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Doctoral Thesis

Technical Regulations and International Trade

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Technical Regulations and International Trade

規制と国際貿易

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A Thesis submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy

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GSAPS THE SUMMARY OF DOCTORAL THESIS

Technical Regulations and International Trade

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Keywords: Additional compliance requirement indicator, extensive and intensive margins of international trade, global value chains participation, non-tariff measures, quality, technical regulations

This research examines whether technical regulations act as hidden barriers for international trade or not, specifically as the conventional trade costs have decreased drastically. Technical regulations typically protect human safety and health, protect animal and environment, and prevent deceptive practices from information asymmetry. To quantify the objects of technical regulations, we adopt non-tariff measures (NTMs) and construct Additional Compliance Requirement Indicator (ACRI) following Nabeshima et al. (2021) to calibrate additional burden for the exporters. Conventional efforts to quantify NTMs focused on the unilateral measurements by the importers, such as coverage ratio and frequency index. However, not all technical regulations are cumbersome for the exporters if their domestic markets are imposing the identical regulations. We take account of both the exporters and importers' imposition of NTMs to examine the additional regulatory burden that exporters need to comply with before entering the foreign market.

We focus on the Sanitary and Phytosanitary Measures (SPS), and Technical Barriers to Trade (TBT) to define technical regulations. While non-technical measures, such as import quotas, and trade subsidies may explicitly affect international trade, technical measures such as SPS and TBT originally concentrate on the safety and health of consumers and environment. We identify the impact of seemingly trade-irrelevant technical regulation on international trade to verify if they are appropriately imposed by the economies and how they hamper or boost international trade.

To thoroughly examine the impact of technical regulations on international trade, we dissect international trade as the extensive and intensive margins of international trade, Global Value Chains (GVCs) participation, and the quality of traded goods. We fist analyze which margin of trade accounts for the trade-diminishing effect of the regulatory burdens. We examine whether the additional requirements diminish trade values, and then look into the different effects on the margins of trade. Within the destination market of a particular industry, we examine whether a country facing more regulatory burdens likely to export a narrower set of goods or lower quantities at higher prices. We follow Hummels and Klenow (2005) to construct the extensive and intensive margins of international trade, and further decompose intensive margin into price and quantity margins.

The results indicate that ACRI hampers international trade through both the extensive and intensive margins of international trade. Additional burden for technical regulations discourages exporters to diversify the goods (extensive margin) and sell larger volume of incumbent goods (intensive margin). Furthermore, additional regulatory burden decreased the quantity margin and increased the price margin of the intensive margin of international trade. Additional costs stem higher marginal costs. The costs push the export price up and the quantity of the products will decrease. This may affect consumer welfare adversely. High unit price and decrease in quantity deteriorates producer surplus and consumer surplus in exporting country and importing country, respectively.

Secondly, we examine the impact of technical regulations on the GVCs participation. The current fragmented production network urges the importance of GVCs participation when examining international trade. We decompose GVCs participation as the forward and backward participation. The backward participation in GVCs refers to the ratio of foreign value-added on total gross exports and the forward participation indicates the ratio of domestic value-added content of exports on total gross exports. Particularly, they depict the downstream and upstream engagements of the economies. The results indicate that ACRI discourage the participation in GVCs through both backward and forward participation. Regardless of the domestic value-added or foreign value-added, regulatory burden discourage countries to participating in global production networks. Compared to non-technical measures which often explicitly hamper international trade, technical regulations even showed higher adverse effect on GVCs participation. The results indicate that exporters face more difficulty complying with technical regulations than explicit trade costs before entering the foreign market. This verifies the adverse effect of NTMs acting as a hidden barrier for international trade.

Lastly, we investigate the impact of technical regulations on the quality of traded goods. Increased regulations may result in higher quality products, but at the same time, producers or exporters may incorporate cheaper inputs that correspond with the regulations, circumventing from producing higher and healthier goods. By constructing both the conventional unit value and quality estimates following Henn et al. (2020), the results overall imply that ACRI increased the quality of traded goods, and the regulations in agriculture sectors seemed to be more harmonized compared to manufacturing sectors.

