Wincoop (2003) point out the issue of multilateral resistance terms, which means that the price indices of a trade partner are reduced because of nearby countries with lower wages. Redding and Venables (2004) suggest using fixed effects for exporters i and importers j against this problem. Another problem is the logarithmic transformation of a dependent variable in the estimation using the ordinary least squares method, which results in different expected values before and after the logarithmic transformation; this is known as Jensen's inequality. To solve this problem, Santos Silva and Tenreyro (2006) propose a single logarithmic transformation of only the independent variables on the right-hand side of the gravity equation using the Poisson pseudo-maximum-likelihood (PPML) method. Hence, this study estimates the following gravity equation with dummies for exporters and importers as the fixed effects using PPML[5]:

$$EX_{ij,t}^{m} = \alpha + \beta_1 \ln DIST_{ij} + \beta_2 COG_{ij} + \beta_3 LNG_{ij} + \beta_4 COL_{ij} + \beta_5 RTA_{ij,t} + \beta_6 ACRI_{ij,t}^{SPS} + \beta_7 ACRI_{ij,t}^{TBT} + \varepsilon_{ij,t} \quad (2)$$

Table 1 lists the independent variables with the expected signs. The expected sign of bilateral distance ($\ln DIST_{ij}$) is negative; the longer the distance, the higher the transportation costs. Sharing the borders involves more cultural experience for both countries, including food culture, owing to easier intercommunication between people and information as transportation costs are lower. If people are enthralled by agricultural products and foodstuffs in another country, they may constantly demand them. For instance, half of the exports from Korean traditional pickles, called *kimchi*, are to Japan, a neighboring country. Therefore, the sign of contiguity (COG_{ij}) is expected to be positive. The expected sign of the common language (LNG_{ij}) and historical relationships (COL_{ij}), which are proxy variables of transaction costs, are positive. The common language helps understand the partner's institutions and border procedures due to accessible communication. Business connections and developments in the colonial period remained, which might have helped trade. $RTA_{ij,t}$ denotes the free trade policy in force between countries i and j in year t; its expected sign is positive.

The variables of additional compliance requirements ($ACRI_{ij,t}^{SPS}$, $ACRI_{ij,t}^{TBT}$) have both positive and negative expected signs. A high ACRI means a higher divergence of regulations for agri-foods between countries i and j or relatively more regulations. A negative ACRI sign might show that a higher divergence of regulations negatively influences agri-food trade as a non-tariff barrier. Conversely, its positive sign might show that the transparency of rules due to many published regulations, despite their large difference, might encourage the agri-food trade (Nabeshima and Obashi, 2021).

The database consisted of 22 countries and areas in the Asia-Pacific region: Japan, China, Hong Kong, South Korea, Vietnam, the Philippines, Malaysia, Singapore, Thailand, Indonesia, Brunei, Myanmar, Cambodia, Laos, India, the United States, Canada, Mexico, Peru, Chile, Australia, and New Zealand. The estimation period was from 2010 to 2020. The data sources are as follows: the bilateral trade values were from

[5] The "ppmlhdfe" module in Stata was used, employing dummy variables for the fixed effects of exporting and importing countries and year for all estimations.

UNCTAD *Comtrade*; the bilateral distance, the status of common language, and the historical relationships were from the databases in the Centre d'Études Prospectives et d'Informations Internationales (CEPII) (Mayer and Zignago, 2011), and the information on free trade policy in force was obtained from the WTO *Regional Trade Agreements Database*. The data used to measure ACRI are from UNCTAD's *TRAINS* database.

Table 1. Independent Variables. Source: the Author.

Variables	Data	Expected sign
$\ln DIST_{ij}$	Distance (logarithmic value)	–
COG_{ij}	Dummy of contiguity	+
LNG_{ij}	Dummy of common language	+
COL_{ij}	Dummy of colonial relationship	+
$RTA_{ij,t}$	Dummy of RTA	+
$ACRI_{ij,t}^{SPS}$	ACRI of SPS in year t	±
$ACRI_{ij,t}^{TBT}$	ACRI of TBT in year t	±

