Impact of Non-Tariff Measures on Agri-Food Trade: Quantitative and Qualitative Regulatory Differences

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Abstract

This study empirically examines the effects of the sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT) on the agri-food trade by simultaneously focusing on both the quantitative and qualitative aspects. Transparency was captured as a quantitative aspect of non-tariff measures, whereas harmonization was illustrated qualitatively. The estimation results demonstrated that quantitative SPS and TBT measurement variables were significantly positive for many primary product trades, such as exports from upper-middle- and low-income countries to high-income countries. The same effects were observed for processed product exports from lower-middle- and low-income countries to high-income countries. However, the quantitative SPS measurement negatively affected processed product exports from high- and upper-middle-income to high-income countries. This means the SPS measures can function as a non-tariff barrier for such trades. Furthermore, qualitative SPS measurement was significantly negative for processed product exports from lower-income, and primary and processed product exports from low-income to high-income countries. Likewise, the qualitative TBT variable was also significantly negative for processed product exports from high-income countries, and primary product exports from lower-middle-income to high-income countries. Hence, the harmonization of SPS measures and TBT, which decreases bilateral regulatory differences, is also required to encourage these trades.

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1. Introduction

There has been a change in the barriers to trade from tariff to non-tariff measures (NTMs). Several studies have noted non-tariff measures including sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT).

Concerns regarding NTMs have gradually increased in international trade negotiations and studies, and numerous free-trade agreements have contributed to the abolition and reduction of agri-food tariffs over the past two decades (Beghin & Schweizer, 2021; Gaigné & Gouel, 2022). For instance, the Trade Facilitation Agreement (TFA) of the World Trade Organization (WTO), which came into effect in 2017, represents one instance of these shifting gears in trade negotiations. The agreement targeted comprehensive rules to enhance the transparency of trade regulations and expedite customs proceedings.

The SPS measures and TBT are critical official border rules to protect public health and domestic agriculture against diseases and pests, and conserve the domestic ecosystem. These factors have contradictory effects on international trade. First, they might decrease trade as a non-tariff barrier if imports are excessively burdened compared to domestic products. Regulatory barriers to the agri-food trade have been examined in many studies (e.g., Disdier & Tongeren, 2010; Li & Beghin, 2014).

Conversely, improvements in transparency and harmonization might improve trade by diminishing trade costs. Several empirical studies support these contradictory effects of NTMs on the agri-food trade. For instance, Medin (2019) found that SPS measures in foreign countries negatively influence seafood exports, and positively impacts fresh seafood trade. Li and Beghin (2012) also showed that technical measures have heterogeneous impacts on agri-food trade through a meta-analysis.

Information on trade measures affects whether NTMs function as non-tariff barriers (Thilmany & Barrett, 1997). International declaration of rules and standards helps reduce exporters' search costs and allows border rules to hamper non-tariff barriers. The issue of transparency has been addressed in TFA and numerous regional trade agreements (RTAs). Cadot and Gourdon (2016) found that higher transparency through RTAs reduced the costs incurred by NTMs. Lejárraga et al. (2013) indicated a positive effect on agricultural trade. Moreover, internationally harmonizing rules and standards also have significant effects on trade. De Frahan and Vancauteren (2006) demonstrated that harmonizing food standards in the European Union (EU) encourages intra-regional agri-food trade. Many studies have examined the effects of harmonizing food safety standards in the EU (e.g., Karemera et al., 2020; Otsuki et al., 2001a, 2001b).

Transparency and harmonization of trade regulations are necessary to encourage the agri-food trade; they are often used together but require different approaches to achieve them. Transparency can be achieved by an increase in each country's declaration of border regulations in the international community. However, harmonization requires a decrease in bilateral regulation differences. The former must be captured as a quantitative aspect of NTMs, whereas the latter should be illustrated qualitatively. No standard method exists to characterize variables for NTMs in a quantitative analysis. For example, counting regulations is a reasonable method to quantitatively capture the burden of regulations. Jayasinghe et al. (2010) employed this measurement to study the U.S. corn seed trade. Moreover, the ad valoren equivalent is also an important measurement to illustrate the NTMs and helps to understand the extent of NTMs burden (e.g., Cadot & Gourdon, 2016; Lejárraga et al., 2013). However, this measure does not consider the consistency of regulations between countries. If the regulations imposed in an importing country are the same as those already complied with in the home country, they are no longer a burden for exporters. Therefore, bilateral regulations should be compared to illustrate harmonization, and constitute a qualitative aspect of the NTMs. Several previous studies have employed the (dis)similarity degree of bilateral regulations to analyze the effects of standards of genetically modified organisms(GMOs) and the maximum residual limits (MRLs) of pesticides (e.g., Drogué & DeMaria, 2012; Liu & Yue, 2013; Vigani et al., 2012; Winchester et al., 2012).

This study empirically examines the impact of bilateral quantitative and qualitative regulatory differences in NTMs, particularly SPS measures and TBT, on agri-food trade. To examine the effects of NTMs on the agri-food trade, we need to focus on quantitative and qualitative aspects, while previous studies have focused only on one. Hence, this study examines the effects of the SPS and TBT on the agri-food trade by simultaneously focusing on both the quantitative and qualitative aspects.