As NTMs are in place to deal with legitimate concerns about citizens' health, safety, and environmental protection, mere elimination of NTMs is not desirable. While technical regulations hampered international trade via the margins of trade and GVCs participation, they sophisticated the quality of traded goods. Therefore, harmonization among NTMs to diminish trade costs is suggested rather than mere elimination of the technical regulations.

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List of Abbreviation

ACRI: Additional Compliance Requirement Indicator

ASEAN: Association of South East Asian Nations

AVE: Ad Valorem Equivalent

CEPII: Centre d'Études Prospectives et d'Informations Internationales

CGE: Computable General Equilibrium

CIF: Cost of Insurance and Freight

CPTPP: Comprehensive and Progressive Agreement for Trans-Pacific-Partnership

DVA: Domestic Value-added

DVX: Domestic Value-added in Exports

EU: European Union

FDI: Foreign Direct Investment

FOB: Free on Board

FTA: Free Trade Agreement

FVA: Foreign Value added

GDP: Gross Domestic Products

GVC: Global Value Chain

HS: Harmonized Commodity Description and Coding System

ICIO: Inter-country Input-Output

ITC: International Trade Centre

ISIC: International Standard Industrial Classification of All Economic Activities

ISO: International Organization for Standardization

I-TIP: Integrated Trade Intelligence Portal

LAIA: Latin American Integration Association

MAST: Multi-Agency Support Team

MFN: Most Favored Nation

MRL: Maximum Residue Level

NTM: Non-tariff Measure

NTB: Non-tariff Barrier

OECD: Organization for Economic Cooperation and Development

POLS: Pooled Ordinary Least Squares

PPML: Poisson Pseudo Maximum Likelihood

PTA: Preferential Trade Agreement

QE: Quality Estimate

RCEP: Regional Comprehensive Economic Partnership

RTA: Regional Trade Agreement

SPS: Sanitary and Phytosanitary Measures

STAN: Structural Analysis

STC: Specific Trade Concerns

TBT: Technical Barriers to Trade

TRAINS: Trade Analysis Information System

UN Comtrade: United Nations Commodity Trade Statistics Database

UNCTAD: United Nations Conference on Trade and Development

US: United States

