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Do Technical Barriers to Trade Restrict Exports? Evidence from South Korea*

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Our study utilizes a gravity model and upgraded database of non-tariff measures to empirically assess the effect that Technical Barriers to Trade have on exports to Korea's 57 trading partners using the Poisson Pseudo Maximum Likelihood (PPML) method. Overall, our results showed that the 1% increase in the level of TBT notification leads to around 0.15% decrease in Korean exports to High-Income trading partners and the 0.13% decrease to Medium-Income trading partners. At the same time, however, TBT measures also promote the export of high demand products by increasing transparency. Given such findings, relevant policy implications are discussed.

JEL Classification: F13, F14, F15, F43, F50
Keywords: non-tariff barriers, technical barriers to trade, Korea, Poisson Pseudo Maximum Likelihood

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1. INTRODUCTION

As an active player within this highly integrated global economy with significant trading relationships (Wood and Jang, 2020), South Korea has gone to great lengths to implement a relatively aggressive trade liberalization policy agenda (Pyo *et al.*, 2016; Wood and Khan, 2015; Wood, 2017). While openly supporting a neo-liberal trade policy agenda in recent years, Korea has made compromises as to how it can deliver better market access. These compromises usually come in the form of tariff rate reductions, which when looked at collectively, have inevitably led to a gradual and continuous decline in global tariff levels since the start of the General Agreement on Tariffs and Trade (GATT) in 1948 (Ghodsi, 2015). In particular, between 1996 and 2018, the global average tariff rate (simple average rates) for all products fell from 15.1% to 4.2%. At the same time, there has also been a growing trend towards the use of other measures non-tariff measures (NTMs) (Wood *et al.*, 2017b; Ghodsi, 2018; Wood *et al.*, 2019).

NTMs have the propensity to restrict imports or exports of goods or services through a range of mechanisms that do not involve tariffs (Wood *et al.*, 2017a; Wood *et al.*, 2017b; Wood *et al.*, 2019). They can take a variety of forms including import quotas, subsidies, customs delays, and technical barriers or other forms of health and safety regulations. Among the different types of NTMs, technical barriers to trade (TBT) are one of the most common forms adopted by nations. Recognized as an acceptable measure that must be applied in a non-discriminatory fashion, TBT are included within the World Trade Organization (WTO) TBT agreement. Defined as technical regulations and standards that set out the specific characteristics of a product, such as its size, shape, design, functions, and performance, or the way it is labelled or packaged before going on sale. Sometimes a TBT is imposed as an amendment to a previous TBT, to either facilitate trade or to implement stricter regulations and as such have been found to have both positive and negative impacts on trade flows (Ghodsi, 2018). The number of TBT notifications from South Korea's major trading partners between 1995 and 1999 was only 1,699, however, in

Table 1 Characteristics of NTMS: Purposes, Examples, and Consequences

Policy Type	Purpose	Examples	Potential Consequence
Protectionist policies	To help domestic firms at the expense of international competitors	Import quotas; local content requirements; public procurement practices	Challenges levied at the WTO
Assistance policies	To help domestic firms in a way that is not detrimental to international competitors	Domestic subsidies; antidumping laws; industry bailouts	Adversely affected countries may respond to protect themselves (CVDs and subsidies)
Non-protectionist policies	To protect the health and safety of people, animals and plants	Licencing, packaging, labelling requirements, SPS rules; food plant and animal inspections	Limited consequences, may help to establish common standards

Notes: NTM = non-tariff barrier; SPS = sanitary and phytosanitary; CVDs = counterveiling duties; WTO = World Trade Organization.
Source: Deardorff (2012).

the subsequent 2011-2015 period this number has increased significantly to 6,180. As of 2015, these trading partners had notified a total of 15,127 TBT measures.

NTMs arise from not only a governmental need to regulate and enforce laws that help to ensure compliance, but also a desire by industry to improve standards and increase economic efficiency. While such actions may help to assure a relative level of product standard, they may also affect international trade. In 2018, the US, whilst implementing a raft of neo-protectionist measures, further stoked the fire of nationalistic sentiment, by announcing the implementation of tariffs and other technical measures on an estimated $60bn worth of Chinese exports (Kim *et al.*, 2018). However, as Table 1 shows,

NTMs have a number of characteristics, (1) they may be overtly protectionist, at the expense of traders from other countries; (2) they may aim to help support domestic industries, with no direct intent to negatively impact international competitors; or (3) they may be non-protectionist but still restrictive of certain trade (Wood *et al.*, 2017b).