Furthermore, the effects of NTMs on trade are assumed to differ depending on the income levels of exporting countries, as high-income countries have an advantage in developing and negotiating trade regulations at high costs. Several empirical studies have noted this. Disdier et al. (2008) indicated that SPS and TBT negatively impact agri-food imports from developing countries to Organisation for Economic Co-operation and Development (OECD) members, despite having no significant effect on bilateral trade between OECD members. Li and Beghin (2012) showed that SPS reduces agri-food trade from developing to developed countries.

Therefore, the study also examined the differences in the impacts of SPS and TBT in four income-level groups: high-, upper middle-, lower middle-, and low-income countries.

Finally, the impacts of SPS and TBT on the agri-food trade are assumed to differ depending on the features of the goods. The SPS may have a more significant impact on primary products, as it requires declarations of the features of goods to protect publish health, domestic agriculture, and ecosystems. Whereas, TBT may have a more significant impact on processed products and it primarily requires a declaration of production processes to assure food safety and hygiene management. Cadot and Gourdon (2016) found that the average ad valorem equivalents (AVEs) of SPS in animals and vegetables were higher than those of TBT, and they in fats and oils, which are processed products, were opposite. Medin (2019) also showed that SPS affects the fresh and processed seafood trade. Therefore, the estimations in this study were divided into two product types: primary and processed agricultural food products.

The remainder of this paper is organized as follows. Section 2 provides a brief overview of the quantitative and qualitative regulatory difference measurements. Section 3 presents the gravity equations, methodology, and data used in the estimation. Section 4 presents the estimation results of the Poisson pseudo-maximum likelihood (PPML) method for the impact of regulatory differences in SPS and TBT on the agri-food trade. Finally, Section 5 concludes the study and discusses its limitations and potential extensions.

2. Quantitative and Qualitative Characteristics of Sanitary and Phytosanitary Measures and Technical Barriers to Trade

The traditional measure of counting the number of regulations was employed to characterize the quantitative aspects of SPS and TBT. To examine the qualitative aspects of NTMs, a (dis)similarity degree based on Jaffe (1986) was employed for regulations of GMOs in Vigani et al. (2012) and for standards of MRLs in Liu and Yue (2013). Obashi (2020) and Nabeshima and Obashi (2021) also suggested the additional compliance requirement indicator (ACRI) for technical measures in the Trade Analysis Information System (TRAINS) at thein United Nations Conference on Trade and Development (UNCTAD) incorporated a cosine similarity degree using Jaffe (1986). The index is measured using the divergence between domestic compliance laws in exporting countries and border regulations in importing countries. In other words, the ACRI shows the degree to which additional requirements lead to additional fixed costs for exporters, and reflects the concept of additional fixed costs in Melitz (2003). This study used the calculated ACRI for SPS measures and TBT, respectively.[3]

Table 1 shows the quantitative and qualitative measurements of SPS measures and TBT.[4] For edible agri-foods, the average quantitative SPS measurement is larger than the TBT; conversely, the average qualitative SPS measurement is smaller than the TBT. On average, SPS regulations are more stringent than TBT regulations. Nonetheless, regarding adherence to additional compliance requirements due to bilateral regulatory disparities, TBT has a greater burden than SPS measures.

Table 1: Quantitative and Qualitative Measurements of SPS measures and TBT

	Quantitative measure (numbers of rules)		Qualitative measure (ACRI)	
	Mean	S.D.	Mean	S.D.
SPS	58.90	54.99	0.08	0.12
TBT	13.91	14.13	0.22	0.28

Source: Author's calculation.

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

[4] The quantitative measurement refers to the total number of import regulations for imports into a country from all countries and each bilateral trade in the TRAINS. The qualitative measurement is the calculated ACRI. The number of observations on trade reported status of regulations in the estimation database in this study is as follows: reported both exporting and importing countries and areas reported them is 26,664, reported either reported them is 449,133, and none reported them is 20,062. The statistics in this section are calculated using observations that both countries and areas reported regulations (26,644).

Table 2 compares the quantitative and qualitative measurements of primary and processed products. The features of SPS measures and TBT in the two product types were identical to those of edible agri-foods, as shown in Table 1. The comparison between primary and processed agri-food products shows that the quantitative measurements of SPS measures and TBT for primary products are higher than those for processed products; however, there is no apparent difference in qualitative measurements.

Table 2: Quantitative and Qualitative Measurements by Product Types

		Quantitative measure (numbers of rules)		Qualitative measure (ACRI)	
		Mean	S.D.	Mean	S.D.
SPS	Primary	54.67	49.48	0.09	0.14
	Processed	61.78	58.28	0.08	0.10
TBT	Primary	11.42	11.81	0.22	0.31
	Processed	15.61	15.29	0.23	0.26

Source: Author's calculation.

Fig. 1 shows the quantitative and qualitative measurements of the SPS measures and TBT against imports in countries categorized by their income levels. The magnitude of the relationship of SPS measures and TBT in each category provides the same features as the overall measurements described above in that the quantitative SPS measurement is higher than that of TBT, whereas the qualitative measurement is the opposite. However, a comparison among income levels reveals the following tendencies: First, the qualitative TBT measurements in high-income countries had the highest mean and variability. As income level decreases, the mean and range also decrease. Qualitative SPS measurements have the same relationship with income levels. In contrast, the SPS measures in the quantitative measurement had similar statistical features among the high-, upper-middle-, and lower-middle-income groups.