The edible agri-food trade for dependent variables in the estimations covers 01–04, 07–12, 15–23, and 35 in two-digit codes of the HS2017, and 01–09, 11, 22, 29, 41–43, 51, and 59 in the two-digit codes of the SITC Rev.4.[6] The database consisted of a six-digit HS2017 database. The estimation was conducted using a two-digit code of SITC in agri-foods, processing stages, and demand destinations. Table 2 shows the data structure of the agri-food trade in the database. Edible agri-foods are divided into primary and processed agri-foods in 7 items in SITC and demand destinations to industries and households in 10 items in SITC. In addition, the high correlation relationships show the ACRIs between SPS and TBT, which are from 0.7 to 0.8. Therefore, the coefficients of these two ACRI variables are estimated in equation (2) separately, and not jointly, to avoid multicollinearity.[7]

[6] The agri-food trade data address edible products from 111, 112, 121, and 122 in BEC. The HS was revised at intervals of several years. The versions are six: HS1988/1992, HS1996, HS2002, HS2007, HS2012, and HS2017. The HS version in *Comtrade* and *TRAINS* depends on the reporting countries. Before merging the data of trade values and ACRI data, the code of goods was unified to HS2017 based on the correspondence tables in UNCTAD.

[7] In 18 regressions including both ACRIs of SPS and TBT, the statistically insignificant ACRI of SPS is 10; that of TBT is 7, including automatically omitted 1 in the estimation process.

Table 2. Agri-Food Trade Data Structure in the Asia-Pacific Region (2010–2019). Source: the Author.

SITC		Agri-foods	Processing stages		Demand destinations	
			Primary	Processed	Industries	Households
00	Live animals	8,207	-	-	-	-
01	Meat and meat preparations	34,070	-	-	3,387	30,683
02	Dairy products and bird eggs	29,280	8,499	20,781	6,418	22,862
03	Fish, crustaceans, mollusks, and aquatic invertebrates and preparations thereof	118,972	31,340	87,632	836	118,136
04	Cereals and cereal preparations	51,701	8,753	42,948	18,052	33,649
05	Vegetables and fruits	182,634	103,364	79,270	14,816	167,818
06	Sugars, sugar preparations, and honey	25,984	2,071	23,913	13,808	12,176
07	Coffee, tea, cocoa, spices, and manufactures thereof	67,156	39,992	27,164	9,134	58,022
08	Feeding stuff for animals	2,290	-	-	-	-
09	Miscellaneous edible products and preparations	43,875	-	-	7,713	36,162
11	Beverages	33,820	-	-	282	33,538
22	Oilseeds and oleaginous fruits	12,068	10,050	2,018	-	-
29	Crude animal and vegetable materials	575	-	-	-	-
41	Animal oils and fats	2,406	-	-	-	-
42	Fixed vegetable fats and oils, crude, refined or fractionated	17,842	-	-	9,610	8,232
43	Animal or vegetable fats and oils, processed; waxes of animal or vegetable origin; inedible mixtures or preparations of animal or vegetable fats or oils	2,583	-	-	-	-
51	Organic chemicals	377	-	-	-	-
59	Chemical materials and products	804	-	-	-	-

Note 1: The figures show case counts of bilateral exports during the database period.
Note 2: The data for each dependent variable are the bilateral exports of edible products in each SITC.

4. ESTIMATION RESULTS

Table 3 shows the estimation results of equation (2) for 18 items in the SITC on the edible agri-food trade in the Asia-Pacific region. The variables traditionally used in trade analysis are as follows. The bilateral distance ($\ln DIST_{ij}$) as a proxy variable of transportation costs is significantly negative for 15 items, as in many previous studies. Another variable of transportation costs, contiguity (COG_{ij}), is significant for 12 items with the expected sign. Hence, transportation costs negatively influence agri-food trade within the region. Likewise, RTA ($RTA_{ij,t}$) is significantly positive for 15 items. Numerous RTAs have encouraged agri-food trades, similar to the decline in transportation costs. Regarding transaction costs, common language (LNG_{ij}) and historical relationships (COL_{ij}) are significantly positive for 10 items, respectively.