WDI: World Development Indicators

WIOD: World Input-Output Database

WITS: World Integrated Trade Solution

WTO: World Trade Organization

2SLS: Two-stage Least Squares

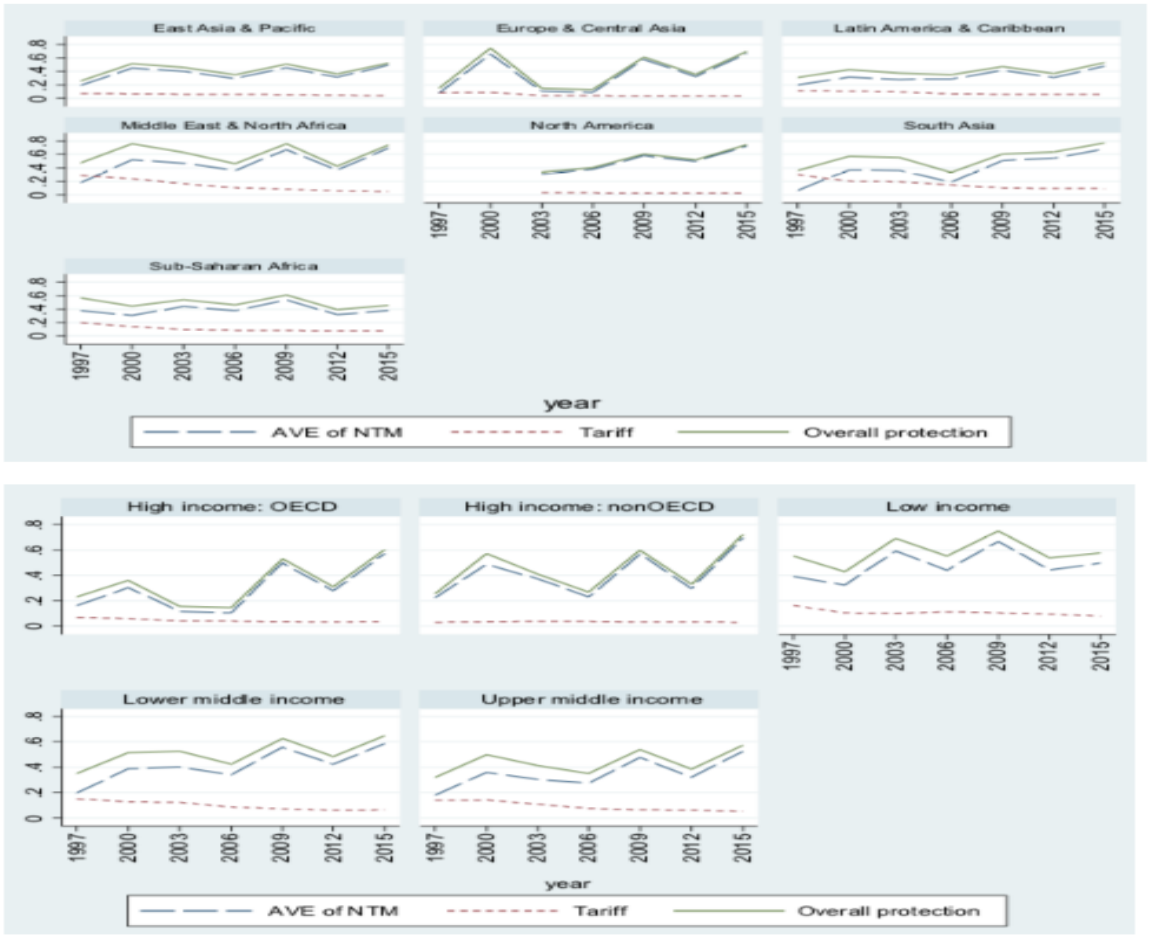
Chapter 1. Introduction

1.1. Background

International trade is the study of agents engaging in exports and imports activity. The traditional literature on international trade often focused on trade policies such as tariffs (Blanchard et al., 2017; Eaton and Kortum, 2002), transactions costs from a physical distance or insurance costs (Anderson and Van Wincoop, 2003), the appearance and effectiveness of World Trade Organization (WTO), and upsurge of trade agreements including Free Trade Agreements (FTAs) and Regional Trade Agreements (RTAs) which reflects Most Favored Nation (MFN) rates or bilateral preferential tariff rates (Baier and Bergstrand, 2007; Kawai and Wignaraja, 2010; Lakatos and Nilsson, 2017; Urata and Kiyota, 2003). While the trade liberalization served substantial reductions in trade costs, trade volume has not proportionally grown relative to the reductions.

This research examines whether technical regulations act as hidden barriers for international trade or not, particularly as the conventional trade costs have decreased drastically. WTO (n.d.) defines technical regulations as government-documented regulations that guarantee the characteristics of products or production methodologies for consumer and environmental safety. As non-tariff measures (NTMs) often refer to government policy measures, we quantify NTMs to represent technical regulations through this research. United Nations Conference on Trade and Development (UNCTAD) (2019) denote NTMs as "policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade in goods." (p. 5) Sound purposes of NTMs on protecting consumer and environment, on the other hand, may act as disguised barriers for international trade. As shown in Figure 1.1, overall protection across country groupings follows the average NTMs, whereas tariff rates across country groupings are meager and converge toward zero.

Figure 1.1. Frequency ratio of average NTMs across country groupings from 1997 to 2015



*Source: Niu et al. (2018).