The purpose of our research is to examine the impact that TBT has on Korea's ability to grow its export base. In order to do so, our study uses the Poisson Pseudo Maximum Likelihood (PPML) method, an adapted version of the gravity model and an upgraded database of NTMs to illustrate the potential impact this form of NTM may have on Korea's exports. Our study builds on these previous works by greatly extending the size of the empirical study to include 57 of Korea's major trading partners.[1)] The vast size of the study allows for a more accurate depiction of the true impact that TBT may have on Korean exports. As many of its trading partners have enacted more protectionist trade policy regimes that include the implementation of significant numbers of NTMs, it is imperative that more is done to better understand their effects. In terms of our methodological approach, our study differs from earlier works by distinguishing between the paths that may have a positive effect on exports and the paths that may have a negative effect on exports by constructing an import market size variable. Although NTMs endeavour to achieve important social, public health, environmental, or other non-economic policy objectives, they have also been found to protect domestic markets (Fernandes *et al.*, 2015). A greater understanding of their true impacts will undoubtedly help to shape the trade policy of Korea and many of its trading partners moving forward.

[1)] We selected a total of 57 countries as analysis objects, including 50 trading partner countries that signed an FTA with Korea between 1996 and 2015 as well as 7 major trading partner countries that account for more than 1% of the country's exports. This is because, if all of the countries are listed as analysis objects, the analysis data will contain a large amount of data from countries that Korea does not export to, regardless of the TBT notification, which will lead to bias in our empirical results.

2. LITERATURE REVIEW

Spurred on by developments in both neo-liberal and neo-protectionist trade policy agendas, NTMs have become an increasingly important means of regulating international trade flows (Fugazza, 2013; Moise and Le Bris, 2013; Kareem, 2014). As the level of tariff rates have fallen in recent decades, NTMs have become an increasing popular tool for achieving various trade policy objectives. Changes in tastes and preferences in importing countries as well as the need to keep the environment safe, especially in developed markets, has contributed to a rising trend in the demand for TBT measures. The TBT issue has many facets arising from the successful efforts to increase the volume of trade and to codify the rules for its conduct (Popper *et al.*, 2004). As the dynamics of trade policy have changed, so has the focus of academic scholars, with many choosing to better understand the ways in which NTMs, in particular TBTs, effect export outcomes. During this analysis, several studies have emerged which help to model (Beghin and Bureau, 2001; Ganslandt and Markusen, 2001) and measure (Disdier *et al.*, 2008a; Disdier *et al.*, 2008b; Bao and Qiu, 2010; Alaeibakhsh and Ardakani, 2012; Wood *et al.*, 2017a; Wood *et al.*, 2017b; Wood *et al.*, 2019) the impacts of non-tariff measures.

Research suggests that TBT measures have various impacts depending on the countries and industries being analysed. Many studies show that developing country exports are more negatively impacted by the introduction of TBTs than richer more advanced economies (Cheminitz *et al.*, 2007; Otsuki *et al.*, 2001). Using firm-level data generated from 16 developing countries, Maskus *et al.* (2005) found that developing country exporters encounter significant additional costs when attempting to adapt their production processes to comply with foreign regulatory measures. This is due to the fact that less developed economies don't have the same administrative, technical and scientific capabilities as their richer counterparts which limits their ability to adhere to tougher foreign regulatory requirements. Moreover, Bao and Qiu (2012) suggest that TBT measures imposed by a developing country have significant effects on other developing countries' exports, but no significant

effects on the exports of developed countries'. These negative impacts can also directly affect developing countries' quests to not only reduce poverty levels but also achieve more sustainable means of development (Heshmati *et al.*, 2019; Kareem, 2014).

Other studies have provided less conclusive findings. In this regard, Swann *et al.* (1996) found that voluntary national and international product standards in the UK and Germany positively impact export performance but had little impact on imports. In contrast, unilateral standards had a positive influence on imports but a negative influence on exports. Disdier *et al.* (2008a) showed, in their study on the impact of standards and other non-tariff measures for 690 agri-food products (HS6-digit level), that OECD exporters are not significantly affected by TBT when exporting products to other OECD countries, whereas the exports of developing countries and LDCs are negatively affected. While, in an East Asian focused study, Choi *et al.* (2015) found that the effect of TBT measures on the trade flow between China, Japan and Korea was also insignificant. Many studies have also been conducted on the impact of TBT on Korea's trade. For example, Jang *et al.* (2011) is one of the first comprehensive studies of TBT research in Korea. Wood *et al.* (2017a) use an adapted version of the gravity model to assess the impact that Chinese TBT measures had on exports from Korea. The results from their study show that when estimated using the coverage ratio, the TBT measures were found to depress Korean manufacturing exports and exports as a whole. However, using the frequency index, Chinese TBT measures were found to have a statistically insignificant negative impact on Korean exports to China. Choi and Jang (2018) found that assistance in developing trade policy and relevant regulation has a significantly positive effect on donor countries' exports to recipients, with this effect being particularly strong when the recipients' incidence of TBT is higher. More recently, Jang *et al.* (2019) analyzed TBT-related international research trends and analyzed the impact of TBT on trade, and found that TBT had a negative impact on Korea's overall exports, especially after the international financial crisis. In particular, it was found that while exports to developed countries had a negative impact, exports to

countries with lower incomes than Korea had a positive impact. In addition, Bai and Oh (2020) and Li and Oh (2019) reported the negative effects of TBT on Exports in Value Added of Korea.