The additional compliance requirements from the bilateral SPS and TBT divergences ($ACRI_{ij,t}^{SPS}$, $ACRI_{ij,t}^{TBT}$) show mixed results. Some point to a negative influence of SPS on trade. For instance, only the ACRI of SPS is significantly negative at “02. Dairy products and bird eggs.” Both ACRIs are significantly negative for “06. Sugars, sugar preparations and honey,” and the estimate of the ACRI of SPS is larger than that of TBT. Meanwhile, for “09. Miscellaneous edible products and preparations,” TBT has a more negative impact on trade than SPS. The former results indicate that the agri-food trade, which is simply processed or made of fewer materials, reflects the negative impacts of a divergence of bilateral SPS. In contrast, agri-food trade that is complexly processed or made of more materials seems to have negative influences from the divergence of bilateral TBT due to numerous and mixed standards.

Moreover, other results are significant at “05. Vegetables and fruits” and “22. Oilseeds and oleaginous fruits.” The ACRI of TBT, and not SPS, is only significantly negative at SITC 05. The estimate of the ACRI of TBT is higher than that of SPS at SITC 22, where both variables are significantly negative. These results are inconsistent with the above explanation that the importance of the SPS measure is higher than that of TBT because the production processes for these items are not highly complex. However, the result of SITC 05 is consistent with the description in Kou and Kusakari (2019) that reporting TBT to the WTO against fruit exports from China has increased.

Moreover, the ACRI of SPS and/or TBT have significantly positive impacts at “42. Fixed vegetable fats and oils, crude, refined or fractionated” and “59. Chemical materials and products.” According to Nabeshima and Obashi (2021), higher transparency through an increase in the number of regulations encourages trade despite expanded divergence.

Table 3. Estimation results of agri-food trade in the Asia-Pacific region.

Source: the Author.

	00		01		02		03		04	
	SPS	TBT	SPS	TBT	SPS	TBT	SPS	TBT	SPS	TBT
$\ln DIST_{ij}$	-0.305***	-0.327***	-0.945***	-0.952***	-0.599***	-0.567***	-0.473***	-0.474***	-0.912***	-0.901***
	(0.0859)	(0.0853)	(0.0535)	(0.0542)	(0.0464)	(0.0455)	(0.0197)	(0.0197)	(0.0277)	(0.0279)
COG_{ij}	2.917***	2.820***	-0.0539	-0.0640	1.258***	1.364***	-0.122**	-0.123**	0.717***	0.724***
	(0.223)	(0.226)	(0.104)	(0.104)	(0.0970)	(0.0986)	(0.0559)	(0.0558)	(0.0639)	(0.0640)
LNG_{ij}	0.329	0.410	0.310***	0.307***	-0.865***	-0.863***	0.533***	0.533***	0.283***	0.323***
	(0.245)	(0.260)	(0.0798)	(0.0797)	(0.106)	(0.105)	(0.0499)	(0.0499)	(0.0680)	(0.0669)
COL_{ij}	0.290	0.0654	0.297**	0.289**	0.851***	0.970***	0.148*	0.149*	0.568***	0.556***
	(0.242)	(0.265)	(0.126)	(0.126)	(0.0825)	(0.0883)	(0.0801)	(0.0804)	(0.112)	(0.114)
$RTA_{ij,t}$	0.345**	0.377**	0.539***	0.532***	0.877***	0.993***	0.191***	0.194***	0.264***	0.269***
	(0.157)	(0.155)	(0.0812)	(0.0814)	(0.0816)	(0.0773)	(0.0445)	(0.0445)	(0.0674)	(0.0688)
$ACRI_{ij,t}^{SPS}$	-0.223		0.263		-2.334***		-0.115		0.474	
	(0.409)		(0.498)		(0.384)		(0.202)		(0.400)	
$ACRI_{ij,t}^{TBT}$		-0.716*		-0.202		-0.243		0.0886		-0.0921
		(0.388)		(0.242)		(0.275)		(0.174)		(0.297)
Constant	4.886***	4.905***	12.74***	12.83***	8.789***	8.395***	7.632***	7.642***	11.64***	11.56***
	(0.789)	(0.784)	(0.471)	(0.478)	(0.425)	(0.414)	(0.171)	(0.171)	(0.243)	(0.244)
Observations	8,017	7,810	33,697	33,593	29,155	29,039	117,779	117,454	51,583	50,740
R2	0.960	0.939	0.884	0.885	0.869	0.868	0.821	0.821	0.899	0.900
log-likelihood	-6264	-5719	-133086	-133162	-51646	-51769	-272739	-272567	-104152	-102202