According to WTO (n.d.), technical regulations have explicit objectives. First, they protect human safety and health. Appropriate usage and placing of safety measures to help human health could be a significant role for the technical regulations. Disparate brake types for automobiles for different countries, or labelling of cigarettes are the examples. Second, they protect animal, plant life, and environment. Usage of pesticides or the level of re-cycling are typical examples. The size of the engine displacement to meet a permissible level for vehicle exhaust emissions for different countries is another effort to protect environment. Third, technical regulations prevent deceptive practices. This is highly related to the right usage of labelling. As consumers need to know the precise information of the products, regardless of manufactured goods or agriculture goods, deceptive practices that take advantage of information asymmetry could perturb the domestic market.

To quantify the objects of technical regulations, we adopt the information from NTMs. We focus on the technical measures of NTMs, where the exporters inevitably have to concord

before entering the foreign market. As shown in Table 1.1, specific NTMs correspond with the objectives of technical regulations. Protecting human safety, animal health, and environment safety correspond with Sanitary and Phytosanitary Measures (SPS). SPS deals with the restriction of hazardous substances, safety measures on food, and the prevention of pesticides. Preventing deceptive practices correspond with Technical Barriers to Trade (TBT). TBT focuses on technical specifications for product characteristics, including quality requirements. Some other objectives of technical regulations including quality control and appropriate inspection for the products correspond with pre-shipment inspection. Therefore, we adopt Chapters A, B, and C of the NTMs to quantify technical regulations for this research.[1] We interchangeably use NTMs, regulations, domestic regulations, technical measures to denote technical regulations throughout the research. Sections 1.2 and 1.3 further describe detailed information on NTMs.

Table 1.1. Coverage of NTMs in UNCTAD database

NTMs chapter	Classification	Objectives of Technical Regulations
Chapter A	Sanitary and Phytosanitary Measures (SPS)	1. Protection of human safety or health 2. Protection of animal and plant life or health / environment safety
Chapter B	Technical Barriers to Trade (TBT)	3. Prevention of deceptive practices 4. Other objectives
Chapter C	Pre-shipment Inspection	4. Other objectives
Chapter D	Trade-protection	
Chapter E	Other restrictions including import quotas	
Chapter F	Price control	
Chapter G	Finance measures	
Chapter H	Measures affecting competition	
Chapter I	Trade-related Investment	
Chapter J	Distribution restrictions	

[1] For Chapter 4 (Technical regulations and the Quality of Traded Goods), we only employ Chapters A and B of the NTMs classification.

Chapter K	Post-sales restrictions	
Chapter L	Subsidies	
Chapter M	Government procurement restrictions	
Chapter N	Intellectual property	
Chapter O	Rules of origin	
Chapter P	Export measures	

*Source: UNCTAD (2019) and WTO (n.d.)

While estimating the precise impact of technical regulations on international trade is challenging, increased regulatory policies may hamper international trade. Demand for high-quality products, safety of the consumers, and encouragement of environmentally-friendly goods are the potential reasons for the adaptation of technical regulations. They prevent the misuse and production of hazardous goods for consumers and environment. However, on the other hand, they involve additional costs for exporters and producers, often from the adjustment of production networks to follow the requirements. Complying with additional regulatory policies from the foreign market would increase the regulatory burden for exporters. They may look for other cost-effective market and deviate from the current bilateral international trade relationship. The burden discourages producers from complying with higher costs, buying intermediate goods for final productions, and selling final goods, particularly for manufacturing producers. Regardless of the original purposes of NTMs, complying with additional NTMs from the foreign market may act as a critical regulatory burden for the exporters and producers. Without proper discipline, technical regulations may act as domestic protection and hamper international trade.