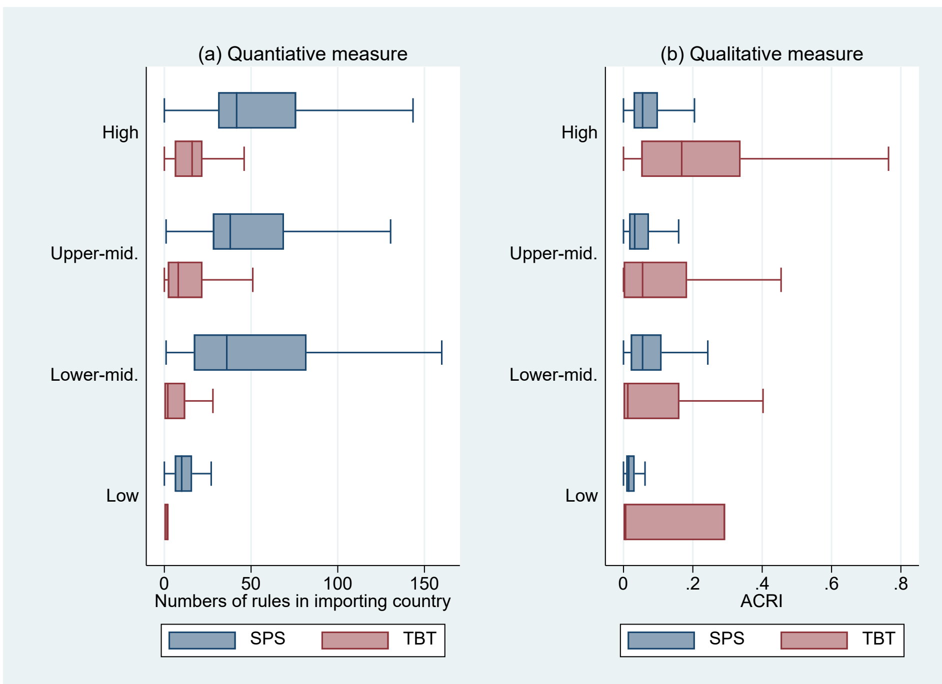

Fig. 1: Quantitative and Qualitative Measurements based on Income-Classified Countries

Note: The ACRI has a range between 0 and 1.
Source: Author's calculation.

Fig. 2 shows the quantitative and qualitative measurements of imports to high-income countries from countries classified by their income levels. The range of quantitative SPS measurements expands in the order of high-, upper-middle-, and lower-middle-income groups. Additionally, exports from low-income countries are subject to stringent SPS regulations. Moreover, as income levels decrease, the mean and range of the qualitative SPS measurements increase gradually.

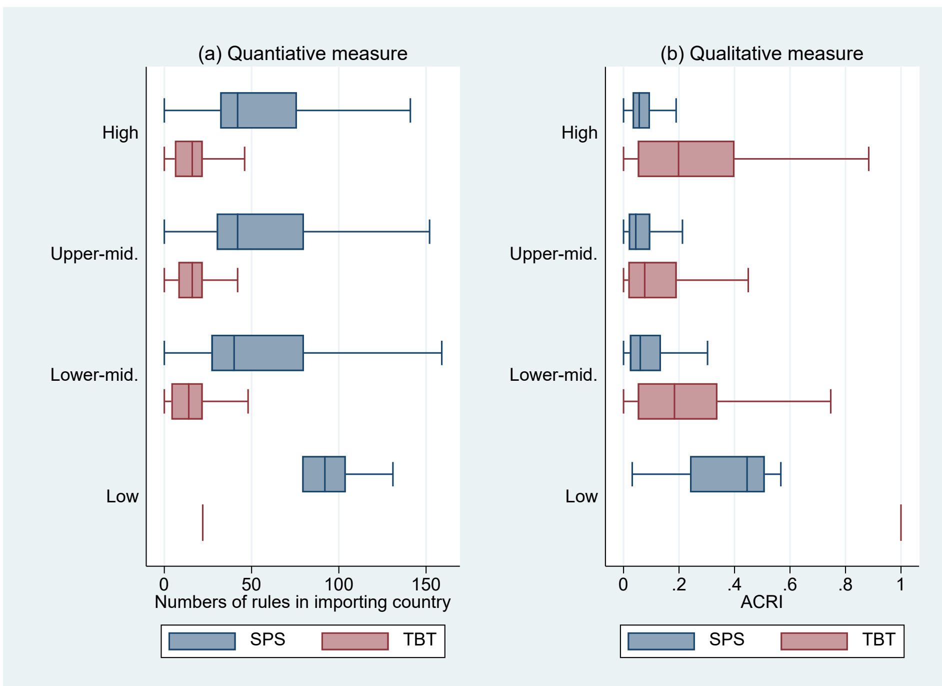

Fig. 2: Quantitative and Qualitative Measurements for Imports from Income Classified Countries to High-income Countries

Note: The ACRI has a range between 0 and 1.
Source: Author's calculation.

Finally, Fig. 3 demonstrates the measurements in Table 2 by categorizing them into primary and processed agri-food products. The means of low-income countries are much higher than those of the other groups for both primary and processed products. Moreover, in the qualitative TBT measurements for primary products, the range for lower-middle income countries was the highest. For processed products, the mean and range of imports from high-income countries were higher than those of the other two income groups, with the exception of imports from low-income countries.