	05		06		07		08		09	
	SPS	TBT	SPS	TBT	SPS	TBT	SPS	TBT	SPS	TBT
$\ln DIST_{ij}$	-0.971***	-0.972***	-0.918***	-0.926***	-0.871***	-0.871***	-0.958***	-1.050***	-0.729***	-0.728***
	(0.0161)	(0.0161)	(0.0292)	(0.0290)	(0.0189)	(0.0192)	(0.143)	(0.142)	(0.0234)	(0.0234)
COG_{ij}	0.767***	0.763***	0.698***	0.707***	0.719***	0.719***	0.911**	0.734**	0.776***	0.776***
	(0.0347)	(0.0347)	(0.0788)	(0.0789)	(0.0492)	(0.0492)	(0.354)	(0.340)	(0.0601)	(0.0602)
LNG_{ij}	0.103***	0.104***	0.144**	0.165**	0.389***	0.387***	1.462***	1.763***	0.0373	0.0370
	(0.0313)	(0.0313)	(0.0695)	(0.0691)	(0.0369)	(0.0370)	(0.296)	(0.266)	(0.0685)	(0.0684)
COL_{ij}	0.209***	0.220***	1.324***	1.320***	0.0984	0.0956	-1.737***	-2.239***	0.120*	0.122*
	(0.0542)	(0.0544)	(0.124)	(0.124)	(0.0712)	(0.0712)	(0.588)	(0.550)	(0.0695)	(0.0695)
$RTA_{ij,t}$	0.193***	0.185***	0.635***	0.645***	0.379***	0.375***	-0.655***	-0.744***	0.456***	0.458***
	(0.0335)	(0.0336)	(0.0829)	(0.0822)	(0.0454)	(0.0456)	(0.223)	(0.228)	(0.0701)	(0.0702)
$ACRI_{ij,t}^{SPS}$	0.0496		-24.06***		0.306		-4.257***		-1.950***	
	(0.132)		(6.170)		(0.296)		(0.755)		(0.515)	
$ACRI_{ij,t}^{TBT}$		-0.229*		-17.55***		-0.385		-27.44**		-4.901***
		(0.125)		(3.122)		(0.266)		(13.81)		(0.770)
Constant	11.64***	11.67***	10.50***	10.56***	9.605***	9.609***	9.792***	10.53***	9.201***	9.194***
	(0.140)	(0.141)	(0.257)	(0.256)	(0.169)	(0.171)	(1.216)	(1.212)	(0.199)	(0.199)
Observations	182,230	178,920	25,964	25,960	67,073	67,021	2,241	2,236	43,846	43,804
R2	0.896	0.897	0.845	0.846	0.832	0.832	0.810	0.809	0.817	0.817
log-likelihood	-239699	-236328	-50404	-50152	-84140	-84027	-1877	-1887	-117589	-117430

Table 3. Estimation Results of Agri-Food Trade in the Asia-Pacific Region (Cont.). Source: the Author.