It is also important to note that TBT measures may provide benefits, not just to domestic consumers but also to foreign suppliers (van der Meer, 2014). For example, if a standard certifies a product as being safe, healthy, and of a certain quality standard etc., it can help to raise consumer demand for the import, which can possibly result in increased profits for foreign firms in spite of the higher costs they may initially face. Some arguments predict that NTMs can have a positive effect on trade performance. Chen and Mattoo (2008) showed that the harmonization of EU technical regulations significantly expanded intra-EU trade and also raised imports from industrialized non-member nations. However, there was a trade diversion effect, in that exports to the EU from developing countries were significantly reduced. Bao and Qiu (2010) found that TBTs imposed by China have a trade promotion effect on Chinese imports during its pre-WTO era. More recently, Santeramo *et al.* (2019) examined the country-specific impact of non-tariff measures in the global wine trade. Using the PPML approach they found that TBTs have a trade enhancing effect for bottled wine, while having a trade-impeding effect for bulk wine.

3. EMPIRICAL FRAMEWORK AND DATA

3.1. Empirical Model

In order to provide the most effective means of estimation, a number of studies have used the frequency index and coverage ratio to measure the restrictiveness of trade or the severity of NTMs (Bao and Qiu, 2010; El-Enbaby *et al.*, 2016; Wood *et al.*, 2017a; Wood *et al.*, 2017b). However, these measures carry their own advantages and disadvantages. In terms of the coverage ratio, a key benefit is its ability to measure the actual percentage of trade value subjected to a particular NTM. However, the ratio can be confusing, as a higher coverage ratio may mean the relative value of the

affected products is higher, which could be interpreted as the NTM having a greater effect on the trade. However, it can also be interpreted that the NTM is having a lesser impact on trade flows since the relative value of the affected products is higher (Wood *et al.*, 2017a). However, if the coverage ratio is lower, the relative value of the impacted products is also smaller, which can be caused by a NTM measure that is either more or less restrictive (Wood *et al.*, 2017a). In summary, such situations can mean the coverage ratio may not accurately illustrate the true restrictiveness of a NTM. Moreover, the coverage ratio can also expose the dependent variable to endogeneity problems, which can be overcome by using frequency index (Wood *et al.*, 2017a). Despite not illustrating actual coverage of a measure, the frequency index is useful as it only accounts for the presence or absence of an NTM for a specific product by showing the percentage of import transactions affected by a NTM (Wood *et al.*, 2017a). Given their respective advantages and disadvantages, for robustness, we adopt both the frequency index and coverage ratio measures as part of our empirical analysis. For the purpose of this study, the adapted version of the Gravity estimation model is as follows:

$$\begin{aligned} \ln EXP_{cjt} = {} & \alpha + \beta_1 \ln GDP_{ct} + \beta_2 \ln Dist_c \\ & + \beta_3 Tariff_{cjt} + \beta_4 TBT_{cjt} \\ & + \beta_5 REER_{ct} + \gamma_{cj} + \delta_t + \varepsilon_{cjt}, \end{aligned} \tag{1}$$

j = product category j of HS2-digit level, from HS01~97;

t is year from 1996 to 2015; c represents 57 major trading partners of South Korea[2)];

[2)] It includes Australia, Austria, Belgium, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, China Hong Kong, Colombia, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Italy, Japan, Lao PDR, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Myanmar, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Russian Federation, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Thailand, Turkey, USA, United Arab Emirates, United Kingdom, Vietnam.

γ_{cj} and δ_t represent importer, product and time-fixed effects respectively, which are added to control for multilateral resistances as suggested by Feenstra (2016). ε_{cjt} is the error term. The variables of GDP_{ct}, $Dist_c$ are logged due to high dispersions. As documented in Silva and Tenreyro (2011), the PPML method allows us to deal with any serious heteroscedasticity problems that may arise. Like that of previous studies, we estimate our gravity model using the PPML method. The mixture of variables in levels and log levels is due to the PPML methodology.[3)]

3.2. Dependent and Independent Variables

3.2.1. Dependent Variable lnEXP_{cjt}

The dependent variable, which represents the value of Korea's exports of product *j* (HS codes 01-96) to trade partner countries in year *t*. The data is obtained from the UN Comtrade Database. The level of exports and imports reported by one country should, in theory, correspond with the imports and exports to that of the counterpart country. However, in reality, export statistics rarely line up exactly with that of the import statistics for partner countries and as such can lead to asymmetrical situations occurring. This is due to quantity measurements (some countries report gross weights while others report net weights), trading systems (some countries use a special trade system which excludes products made in trade free zones, while others use the general trade system which includes these free zones), time lags (discrepancies may result if exports are registered in one year and the corresponding imports in the following year) etc.