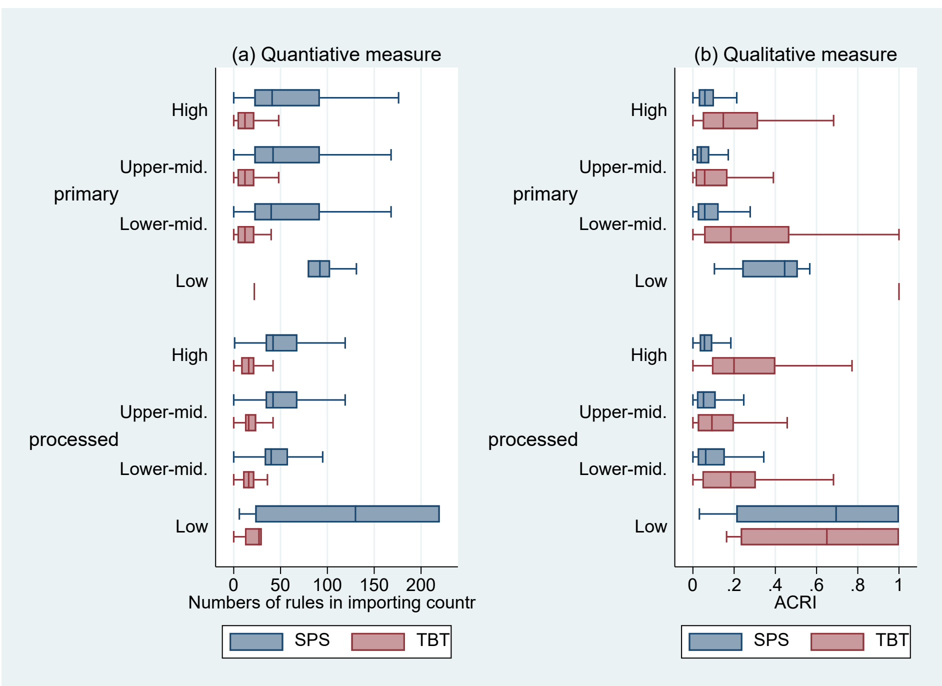

Fig. 3: Quantitative and Qualitative Measurements for Imports from Income-Classified Countries to High-income Countries by Product Types

Note: The ACRI has a range between 0 and 1.
Source: Author’s calculation.

3. Method and Data

Previous studies have indicated several issues regarding the estimate of a traditional gravity equation to explain bilateral trade. Anderson and van Wincoop (2003) pointed out the issue of multilateral resistance terms, which means that the price indices of a trade partner are reduced in nearby countries with lower wages. Redding and Venables (2004) suggested using fixed effects for the exporter country i and importing country j to address this issue. Another issue is the logarithmic transformation of the 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 inequality. Thereby, Santos Silva and Tenreyro (2006) proposed a single logarithmic transformation of only the independent variables on the right-hand side of the gravity equation using the PPML method. Hence, this study estimates the following gravity equation with dummies for exporters and importers, using PPML:

$$EX_{ij,h} = \alpha + \beta_1 \ln DIST_{ij} + \beta_2 COG_{ij} + \beta_3 LNG_{ij} + \beta_4 RTA_{ij} + \beta_5 NR_{ij,h}^{NT} + \beta_6 ACRI_{ij,h}^{NT} + \gamma_i + \lambda_j + \tau_h + \varepsilon_{ij} \quad (1)$$

where $EX_{ij,h}$ is the agri-food export of commodity h from country i to j. The trade costs in the gravity equation in this study includes bilateral distance ($DIST_{ij}$), contiguity (COG_{ij}), common language (LNG_{ij}), and regional trade agreements (RTA_{ij}). $NR_{ij,h}^{NT}(NT = SPS, TBT)$ denotes the quantitative aspects and is measured by the number of SPS or TBT regulations for imported commodity h from all countries and country i to country j.[5] $ARCI_{ij,h}^{NT}$ are the measured ACRIs of SPS measures or TBT for imported commodity h, indicating bilateral qualitative regulatory differences. α and $\beta_m(m = 1, \dots, 6)$ are unknown parameters. Three dummy variables (γ_i, λ_j, and τ_h) are used as fixed effects for exporters, importers, and commodities, respectively. ε_{ij} is an error term.

Table 3 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. If both countries share a border, transportation costs are unnecessary; hence, the sign of contiguity (COG_{ij}) is expected to be positive. The common language helps to understand the partner's institutions and border procedures owing to accessible communication, and leads to reduced transaction costs; hence, the expected sign of the common language (LNG_{ij}) is positive. RTA_{ij}

[5] The high correlation relationships show the number of regulations and the ACRI between SPS measures and TBT, which are from 0.6 to 0.7. Therefore, these variables are separately estimated in equation (1) to avoid multicollinearity.

denotes the free-trade policy in force between countries i and j; and its expected sign is positive.