	11		22		29		41		42	
	SPS	TBT	SPS	TBT	SPS	TBT	SPS	TBT	SPS	TBT
$\ln DIST_{ij}$	-0.920***	-0.909***	-0.662***	-0.697***	-1.028***	-1.041***	-0.0271	-0.0297	-0.859***	-0.860***
	(0.0243)	(0.0230)	(0.0775)	(0.0805)	(0.0921)	(0.0897)	(0.0626)	(0.0622)	(0.0584)	(0.0585)
COG_{ij}	1.068***	1.071***	-0.194	-0.182	0.218	0.211	0.792***	0.764***	-0.0652	-0.0694
	(0.0524)	(0.0524)	(0.150)	(0.152)	(0.165)	(0.169)	(0.143)	(0.143)	(0.149)	(0.149)
LNG_{ij}	0.691***	0.715***	-0.230*	-0.275**	0.628***	0.621***	-0.428***	-0.410***	-0.271**	-0.271**
	(0.0691)	(0.0681)	(0.133)	(0.138)	(0.116)	(0.116)	(0.118)	(0.117)	(0.110)	(0.110)
COL_{ij}	0.613***	0.617***	0.401	0.399	-0.504	-0.595*	0.171	0.147	2.028***	2.028***
	(0.0862)	(0.0859)	(0.261)	(0.259)	(0.362)	(0.317)	(0.242)	(0.243)	(0.157)	(0.157)
$RTA_{ij,t}$	0.115*	0.134**	-0.407**	-0.618***	-0.0840	-0.0783	0.573***	0.579***	0.996***	0.993***
	(0.0675)	(0.0679)	(0.161)	(0.186)	(0.155)	(0.155)	(0.105)	(0.105)	(0.160)	(0.159)
$ACRI_{ij,t}^{SPS}$	-1.304**		-0.731**		1.189		-2.235*		5.360***	
	(0.509)		(0.320)		(1.191)		(1.241)		(1.600)	
$ACRI_{ij,t}^{TBT}$		-1.389		-2.404**		0.0919		-1.501***		9.857***
		(0.869)		(1.005)		(1.345)		(0.550)		(2.531)
Constant	10.79***	10.69***	13.43***	13.82***	11.51***	11.65***	2.096***	2.133***	12.27***	12.28***
	(0.214)	(0.201)	(0.711)	(0.741)	(0.779)	(0.755)	(0.588)	(0.584)	(0.544)	(0.544)
Observations	33,799	33,799	11,959	11,694	558	558	2,362	2,330	17,781	17,781
R2	0.874	0.874	0.975	0.975	0.912	0.912	0.669	0.671	0.944	0.944
log-likelihood	-76787	-76832	-27798	-26904	-644	-644.6	-3961	-3907	-45007	-45002

	43		51		59	
	SPS	TBT	SPS	TBT	SPS	TBT
$\ln DIST_{ij}$	-1.430***	-1.431***	-0.193	-0.193	0.180	0.188
	(0.114)	(0.114)	(0.158)	(0.158)	(0.269)	(0.271)
COG_{ij}	-0.761***	-0.761***	2.741***	2.741***	4.919***	4.977***
	(0.282)	(0.283)	(0.589)	(0.589)	(0.800)	(0.814)
LNG_{ij}	0.215	0.215	0.438	0.438	2.368***	2.366***
	(0.136)	(0.136)	(0.754)	(0.754)	(0.327)	(0.330)
COL_{ij}	0.690***	0.696***	-0.0974	-0.0974	-0.118	-0.143
	(0.263)	(0.259)	(1.244)	(1.244)	(0.541)	(0.552)
$RTA_{ij,t}$	0.637***	0.643***	1.420***	1.420***	2.255***	2.245***
	(0.186)	(0.184)	(0.418)	(0.418)	(0.378)	(0.387)
$ACRI_{ij,t}^{SPS}$	-2.388		-10.09		-7.743***	
	(5.587)		(29.56)		(1.900)	
$ACRI_{ij,t}^{TBT}$		0.456		-29.25		346.8***
		(3.459)		(85.66)		(67.23)
Constant	15.82***	15.82***	-0.987	-0.987	-0.351	-0.414
	(1.035)	(1.036)	(1.699)	(1.699)	(2.639)	(2.670)
Observations	2,563	2,561	271	271	728	689
R2	0.895	0.895	0.434	0.434	0.905	0.906
log-likelihood	-4848	-4847	-63.29	-63.29	-713.7	-693.9

Note 1: Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Note 2: The figures in the first row show the two-digit SITC code. Their names are as follows: 00. Live animals; 01. Meat and meat preparations; 02. Dairy products and birds' eggs; 03. Fish, crustaceans, mollusks, and aquatic invertebrates and preparations thereof; 04. Cereals and cereal preparations; 05. Vegetables and fruits; 06. Sugars, sugar preparations and honey; 07. Coffee, tea, cocoa, spices, and manufactures thereof; 08. Feeding stuff for animals; 09. Miscellaneous edible products and preparations; 11. Beverages; 22. Oilseeds and oleaginous fruits; 29. Crude animal and vegetable material; 41. Animal oils and fats; 42. Fixed vegetable fats and oils, crude, refined or

fractionated; 43. Animal or vegetable fats and oils, processed; waxes of animal or vegetable origin; inedible mixtures or preparations of animal or vegetable fats or oils; 51. Organic chemicals; and 59. Chemical materials and products.

Note 3: The data for each dependent variable are the bilateral exports of edible products in each SITC.

Note 4: All estimations involve dummy variables for the fixed effects of exporting and importing countries and years.