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3) The PPML estimation procedure converts (1) into the following form:

$$EXP_{cjt} = \exp(\alpha + \beta_1 \ln GDP_{ct} + \beta_2 \ln Dist_c + \beta_3 Tariff_{cjt} + \beta_4 TBT_{cjt} + \beta_5 REER_{ct} + \gamma_{cj} + \delta_t) + \varepsilon_{cjt}.$$

3.2.2. Independent Variables

Market Size $\ln GDP_{ct}$: *GDP* is usually used as a means of measuring the market size of the importing country, the larger the market size, the more positive the effect would be on Korea's exports to its trading partners. We obtain the data from the World Bank's World Development Indicators.

Distance $Dist_c$: *Dist* refers to population weighted distance between Korea and its respective trading partners by kilometre. The data is obtained from CEPII Gravity Dataset. As a variable representing trade cost, it is assumed that the greater the distance a trading partner is from Korea, the greater the negative effect would be on Korea's exports to its trading partners.

Tariff and Technical barriers to trade imposed by trading partners $Tariff_{cjt}$ and TBT_{cjt} : Using data obtained from the WTO's Integrated Database (IDB), $Tariff_{cjt}$ denotes the simple average tariff and TBT_{cjt} refers to the non-tariff measures imposed by Korea's trade partners on product *j* at year *t*. This field of enquiry represents seven variables that measure the effect that tariffs and TBT may have on Korea's exports to trading partners. In order to assess this, we use the applied average tariff to measure any potential effect the tariffs may have. The WTO IDB, provides comprehensive information on tariff data but missing data still remains for some countries in certain years. Therefore, it is necessary to go through the process of assessing the data in accordance with the sample period required for analysis. For data that is unavailable, we use the tariffs for the most recent years to replace the missing values. We expect that an increase in tariff levels should lead to a reduction in exports from the target country. In addition, we consider two ways to account for TBT measures: a coverage ratio (the coverage ratio measures the percentage of trade value subjected to TBT measures, TBTC) and a frequency index (the frequency index represents the percentage of products subjected to TBT measures, TBTF). As most of the partner countries' TBT notifications are interpreted at the HS6-digit level, the TBT coverage ratios and frequency indexes are calculated at the HS6-digit level (5,134 products) for the period 1996 to 2015 and aggregated to the HS2-digit level format.

The coverage ratio measures the percentage of trade value subject to TBT for Korean products. In formal terms, the coverage ratio of product category *j* in year *t* is given by:

$$CR_{jt}=\left[\frac{\Sigma_{i\in j} D_{it}V_{it}}{\Sigma_{i\in j} V_{it}}\right]*100, \tag{2}$$

where *i* is the product item *i* of HS6-digit level, $i = 1, 2, \ldots, 5134$; *j* is the product category *j* of HS2-digit level, $j = 1, 2, \ldots, 97$; and *t* is years 1996-2015. If a TBT is applied to product *i* in year *t*, the dummy variable D_{it} takes the value one or zero otherwise; and V_{it} is the value of Korean exports in product *i*; of course, the sum of V_{it} ($\sum V_{it}$) is the export value of product category *j* in year *t*. The frequency index accounts for the presence or absence of a TBT measure for a particular product. It shows the percentage of import transactions affected by a TBT requirement. The frequency index of product category *j* in year *t* is computed as:

$$FI_{jt}=\left[\frac{\Sigma_{i\in j} D_{it}M_{it}}{\Sigma_{i\in j} M_{it}}\right]*100, \tag{3}$$

where *i* is the product item *i* of HS6-digit level, $i = 1, 2, \ldots, 5134$; *j* is the product category *j* of HS2-digit level, $j = 1, 2, \ldots, 97$; and *t* is the years 1996-2015. D_{it} is defined in the same manner as in equation (2); M_{it} is a dummy variable equal to one if there is an import of product *i* or zero if there is not. The coverage ratio and frequency index are used to measure the restrictiveness of trade measures. Their respective values both range from 0 and 100, however as they interpret the restrictiveness of trade measures from different perspectives, the coverage ratio in terms of depth, and the frequency index in terms of range, then the calculated values for the two approaches are different.[4)]

[4)] For example, in regard to HS06, there are 4 product categories at the 4-digit HS code level (i.e., HS0601, HS0602, HS0603 and HS0604). Of these only three (HS0602, HS0603, HS0604) have export value data and one of them (i.e., HS0602) is covered by a TBT based

Real Effective Exchange Rate $REER_{ct}$: REER is the real effective exchange rate of the importing countries. It represents the value that an individual consumer in the importing countries pay for an imported good at the consumer level. The higher the REER, the more positive the effect would be on Korea's exports to its trading partners. Therefore, the estimated coefficient of $REER_{ct}$ is expected to be positive.