The variables for the quantitative measurements of SPS measures and TBT (NR_{ij}^{NT}) have the expected signs for the estimates. Increasing regulations may increase the compliance time and costs; in this case, the sign is negative. However, an increase in rules might lead to decreased costs in searching for hidden foreign domestic regulations. In this case, the sign is expected to be positive, as the enhancement of SPS or TBT transparency encourages trade. Another variable that described SPS measures and TBT qualitatively, the additional compliance requirements ($ACRI_{ij}^{NT}$), have the expected negative signs. A higher divergence of bilateral regulations increases the additional cost to comply with domestic sales, and this negatively influences the agri-food trade. In other words, the significant and negative sign of the qualitative measurement shows that their NTMs might function as non-tariff barriers, and there is space for harmonization.

Table 3: Independent Variables and their Expected Signs

	Data	Expected sign
$\ln DIST_{ij}$	Distance between countries i and j (logarithmic value)	$-$
COG_{ij}	Dummy of contiguity between countries i and j	$+$
LNG_{ij}	Dummy of common language between countries i and j	$+$
RTA_{ij}	Dummy of RTA between countries i and j	$+$
$NR_{ij,h}^{NT}$	Number of rules of SPS measures or TBT against imported commodity h from country i to country j	$\pm$
$ACRI_{ij,h}^{NT}$	ACRI of SPS measures or TBT against imported commodity h from country i to country j	$-$

The database included 809 edible commodities with the HS six-digit code, 98 exporting countries, and 117 importing countries and areas in 2019.[6] The bilateral trade values were sourced from the UNCTAD Comtrade; bilateral distance and the status of common language from the databases in the Centre d'Études Prospectives et d'Informations Internationales (Mayer & Zignago, 2011); and information on free trade policy in force from the World Trade Organization Regional Trade Agreements Database. The data used to measure the ACRI were obtained from the UNCTAD TRAINS.

Table 4: Descriptive statistics (edible agri-food trade)

	Observation	Mean	S.D.	Min	Max
$\ln DIST_{ij}$	495,859	7.88	1.19	4.09	9.89
COG_{ij}	495,859	0.13	0.34	0	1
LNG_{ij}	495,859	0.16	0.37	0	1
RTA_{ij}	495,859	0.66	0.47	0	1
$NR_{ij,h}^{SPS}$	495,859	0.01	0.06	0	1
$ACRI_{ij,h}^{SPS}$	495,859	20.80	19.72	0	362
$NR_{ij,h}^{TBT}$	495,859	0.01	0.09	0	1
$ACRI_{ij,h}^{TBT}$	495,859	3.83	6.10	0	86

[6] The data was selected based on 111, 112, 121, and 122 in BEC as edible agri-foods. They cover 01–04, 07–12, 15–23, and 35 in two-digit code of the Harmonized Commodity Description and Coding System (HS) 2017, and 01–09, 11, 22, 29, 41–43, 51, and 59 in the two-digit code of the Standard International Trade Classification (SITC) Rev.4.The HS was revised at intervals of several years; there are six versions: HS1988/1992, HS1996, HS2002, HS2007, HS2012, and HS2017. The HS version in Comtrade and TRAINS depends on reporting countries. In this study, 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.

Table 4: continued

	$\ln DIST_{ij}$	COG_{ij}	LNG_{ij}	RTA_{ij}	$NR_{ij,h}^{SPS}$	$ACRI_{ij,h}^{SPS}$	$NR_{ij,h}^{TBT}$	$ACRI_{ij,h}^{TBT}$
$\ln DIST_{ij}$	1							
COG_{ij}	-0.5364	1						
LNG_{ij}	-0.0829	0.2391	1					
RTA_{ij}	-0.5358	0.232	0.0632	1				
$NR_{ij,h}^{SPS}$	0.0577	-0.0213	0.013	-0.0672	1			
$ACRI_{ij,h}^{SPS}$	0.097	0.0124	0.0042	-0.0236	0.2763	1		
$NR_{ij,h}^{TBT}$	0.0387	0.0035	0.0375	-0.0453	0.6268	0.2916	1	
$ACRI_{ij,h}^{TBT}$	0.2313	-0.0176	0.053	-0.0906	0.2291	0.6105	0.2933	1

4. Estimation results

Table 5 shows the estimated results of the quantitative and qualitative impacts of SPS measures and TBT on edible agri-food exports around the world: Columns (1) to (3) are the estimation results for equation (1) describing the impacts of SPS measures, and Columns (4) to (6) are the results for equation (1) denoting the impacts of TBT. The impacts on the overall agri-food trade are described in Columns (1) and (4), while the effects on primary product trade in Columns (2) and (5), and those on processed product trade in Columns (3) and (6).

The traditional variables in the gravity equation, bilateral distance, contiguity, common language, and RTA are all significant with the expected signs, except for the results of the primary product trade, which are only significant for distance and contiguity. The effects of SPS measures and TBT differ according to the type of product and NTMs. Regarding the impact of the SPS measures on primary product trade in Column (2), the number of SPS regulations ($NR_{ij,h}^{SPS}$) is significantly positive. The quantitative TBT variables ($NR_{ij,h}^{TBT}$) are also significantly positive for all kinds of agri-food trade in Columns (4), (5), and (6). This means that the transparency of SPS measures encourages primary product trade, and that of TBT leads to an increase in all types of edible agri-food trade worldwide. However, the variables of qualitative regulatory differences between SPS measures and TBT are insignificant.