As the impact of tariffs are continuously diminishing, technical regulations serve as new frontier for market access and global integration. As complying with technical regulations are compulsory, cumbersome processes or higher costs could be crucial to the current international trade regime, where the production networks are immensely fragmented. To highlight the mandatory characteristics of technical regulations, this research strictly distinguishes technical regulations and standards. Technical regulations are government documents that are highly related to the size, shape, performance, and the label of the products before the sale. Specifically,

the characteristics and production process of the products are closely related to the regulations. The crux of distinction relies on compliance. While conforming to standards is voluntary, complying with technical regulations is mandatory (ITC, n.d.). Products that are not fulfilling foreign standards may still be allowed to enter the foreign market. On the other hand, products without appropriate regulation-compliance may not enter the foreign border.[2] Therefore, the impact of technical regulations on international trade could be larger than the impact of standards, and even tariffs, as they force those products that do not meet the appropriate regulations out of the market. We need to strictly distinguish technical regulations and standards, and carefully examine the impact of technical regulations on the current international trade system.

1.2. Overview of Non-tariff Measures

We adopt technical measures of NTMs to define technical regulations. UNCTAD initiated the Multi-Agency Support Team (MAST) in 2006 to categorize NTMs, where they revised the NTMs classification in 2012, 2016, and 2019 (UNCTAD, n.d.). The original purposes of NTMs do not intend to hamper international trade. NTMs are necessary to protect consumers and environment when appropriately utilized. Policy measures that could fulfill the original purposes with minimum costs as possible would be a desirable effect of NTMs. The NTMs include both technical and non-technical measures. Technical measures focus on the production or production processes, such as SPS and TBT. Non-technical regulations, on the other hand, focus on measures that directly affects the quantity or price of the products. Import license, import quotas, price measures, and financial rate regulations are the examples of non-technical regulations. As non-technical regulations often explicitly impinge international trade, they may not be suitable to examine the impact of technical regulations on international trade. Table 1.1 from Section 1.1 describes the NTMs classification chapters. Chapters A, B, and C typically refer to the technical measures of NTMs. They restrict hazardous substances which could violate food safety (Chapter A: SPS), require necessary production methods and quality requirements suitable for local facilities, consumers, and environment (Chapter B: TBT), and implement pre-shipment inspection for appropriate labelling for potential misusage of information asymmetry (Chapter C). Technical measures often focus on the safety of consumers

[2] Market share of those not complying with standards may still be affected, as consumers prefer higher-quality and safer goods.

and environment which are necessary for local environment. Chapters D through O refer to non-technical measures. Counteracting unfair foreign trade policies such as safeguard measures and anti-dumping (Chapter D), hard measures that increase the cost of imports to control the price of imported goods such as import quotas, licensing (Chapters E and F), restricting the payment methods (Chapter G), granting economic privileges for certain groups (Chapter H), trade-related investment (Chapter I), post-sales services (Chapters J and K), trade subsidies (Chapter L), government procurement restrictions (Chapter M), intellectual property rights (Chapter N), and rules of origin (Chapter O) resemble non-technical measures of the NTMs. Compared to technical measures, they explicitly affect international trade via quality control, price control, and quantity control. Chapter P refers to the exporters' measures of technical regulations. As this research aims to identify the impact of regulations that protect consumer and environmental safety may act as a hidden barrier in international trade framework, we incorporate technical measures of NTMs to depict technical regulations.

UNCTAD began collecting the NTMs data from the six economies participating in Regional Comprehensive Economic Partnership (RCEP): Australia, China (Republic of), India, Japan, New Zealand, and the Republic of Korea. They incorporated the data from Association of Southeast Asian Nations (ASEAN) and constructed global NTMs database.[3] Professionals from each country aggregated government documents and collected information on NTMs to establish consistent and comprehensive database for NTMs. Experts from each economy collected the regulations that are legally documented. They counted the number of each regulation in force and identified individual requirements for each regulation. Then, they sorted the NTMs information by type and imposing bodies, such as government or ministry department. Lastly, they corresponded each regulation with product codes. According to ERIA and UNCTAD (2020), most products have multiple regulations requirements before entering the foreign market.