Table 4 lists the results of the ACRIs of SPS and TBT estimated by processing stages and demand destinations. Four in seven items divided into primary and processed agri-foods have the same results as the aggregated agri-foods. By contrast, the following three items have different results: (1) at SITC 02, the significant negative of the ACRI is SPS at the aggregated agri-foods and the processed goods, but TBT for the primary goods is significantly positive; (2) at SITC 05, the agri-foods' result that the ACRI of TBT is significantly negative is only the same with the primary goods and not the processed ones; (3) at SITC 22, primary and processed goods show the same sign and significance results. However, compared to the impacts on trade, the estimate of TBT is higher than that of SPS for primary goods, while the opposite is true for processed goods.

The results for the 10 items that are either supplied to industries or households are as follows. The results of SITC 02 and 09 are the same as the aggregated agri-food results, regardless of the two demand destinations. At SITC 02, the ACRI of SPS is significantly negative for supply to industries and households. This means that the bilateral divergence of SPS can negatively influence the dairy trade in industries and households. At SITC 09, the significant estimate of the ACRI for SPS is greater than that for TBT. This indicates that the bilateral divergence of TBT has a bigger impact than its SPS on processed foodstuff trade, regardless of the demand destinations.

In contrast, six items, SITC 01, 03, 05, 06, 11, and 42, have different results for the two demand destinations. At "03. Fish, crustaceans, mollusks and aquatic invertebrates and preparations thereof," the ACRIs of SPS and TBT for supplying industries are significantly negative, whereas all ACRIs are insignificant in the above estimations: aggregated agri-foods and two processing stages. At SITC 05, the ACRI of SPS is significantly negative for intermediate trade, and the ACRI of TBT is significantly negative for final goods trade. At SITC 11, the ACRI results for the final demand trade are the same as those for the aggregated goods; the ACRI variables are significantly negative, but the results for the supply to industries are significantly positive. Similar results were obtained for SITC 42.

Table 4. Estimation Results of $ACRI_{ij,t}^{SPS}$ and $ACRI_{ij,t}^{TBT}$. Source: the Author.

		Processing stages				Demand destinations			
		Primary		Processed		Industries		Households	
		SPS	TBT	SPS	TBT	SPS	TBT	SPS	TBT
01	Meat and meat preparations	-	-	-	-	2.144**	1.431**	0.235	-0.215
						(0.886)	(0.706)	(0.507)	(0.244)
02	Dairy products and bird eggs	-0.176	1.694**	-2.502***	-0.374	-2.779***	-0.0702	-1.623***	-0.345
		(0.800)	(0.834)	(0.411)	(0.286)	(0.579)	(0.424)	(0.406)	(0.300)
03	Fish etc. and preparations thereof	0.161	-0.155	-0.136	0.112	-19.92***	-15.83***	-0.117	0.0878
		(0.326)	(0.362)	(0.219)	(0.189)	(6.973)	(3.081)	(0.202)	(0.174)
04	Cereals and cereal preparations	0.235	-0.00486	-0.0465	-0.841	0.435	0.0766	-0.130	-0.810
		(0.452)	(0.268)	(0.842)	(0.834)	(0.396)	(0.254)	(0.907)	(0.835)
05	Vegetables and fruits	-0.0417	-0.327**	0.374	0.986	-1.046**	-0.449	0.0619	-0.225*
		(0.155)	(0.136)	(0.531)	(1.219)	(0.528)	(0.546)	(0.133)	(0.126)
06	Sugars, sugar preparations and honey	-44.61***	-18.12***	-3.644	-2.757***	2.568	-5.766**	-26.81***	-17.94***
		(10.88)	(2.367)	(2.311)	(0.998)	(4.467)	(2.638)	(6.978)	(3.063)
07	Coffee, tea, cocoa, and manufactures thereof	0.0425	-0.193	0.429	-0.781	0.170	-0.607	0.350	-0.215
		(0.294)	(0.285)	(0.391)	(0.765)	(0.517)	(0.431)	(0.324)	(0.336)
09	Miscellaneous edible products	-	-	-	-	-1.806**	-4.419***	-2.257***	-5.195***
						(0.727)	(1.435)	(0.587)	(0.865)
11	Beverages	-	-	-	-	15.66***	22.32***	-1.311**	-1.388
						(4.803)	(6.199)	(0.511)	(0.870)
22	Oilseeds and oleaginous fruits	-0.809**	-2.647**	-65.25***	-36.74*	-	-	-	-
		(0.354)	(1.150)	(18.00)	(19.74)				
42	Fixed vegetable fats and oils	-	-	-	-	11.75***	20.12***	-5.039***	-9.977***
						(1.560)	(2.552)	(1.925)	(3.354)

Note 1: Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Note 2: The data for each dependent variable are the bilateral exports of edible products in each SITC.
Note 3: All estimations involve dummy variables for the fixed effects of exporting and importing countries and years.