Cross term effect TBT * $\widetilde{IM}_{cjt}$: TBTs have both trade diversion and trade promotion effects (Chen and Mattoo, 2008). According to research by Ryu *et al*. (2015), the impact of TBT measures on a country's trade is related to import market demand. When TBTs are imposed, producers and exporters need to bear the additional fixed and variable costs to meet the technical requirements of trading partner countries. This increasing cost can influence the exporting firms' ability and decision to export, resulting in a reduction in imports from the partner country. However, TBTs may also have a trade promotion effect by increasing commodity transparency, especially when the import market is in great demand. This is because people tend to pay more attention to the quality of products in high demand. TBT measures can increase the transparency of commodities through information sharing, enhancing consumers' trust in commodities, which therefore stimulates the import demand for related products and in doing so promotes the export of commodities certified by the TBT. In order to better understand the interaction between import consumption demand and TBT, we therefore use the import market size IM_{cjt} (which is defined as the total imports of product *j*, country *c* from the world) as a proxy variable for TBT's transparency effect on product *j*'s demand following Ryu *et al*. (2015). If the TBT has a trade promotion effect, then the estimated coefficient of the cross-term variable TBT * $\widetilde{IM}_{cjt}$ should be positive. However, if we simply use the formula of trading partners' import market size of product *j* as defined in equation (4), two major problems

on the data of Korea in 2008. Hence, the corresponding HS06's TBT frequency index is equal to 33.33% (i.e., 1 of the 3 product categories contains a TBT measure) while HS06's TBT coverage ratio is equal to 97.77% (because the value for HS0602 is 14,114 thousand US$ while the value of HS06 is 14,436 thousand US$, so the coverage ratio is 14,114/14,436=97.77%).

can arise. Firstly, as the trading partners' import market size variable of equation (4) contains Korea's export levels, this will lead to a correlation with the error term ε_{cjt}, and as a result an endogeneity problem can occur. Secondly, the trading partners' total import market size variable and GDP are highly correlated which may create a multicollinearity problem.

$$IM_{cjt} = \sum_{w=1}^{W} EXP_{cwjt} \,. \tag{4}$$

In order to solve the endogeneity problem, we subtract the trading partner's import value of *j* product from that of the import value for the same product item from Korea. We then divide it by the trading partner's total imports minus its total import from Korea to solve the problem of multicollinearity. As such, we are able to generate the ratio variable for the trading partners' import market size of product *j* as defined in equation (5).

$$\widetilde{IM_{cjt}} = \frac{IM_{cjt} - IM_{kjt}}{\sum_{j=1}^{97} IM_{cjt} - \sum_{j=1}^{97} IM_{kjt}} * 100. \tag{5}$$

Therefore, we can obtain the extended empirical model as equation (6).

$$\begin{aligned} \ln EXP_{cjt} = {} & \alpha + \beta_1 \ln GDP_{ct} + \beta_2 \ln Dist_c + \beta_3 \ln Tariff_{cjt} \\ & + \beta_4 TBT_{cjt} + \beta_5 REER_{ct} + \beta_6 \widetilde{IM}_{cjt} \\ & + \beta_7 TBT * \widetilde{IM}_{cjt} + \gamma_{cj} + \delta_t + \varepsilon_{cjt} \end{aligned} \tag{6}$$

3.3. Data

For the purpose of this study, all export data were gathered from UN Comtrade database; while the TBT notifications at the HS 6-digit level were provided by the Productivity, Non-Tariff Measures and Openness (PRONTO) NTM Database.[5] With regards to the other related variables GDP, GDP per

[5] Although the WTO's Integrated Trade Intelligence Portal (I-TIP) provides a good platform

capita, tariff rate, real effective exchange rate, and distance, the relevant data were gathered from World Bank, WTO's Integrated Database (IDB), and the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). Our research utilized the PPML methodology to conduct our empirical analysis. The total number of observations is 101,021. The preliminary calculation shows a low level of correlation exists between the variables, which means there is little multi-collinearity problem.