Table 5: Estimation Results of Edible Agri-food Trade around the World

	SPS			TBT		
	(1) All	(2) Primary	(3) Processed	(4) All	(5) Primary	(6) Processed
$\ln DIST_{ij}$	-0.397***	-0.536***	-0.423***	-0.401***	-0.530***	-0.424***
	(0.0268)	(0.0609)	(0.0284)	(0.0270)	(0.0592)	(0.0285)
COG_{ij}	0.577***	0.382***	0.644***	0.572***	0.387***	0.644***
	(0.0493)	(0.113)	(0.0498)	(0.0496)	(0.109)	(0.0495)
LNG_{ij}	0.163***	0.0819	0.214***	0.160***	0.0766	0.210***
	(0.0622)	(0.142)	(0.0620)	(0.0619)	(0.140)	(0.0613)
RTA_{ij}	0.329***	0.123	0.392***	0.345***	0.119	0.423***
	(0.0552)	(0.0886)	(0.0652)	(0.0553)	(0.0886)	(0.0646)
$NR_{ij,h}^{SPS}$	-2.68e-05	0.00407**	-0.00134			
	(0.000737)	(0.00174)	(0.000843)			
$ACRI_{ij,h}^{SPS}$	-0.259	0.217	-0.599			
	(0.290)	(0.349)	(0.579)			
$NR_{ij,h}^{TBT}$				0.0263***	0.0296***	0.0263***
				(0.00392)	(0.00642)	(0.00459)
$ACRI_{ij,h}^{TBT}$				-0.234	-0.316	-0.284
				(0.174)	(0.240)	(0.227)
Constant	5.070***	6.723***	5.143***	4.900***	6.624***	4.880***
	(0.245)	(0.551)	(0.256)	(0.249)	(0.545)	(0.255)
Observations	495,857	165,308	330,541	495,857	165,308	330,541
log-likelihood	-2.207e+06	-688395	-1.422e+06	-2.192e+06	-686354	-1.411e+06

Note1: Robust standard errors are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Note2: The estimation involves dummy variables for fixed effects of exporting countries and areas, importing countries and areas, and commodities (HS six-digit code).

However, estimations of the bilateral agri-food trade between certain income-level groups provide varying results. Table 6 shows the estimated impact on exports to high-income countries for all countries. In particular, the results for the processed product trade in Columns (3) and (5) are interesting. The number of SPS regulations ($NR_{ij,h}^{SPS}$) were significantly negative, whereas the number of TBT regulations ($NR_{ij,h}^{TBT}$) were significantly positive. Moreover, additional requirements for complying with the TBT ($ACRI_{ij,h}^{TBT}$) have a significant negative impact. Increases in SPS and TBT regulations have opposite effects on processed product exports to high-income countries. Particularly, the rise in TBT regulations enhances transparency and encourages trade, whereas SPS measures do not, and it can function as a non-tariff barrier. Moreover, the increase in the bilateral regulatory heterogeneity of the TBT leads to an increase in additional costs to complement them and restrict trade.

Table 6: Estimation Results of Agri-food Trade to High-income from All Countries

	SPS			TBT		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Primary	Processed	All	Primary	Processed
$\ln DIST_{ij}$	-0.438***	-0.475***	-0.481***	-0.442***	-0.475***	-0.479***
	(0.0241)	(0.0432)	(0.0282)	(0.0243)	(0.0427)	(0.0284)
COG_{ij}	0.769***	0.912***	0.725***	0.770***	0.908***	0.733***
	(0.0477)	(0.0931)	(0.0544)	(0.0475)	(0.0929)	(0.0540)
LNG_{ij}	0.209***	-0.249***	0.358***	0.194***	-0.250***	0.344***
	(0.0651)	(0.0865)	(0.0779)	(0.0640)	(0.0864)	(0.0766)
RTA_{ij}	0.148**	0.245***	0.139*	0.187***	0.229**	0.195**
	(0.0650)	(0.0918)	(0.0805)	(0.0629)	(0.0911)	(0.0780)
$NR_{ij,h}^{SPS}$	-0.00283***	-1.09e-06	-0.00392***			
	(0.000657)	(0.00125)	(0.000888)			
$ACRI_{ij,h}^{SPS}$	-0.225	0.711**	-0.389			
	(0.389)	(0.300)	(0.829)			
$NR_{ij,h}^{TBT}$				0.0204***	0.0205***	0.0220***
				(0.00414)	(0.00474)	(0.00500)
$ACRI_{ij,h}^{TBT}$				-0.155	-0.226	-0.703**
				(0.175)	(0.214)	(0.313)
Constant	5.329***	5.484***	5.766***	5.110***	5.403***	5.446***
	(0.219)	(0.377)	(0.260)	(0.219)	(0.374)	(0.258)
Observations	345,930	122,640	223,284	345,930	122,640	223,284
log-likelihood	-1.407e+06	-403511	-945638	-1.401e+06	-402589	-942729

Note1: Robust standard errors are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Note2: The estimation involves dummy variables for fixed effects of exporting countries and areas, importing countries and areas, and commodities (HS six-digit code).

Table 7 displays the results of exports to high-income countries based on their income levels. It comprises four panels: (a) trade among high-income countries, (b) exports from upper-middle-income countries, (c) exports from lower-middle-income countries, and (d) exports from low-income countries.

In panel (a), the impacts of SPS measures and TBT on trade among high-income countries are the same as the results for exports from all countries in Table 6. The transparency and harmonization of TBT are important for increasing the processed product trade among high-income countries.