In addition, the ACRIs of SPS and TBT are insignificant in all estimations of "04. Cereals and cereal preparations" and "07. Coffee, tea, cocoa, spices, and manufactures thereof."

5. CONCLUSION

This study empirically examined the impact of SPS and TBT on the agri-food trade in the Asia-Pacific region. It focused on the bilateral divergence of SPS and TBT, which causes additional fixed costs. In addition, this study examined the differences between these impacts on two processing stages and two destinations in the supply chain.

As a result of the estimation of 18 items in the SITC, the agri-food trade that is simply processed or made of fewer materials, namely dairy and eggs (SITC02) and sugars (SITC06), reflected negative impacts from the divergence of bilateral SPS. In contrast, the agri-food trade that is complexly processed or made of more materials, namely processed foodstuffs (SITC09), had a more negative influence from the divergence of bilateral TBT due to numerous and mixed standards. These results are consistent with the main purports of both NTMs. In contrast, the results for vegetables and fruits (SITC 05) and oilseeds, and oleaginous fruits (SITC 22), which showed significant or larger negative impacts from the bilateral divergence of TBT than SPS, conflicted with the above explanation. The result of SITC 05 was consistent with a description that reporting TBT to the WTO against fruit exports from China increased in Kou and Kusakari (2019). Hence, these results seem to show that the bilateral divergence of TBT might work as NTBs in intra-regional trade regardless of the primary or lower degree of agri-food processing. On the other hand, results for some commodities, such as fixed vegetable fats and oils (SITC 42) and chemical materials (SITC 59), showed that higher transparency encourages trade despite increased rules and expanded divergence.

Moreover, the estimations were conducted by subdividing them into processing stages and demand destinations. This study supposed that SPS might affect the trade of primary agri-food more than processed agri-food as it makes a judgement decision on pests and disease-carrying or causing organisms; TBT might have the opposite effect as it requires the declaration of production processes and the assessment of producers. However, the effects of SPS and TBT on trade showed varying results for commodities. For instance, at SITC 09, the impacts from these NTMs were the same for the aggregation and the above-divided estimation. In contrast, at SITC 02, the divergence SPS negatively affected the processed agri-food trade and both trades to demand destinations, while that of TBT positively influenced primary goods. At SITC 05, the ACRI of SPS was significantly negative for intermediate trade, and the ACRI of TBT was significantly negative for final goods trade. In addition, in fish (SITC 03), the ACRIs of SPS and TBT for supply to industries were significantly negative, whereas all ACRIs were insignificant in other estimations: the aggregated agri-foods and two processing stages. The fragmentation of agri-food production has progressed under trade liberalization. The varying impacts of product types in the same SITC-based commodity demonstrate the importance of considering the potential unexpected effects of SPS and TBT through complex international agri-food supply chains.

Finally, certain limitations remain. This study mainly focused on harmonization in trade facilitation using the indicator denoting the bilateral regulatory divergence of SPS and TBT. To analyze the effect of NTMs on trade, it is also necessary to clearly focus on transparency. Moreover, although this study targeted the Asia-Pacific region, it is necessary to analyze global trade among high-income countries, middle-income countries, and low-income countries. Moreover, it would be necessary to analyze broader categories, such as a whole primary agri-food trade and a whole trade to household demands, rather than SITC categories. This could facilitate the comparison with previous papers and help recognize the role of analysis using an additional requirement incurred from the bilateral divergence of NTMs. Finally, this study focused on the effects of agri-food trade on official NTMs controlled by nations. The private sector has a considerable influence on trading among producers and wholesalers, such as the Global Food Safety Initiatives that select food safety certifications; hence, it is necessary to analyze the influence of rules controlled by the private sector.

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