4. EMPIRICAL RESULTS AND DISCUSSION

The estimation results are presented in Tables 2-4. We first estimate equation (1) using the full sample data that includes all countries, and then assess the countries according to income level using World Bank classifications. Here, high income countries are defined as countries that have incomes of $12,236 per year. For the purpose of this study the following countries were included as high-income: Australia, Austria, Belgium, Brunei Darussalam, Canada, Chile, China Hong Kong SAR, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Saudi Arabia, Singapore, Slovakia,

for obtaining non-tariff barrier notification information it also has serious missing data issues which can limit its research scope. According to the provisions of the WTO (TBT and SPS Agreement), each member state must provide the WTO with all the information related to its implementation measures. In addition to this, all WTO member nations must be notified in advance so that they have time to comment on the measures, thereby also increasing the level of transparency for the overall implementation process. However, some member states do not report to the WTO, with many countries failing to provide detailed HS product classifications. As a result of this, there were instances whereby data from the I-TIP database was missing, making it difficult to accurately reflect the impact of NTMs. As shown in Table A1, in the raw I-TIP data, only 5,290 out of a total of 15,127 TBT measures had HS codes. The rest of the 9,837 measures, were missing HS codes and were therefore unsuitable for further economic analysis. In order to overcome this problem and broaden the coverage of the data, so that it could be used for economic analysis purposes, Ghodsi *et al*. (2015) matched as many HS codes as possible and reduced the number of measures with missing HS codes down to 5,591. This relevant data is downloadable from the PRONTO NTM database.

Slovenia, Spain, Sweden, Switzerland, USA, United Arab Emirates, and the United Kingdom. Medium-income countries were defined as including both low-middle-income and upper middle-income countries which therefore have incomes greater than $1,006 but less than $12,235 per year and included Brazil, Bulgaria, Cambodia, China, Colombia, Croatia, India, Indonesia, Lao PDR, Malaysia, Mexico, Myanmar, Peru, Philippines, Russian Federation, Thailand, Turkey, Vietnam.

As can be seen from table 2, the *GDP* of trade partner countries had a statistically significant positive effect on trade flows (0.45-1.07), while the *distance* displayed a statistically significant negative effect, which implies that the further the trading partner is from Korea the fewer exports it receives.

Table 2 Benchmark Estimation

Variables	Total		High-Income Countries		Medium-Income Countries	
GDP	0.63***	0.62***	1.07***	1.07***	0.47***	0.45***
	(0.09)	(0.09)	(0.17)	(0.17)	(0.12)	(0.12)
Dist	–0.15***	–0.16***	–0.20***	–0.20***	–0.90***	–0.91***
	(0.05)	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)
Tariff	–3.70***	–3.67***	4.17***	4.20***	–1.09**	–1.04**
	(0.46)	(0.46)	(0.62)	(0.62)	(0.51)	(0.51)
TBTC	–0.03		–0.08		0.06	
	(0.06)		(0.06)		(0.06)	
TBTF		0.02		–0.08		0.12*
		(0.06)		(0.07)		(0.06)
REER	0.35*	0.37*	0.18	0.18	0.17	0.19
	(0.20)	(0.20)	(0.28)	(0.28)	(0.29)	(0.28)
Importer-product pair fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Constant	–2.04	–1.70	–14.1***	–14.06***	8.75***	9.36***
	(2.62)	(2.64)	(4.33)	(4.33)	(3.31)	(3.30)
Ob.#	101,021	101,021	71,897	71,897	29,124	29,124
R^2	0.86	0.86	0.79	0.79	0.95	0.95

Notes: Robust standard errors in parentheses; * ($p < 0.10$), ** ($p < 0.05$), and *** ($p < 0.01$).

Table 3 Extended Estimation

Variables	Total		High-Income Countries		Medium-Income Countries	
GDP	0.69***	0.68***	0.92***	0.90***	0.57***	0.56***
	(0.08)	(0.08)	(0.15)	(0.15)	(0.11)	(0.11)
Dist	–0.15***	–0.16***	–0.18***	–0.19***	–0.84***	–0.84***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Tariff	–3.37***	–3.31***	2.50***	2.50***	–0.55	–0.53
	(0.39)	(0.39)	(0.34)	(0.34)	(0.42)	(0.42)
TBTC	–0.17*		–0.04		–0.19**	
	(0.09)		(0.09)		(0.09)	
TBTF		–0.13		–0.18*		–0.15*
		(0.09)		(0.09)		(0.09)
IM	6.27***	6.27***	5.69***	5.70***	6.31***	6.29***
	(0.28)	(0.27)	(0.37)	(0.36)	(0.40)	(0.40)
*TBTC*IM*	1.35***		0.45		1.77***	
	(0.50)		(0.77)		(0.54)	
*TBTF*IM*		1.65***		2.43***		1.95***
		(0.55)		(0.92)		(0.58)
REER	0.61***	0.63***	0.72***	0.75***	0.03	0.05
	(0.18)	(0.18)	(0.24)	(0.24)	(0.25)	(0.25)
Importer-product pair fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Constant	–4.01*	–3.63	–10.4***	–9.83***	5.37*	5.83*
	(2.37)	(2.38)	(3.71)	(3.67)	(3.19)	(3.16)
Ob.#	101,021	101,021	71,897	71,897	29,124	29,124
R^2	0.86	0.86	0.84	0.84	0.94	0.94

Notes: Robust standard errors in parentheses; * ($p < 0.10$), ** ($p < 0.05$), and *** ($p < 0.01$).