In panel (b), the impacts of the quantitative TBT variable ($NR_{ij,h}^{TBT}$) on all kinds of exports from upper-middle-income countries to high-income countries in Columns (4) to (6) are the same as the above results; however, the increase in SPS regulations ($NR_{ij,h}^{SPS}$) has opposite impacts on the primary and processed product trades in Columns (2) and (3). They have a significant positive impact on the primary product trade and negative effects on the processed product trade.

Table 7: Estimation Results of Agri-food Trade to High-income from Four Income Levels Countries

(a)High-income	SPS			TBT		
	(1) All	(2) Primary	(3) Processed	(4) All	(5) Primary	(6) Processed
$\ln DIST_{ij}$	-0.555***	-0.521***	-0.602***	-0.556***	-0.519***	-0.598***
	(0.0312)	(0.0540)	(0.0347)	(0.0319)	(0.0534)	(0.0355)
COG_{ij}	0.651***	0.758***	0.654***	0.655***	0.758***	0.663***
	(0.0493)	(0.112)	(0.0541)	(0.0489)	(0.112)	(0.0535)
LNG_{ij}	0.294***	-0.00731	0.375***	0.291***	-0.0132	0.373***
	(0.0726)	(0.0985)	(0.0833)	(0.0715)	(0.0985)	(0.0820)
RTA_{ij}	0.148	0.0483	0.243**	0.213**	0.0635	0.318***
	(0.101)	(0.147)	(0.118)	(0.0996)	(0.144)	(0.116)
$NR_{ij,h}^{SPS}$	-0.00325***	-0.000375	-0.00364***			
	(0.000724)	(0.00138)	(0.000969)			
$ACRI_{ij,h}^{SPS}$	0.287	1.239***	-0.323			
	(0.445)	(0.362)	(1.047)			
$NR_{ij,h}^{TBT}$				0.0253***	0.0173***	0.0258***
				(0.00431)	(0.00530)	(0.00495)
$ACRI_{ij,h}^{TBT}$				-0.386	0.100	-0.928***
				(0.246)	(0.275)	(0.265)
Constant	6.109***	5.572***	6.555***	5.820***	5.464***	6.186***
	(0.292)	(0.469)	(0.332)	(0.292)	(0.468)	(0.329)
Observations	257,875	88,206	169,665	257,875	88,206	169,665
log-likelihood	-888856	-232604	-621882	-881958	-232361	-617494

Table 7: continued

(b)Upper-middle-income	SPS			TBT		
	(1) All	(2) Primary	(3) Processed	(4) All	(5) Primary	(6) Processed
$\ln DIST_{ij}$	-0.383***	-0.754***	-0.280***	-0.388***	-0.737***	-0.271***
	(0.0594)	(0.102)	(0.0702)	(0.0596)	(0.0995)	(0.0704)
COG_{ij}	1.245***	1.390***	1.138***	1.198***	1.433***	1.053***
	(0.186)	(0.255)	(0.259)	(0.167)	(0.265)	(0.211)
LNG_{ij}	-0.233	-0.495	0.0153	-0.219	-0.501	0.0647
	(0.191)	(0.311)	(0.262)	(0.185)	(0.312)	(0.236)
RTA_{ij}	0.359***	0.329**	0.249	0.358***	0.301*	0.234
	(0.125)	(0.156)	(0.168)	(0.124)	(0.154)	(0.164)
$NR_{ij,h}^{SPS}$	-0.00154	0.00923***	-0.00671**			
	(0.00228)	(0.00301)	(0.00263)			
$ACRI_{ij,h}^{SPS}$	0.0537	0.379	0.333			
	(0.384)	(0.411)	(0.582)			
$NR_{ij,h}^{TBT}$				0.0254**	0.0282**	0.0302**
				(0.0108)	(0.0124)	(0.0141)
$ACRI_{ij,h}^{TBT}$				-0.196	-0.204	-0.942
				(0.274)	(0.311)	(0.797)
Constant	5.649***	8.570***	4.919***	5.441***	8.595***	4.427***
	(0.545)	(0.941)	(0.640)	(0.552)	(0.921)	(0.650)
Observations	58,823	21,497	37,320	58,823	21,497	37,320
log-likelihood	-256283	-89487	-155562	-254858	-90005	-154686

(c)Lower-middle-income	SPS			TBT		
	(1) All	(2) Primary	(3) Processed	(4) All	(5) Primary	(6) Processed
$\ln DIST_{ij}$	-0.714***	-0.861***	-0.673***	-0.721***	-0.909***	-0.669***
	(0.116)	(0.166)	(0.147)	(0.115)	(0.162)	(0.147)
COG_{ij}	1.351*	0.703	2.768***	1.244*	0.508	2.760***
	(0.716)	(1.032)	(0.779)	(0.741)	(1.076)	(0.775)
LNG_{ij}	0.151	-0.136	0.368	0.156	-0.150	0.359
	(0.223)	(0.257)	(0.287)	(0.217)	(0.252)	(0.286)
RTA_{ij}	0.444**	-0.0369	0.766***	0.476**	-0.0825	0.827***
	(0.219)	(0.271)	(0.261)	(0.216)	(0.254)	(0.253)
$NR_{ij,h}^{SPS}$	0.00790*	0.00940	0.00869**			
	(0.00415)	(0.00921)	(0.00423)			
$ACRI_{ij,h}^{SPS}$	-4.740**	-2.784	-6.722***			
	(1.884)	(1.724)	(2.415)			
$NR_{ij,h}^{TBT}$				0.0226*	0.0398*	0.0154
				(0.0129)	(0.0242)	(0.0141)
$ACRI_{ij,h}^{TBT}$				-0.580	-1.020**	0.0728
				(0.372)	(0.470)	(0.465)
Constant	8.435***	9.783***	8.158***	8.549***	10.27***	8.242***
	(1.029)	(1.516)	(1.305)	(1.023)	(1.435)	(1.301)
Observations	28,432	12,414	16,017	28,432	12,414	16,017
log-likelihood	-89436	-36074	-47864	-89612	-35951	-48008