As can be seen from table 3, when taking into consideration the impact of import market size, the effects of TBT (i.e., coverage ratio) were statistically significant negative (–0.17). It was confirmed that TBTs imposed by partners negatively affect the exports of Korea. In addition, the cross-term variable of TBT and import market size (*TBT*IM*) were statistically significant positive (1.35-1.65).[6] This means that the TBT will have a different impact on the

[6] This particular result provides evidence of the different impacts that TBTs may have on export flows. On the one hand, it can increase the transparency of commodities through information sharing, enhance consumer trust in commodities, and in doing so stimulate import demand and promote trade partner' exports; while on the other hand, a TBT can act

export of popular products (those that have a higher level of demand) in the import market through the channel of transparency. Through the mandatory labelling of products, transparency can increase the level of information provided to the consumers which can lead to finally stimulate the consumers to buy them. According to the analysis results of the frequency index (*TBTF*), if the proportion of products subject to TBT measures increase by 1%, South Korea's exports to High-Income Countries would fall by 0.16%, while exports to Medium-Income Countries would fall by 0.13%.[7)]

In addition, we also assess the impact of TBT measures from the perspective of the manufacturing sector (HS 2-digit levels 25-97). As can be seen from table 4, we also obtained similar results to that of our full sample assessment in table 3. In the case of TBT measures that function as a barrier to trade, a 1% increase in the level of TBT notifications leads to a 0.14 - 0.18% decrease in the level of Korean manufacturing exports to its trading partners, while the TBT measures can also promote export growth by around 0.02%[8)] through increasing transparency.

The decrease in exports resulting from the introduction of TBTs highlights may be explained by the increases in costs that firms may be exposed to. For example, to meet these new technical standards, business may have to improve the product's quality and design, which leads to new costs being incurred.

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as a tool for some countries to implement trade protectionism in disguise and thus negatively impact trading partner exports. Therefore, the overall impact of a TBT on exports depends on which of the two action pathways is stronger.

7) As the mean of the import market size (IM) is 0.0102, therefore, the net effect of TBT imposed by High-Income and Medium-Income countries are –0.18+2.43*0.0102 = –0.16% and –0.15+1.95*0.0102 = –0.13%, respectively.

8) The coefficients of cross-term variables of TBT and import market size (*TBTC*IM* and *TBTF*IM*) were 1.36 - 1.64, given that the mean of the IM of manufacturing industries is 0.0123, therefore, the positive impact of TBT on Korean's manufacturing exports is 1.36*0.0123 - 1.64*0.0123=0.0167 - 0.0202.

Table 4 An Assessment of Impact of Manufacturing Industry

Variables	Total		High-Income Countries		Medium-Income Countries	
GDP	0.69***	0.67***	0.87***	0.86***	0.57***	0.56***
	(0.08)	(0.08)	(0.15)	(0.15)	(0.11)	(0.11)
Dist	–0.12***	–0.12***	–0.15***	–0.15***	–0.84***	–0.84***
	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Tariff	–3.60***	–3.53***	3.81***	3.87***	–0.39	–0.37
	(0.43)	(0.42)	(0.79)	(0.78)	(0.45)	(0.45)
TBTC	–0.18**		–0.02		–0.20**	
	(0.09)		(0.10)		(0.09)	
TBTF		–0.14		–0.20*		–0.15*
		(0.09)		(0.11)		(0.09)
IM	6.24***	6.25***	5.65***	5.64***	6.32***	6.30***
	(0.28)	(0.28)	(0.37)	(0.36)	(0.40)	(0.40)
*TBTC*IM*	1.36***		0.38		1.78***	
	(0.52)		(0.83)		(0.55)	
*TBTF*IM*		1.64***		2.65***		1.96***
		(0.58)		(1.02)		(0.59)
REER	0.62***	0.64***	0.78***	0.82***	0.03	0.04
	(0.18)	(0.18)	(0.24)	(0.24)	(0.25)	(0.25)
Importer-product pair fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Constant	–4.11*	–3.73	–9.48**	–8.93**	8.70***	5.76*
	(2.39)	(2.40)	(3.72)	(3.68)	(3.23)	(3.23)
Ob.#	75,731	75,731	53,897	53,897	21,834	21,834
R^2	0.89	0.89	0.84	0.84	0.94	0.94

Notes: Robust standard errors in parentheses; * ($p < 0.10$), ** ($p < 0.05$), and *** ($p < 0.01$).

5. POLICY IMPLICATIONS AND CONCLUDING REMARKS

Our study provides two key areas for further discussion, both of which provide important points of focus for policy makers. Firstly, our study showed the negative impact that TBTs can have on trade flows. In this regard, the

negative effects of TBTs may take the form of increased recurring costs associated with regulatory compliance; one-time costs, perhaps resulting from the need to change manufacturing processes; and the opportunity costs associated with lost or reduced sales, perhaps due to a country's regulations or de facto processes therefore presenting unacceptable risks to potential exporters. In order to overcome these issues, governments need to work with business and other relevant governments to help bring down compliance costs either through negotiation with governments or by helping business to become more innovative through the introduction of research and development tax credits or through closer public-private partnerships. Governments can also create new organizational bodies that work on behalf of industry to seek out new export markets where TBTs are particularly prohibitive. From a firm perspective, business owners also need to be aware of the ramifications that these NTMs may have on their day-to-day operations. While many businesses may look at how they can accommodate the technical requirements, through redeveloping their product to comply with new standards. As Fontagne and Orefice (2018) note, the impact of TBT measures may see a business simply exiting the market (drop strategy) or it may choose to both exit the market and add a new TBT-free destination (add strategy).

In the case of Korea, many businesses can utilize the benefits of being associated with the Korean Wave and positive consumer perceptions in order drive export growth, even when confronted with the head winds associated with technical trade measures. Secondly, our research also showed that if the size of the partner country's import market is large, the negative effects of the TBT on Korea's exports could be mitigated through increasing the level of policy and regulatory transparency that exists between itself and its large export partner. Given the breakdown of our analysis from a manufacturing sector perspective, the study also highlighted the need for governments to embrace new developmental opportunities. For a country like South Korea, which seeks to develop an economic climate that encourages investment and allows high-tech business to thrive, it is imperative that the government continues to pursue its 'creative economy' ambitions. Under such a pretext,

these innovative hi-tech ventures can overcome NTM issues by mapping out a path from which new bilateral or regional trade relationships can prosper. For many years, tariffs were used as a form of protection against imports. However, as shown above, policy instruments such as TBT measures can also have a detrimental impact on export growth. Given their growing importance, it is imperative that governments educate industry about their potential ramifications and the steps that businesses can take to manage any potential shortcomings or growth opportunities. We can also mitigate the negative effect caused by TBT by considering other policies such as the AfT (Aid for Trade) or MRA (Mutual Recognition Agreement) initiatives (see Choi and Jang, 2018; Jun and Kang, 2015).

APPENDIX

Table A1 TBT Measures Implemented in Korea Trading Partner Countries: 1995-2015

Country	HS Original	HS missing before	HS match	HS missing after	Sum
Australia	51	159	44	115	210
Brazil	742	603	218	385	1345
Brunei	0	2	1	1	2
Cambodia	1	2	0	2	3
Canada	37	867	487	380	904
Chile	6	483	134	349	489
China	1,182	1,458	464	994	2,640
Columbia	226	360	84	276	586
European Union	82	1,170	429	741	1,252
Hong Kong, China	48	43	11	32	91
Iceland	0	2	1	1	2
India	12	102	54	48	114
Indonesia	141	60	30	30	201
Japan	375	409	141	268	784
Laos	0	1	0	1	1
Malaysia	38	195	92	103	233
Mexico	52	765	165	600	817
Myanmar	0	2	0	2	2
New Zealand	51	84	31	53	135
Norway	5	83	13	70	88
Peru	79	15	6	9	94
Philippines	1	257	164	93	258
Russian Fed.	0	47	26	21	47
Saudi Arabia	112	805	632	173	917
Singapore	18	26	8	18	44
Switzerland	16	280	152	128	296
Thailand	461	180	103	77	641
Turkey	22	63	34	29	85
U. A. Emirates	3	299	264	35	302
United States	1,526	930	412	518	2,456
Vietnam	3	85	46	39	88
Total	**5,290**	**9,837**	**4,246**	**5,591**	**15,127**

Notes: "HS Original" represents the number of TBT measures from I-TIP data with original HS code, "HS missing before" the number of measures with missing HS code before matching, "HS match" the number of measures with matched HS code, "HS missing after" the number of measures with missing HS code after matching. In the raw I-TIP data, 9837 measures of a total of 15,127 had missing HS codes, while in the matched PRONTO NTM data, the number of measures with missing HS codes down to 5591.

Source: WTO I-TIP database and PRONTO NTM Database.

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