Table 7: continued

(d)Low-income	SPS			TBT		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Primary	Processed	All	Primary	Processed
$\ln DIST_{ij}$	-1.348**	-1.530**	-5.328***	-0.925*	-0.923	-1.009
	(0.628)	(0.696)	(1.897)	(0.562)	(0.584)	(1.269)
LNG_{ij}	0.380	0.616	-6.908**	0.487	0.706	-0.749
	(0.668)	(0.673)	(2.928)	(0.711)	(0.750)	(1.183)
$NR_{ij,h}^{SPS}$	0.0393***	0.0475***	0.115**			
	(0.0104)	(0.0154)	(0.0541)			
$ACRI_{ij,h}^{SPS}$	-3.705**	-3.235**	-11.85**			
	(1.707)	(1.428)	(5.231)			
$NR_{ij,h}^{TBT}$				0.0808***	0.0845***	0.621**
				(0.0282)	(0.0287)	(0.280)
$ACRI_{ij,h}^{TBT}$				-0.0615	0.453	-0.753
				(0.924)	(1.016)	(0.636)
Constant	12.21**	13.77**	45.09***	8.935*	9.020*	5.321
	(5.413)	(5.916)	(16.11)	(4.924)	(5.101)	(11.57)
Observations	595	437	150	595	437	150
log-likelihood	-247.4	-210.6	-29	-250.4	-213.8	-29.02

Note1: Robust standard errors are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Note2: The estimation involves dummy variables for fixed effects of exporting countries and areas, importing countries and areas, and commodities (HS six-digit code).
Note3: COG_{ij} and RTA_{ij} in panel (d) are ommited in the estimation process.

In panel (c), with respect to exports from lower-middle-income to high-income countries, SPS measures significantly affect the processed product trade, and TBT significantly influences the primary product trade. For both, the quantitative variables ($NR_{ij,h}^{SPS}$ and $NR_{ij,h}^{SPS}$) have positive impacts, whereas the qualitative variables ($ACRI_{ij,h}^{SPS}$ and $ACRI_{ij,h}^{TBT}$) have negative effects. This means that an increase in SPS and TBT regulations leads to enhanced transparency and encourages trade. Simultaneously, rising bilateral regulatory differences lead to an increase in exporters' additional compliance requirements, which might restrict trade. Therefore, harmonization of TBT is important for raising primary product exports from upper-middle-income to high-income countries.

In panel (d), the impacts of SPS measures and TBT on exports from lower- to high-income countries are the same regardless of the agri-food trade type. The two quantitative variables ($NR_{ij,h}^{SPS}$ and $NR_{ij,h}^{TBT}$) have significant positive impacts, whereas the qualitative SPS variable ($ACRI_{ij,h}^{SPS}$) has a significant negative impact. In other words, the enhanced transparency of the SPS measures and TBT encourages exports, along with the harmonization of the SPS measures, which decreases the bilateral regulatory difference.

5. Conclusion

This study empirically examined the impact of bilateral quantitative and qualitative regulatory differences in NTMs, particularly the SPS measures and TBT, on the agri-food trade. The harmonization was captured as a quantitative aspect of NTMs, whereas the transparency was be illustrated qualitatively.

The estimation results demonstrated the transparency of SPS measures, indicating the effect of the quantitative aspect, found a significant positive effect on many primary product trades, such as exports from upper-middle- and low-income countries to high-income countries. The same effects were observed for processed product exports from lower-middle- and low-income countries to high-income countries. Furthermore, the transparency of the TBT significantly encouraged all primary and processed product trade, except for exports from lower-middle-income to high-income countries. However, the quantitative SPS measurement had a significant negative effect on processed product exports from high- and upper-middle-income countries to high-income countries. This means that the SPS measures can function as a non-tariff barrier for such trades.

Qualitative SPS measurement was significantly negative for processed product exports from lower-income, and primary and processed product exports from low-income to high-income countries. Likewise, the qualitative TBT measurement was also significantly negative for processed product exports from high-income countries, and primary product exports from lower-middle-income to high-income countries. Hence, the harmonization of SPS measures and TBT, which decreases bilateral regulatory differences, is also required to encourage these trades.

This study has some limitations. The estimation period used in the study was a single year, and the results indicated that there is space for transparency and harmonization. Future work would benefit from an intertemporal analysis to confirm the changing effects. Although this study focused on macro trade analysis, quantitative and qualitative NTMs are also related to individual firms' decisions. Therefore, a microdata analysis is required.

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