UNCTAD NTMs database aggregates the NTMs information from each country's legal texts and constructs comprehensive NTMs database associating with all tariff line codes.[4] Past NTMs databases including WTO Integrated Trade Intelligence Portal (I-TIP) database, Specific Trade Concerns (STC) database, and International Trade Centre (ITC) business survey database, often

[3] See https://trains.unctad.org/ for more details.
[4] See ERIA and UNCTAD (2020) for more details on specific departments in government that impose regulations related to NTMs. They are different for each country.

aggregates NTMs information when each importing or exporting country reports any regulations; often time from improper imposition of regulations by the partner country. These databases may lack information on NTMs if they are not reported. Therefore, we utilize the NTMs data from UNCTAD database to take advantage of the recently published comprehensive NTMs database.

1.3. Objectives

Defining domestic technical regulations as NTMs, trade literature, however, has focused on the trade-distorting effect of NTMs. Domestic regulations constitute a grey area where trade policy meets public policy goals. They protect plants, animals, and humans from imported diseases, regulate the usage of hazardous substances in production, ensure conformity with common standards, and protect the environment. By incurring procedural costs and compliance costs, however, NTMs may hamper the competitiveness of some exporting firms and, consequently, impede trade flows, notably for small exporters in low-income countries. Blum et al. (2020) suggest countries to impose NTMs that avoid per-shipment costs. They theoretically argue that the implementation of NTMs creates per shipment cost (fixed cost). Existence of per-shipment cost enforces firms to deviate from the current foreign market and change the shipping frequency and decisions to ship. They suggest that harmonization on the information of NTMs imposition pattern would immensely decrease the cost of NTMs and lowering per-shipment cost is significant.

Utilizing French firm level custom exporter data, Fontagné et al. (2015) and Fontagné and Orefice (2018) show negative impact of NTMs on international trade. Fontagné and Orefice (2018) theoretically and empirically tested the impact of TBT on international trade. They constructed dummy variable from WTO STC NTMs database to represent the existence of TBT. The results indicate that stringent TBT imposition increased the fixed costs and enforced exporters to divert trade toward partners with less TBT measures. While TBT affected the extensive margin of international trade over different counterparts (diversification over different partners), Fontagné et al. (2015) showed that SPS imposition negatively affect both the extensive and intensive margin of international trade. Defined as the dummy variable representing the existence of the regulations using NTMs data from WTO STC database, SPS reduced both the new participating firms and the value of the goods remaining in the market.

The effects were severe for small countries and alleviated for large exporters. Fugazza et al. (2018) examined the role of NTMs on exports from Peru to other Latin American Integration Association (LAIA) nations. Unlike Fontagné et al. (2015) and Fontagné and Orefice (2018), they aggregated NTMs data from existing trade legislation from LAIA economies. They empirically test the impact of NTMs on Peruvian exports and argue that both tariffs and technical regulations hamper international trade of small exporters, whereas benefit large exporters. The results indicate that regardless of the purposes, domestic protection and trade protection both benefit large exporters at the expense of relatively small exporters. Indeed, as suggested by Kee et al. (2009), developing nations have higher restriction on trade regimes and at the same time face higher trade barriers. Multilateral and bilateral reciprocity explains the results. Based on gravity analysis, Hoekman and Nicita (2008) also argue that both tariffs and NTMs restrict trade particularly for low-income countries.

There have been lively policy debates at national and international levels on NTMs, and whether trade-restrictive NTMs should be eliminated (Doan et al., 2019). To assist policymakers in formulating appropriate policy responses, analysis on the impact of NTMs on trade policies and whether NTMs restrict trade or pursue any legitimate regulative aim is necessary. Following the traditional literature on trade, trade restriction may induce welfare losses (Baldwin, 1989; Irwin, 2010), while positive externalities associated with NTMs may improve welfare (Beghin et al., 2015a). They are legitimate public policy tools to address market failures, and disregarding the necessity of regulations leads to the common misconception of regulations as a merely disguised trade barrier. Nevertheless, empirical evidence on the potential welfare-improving aspect of NTMs is scarce.

To thoroughly examine the impact of technical regulations on international trade, we dissect international trade as i) the extensive and intensive margins of international trade, ii) Global Value Chains (GVCs) participation, and iii) the quality of traded goods. We begin by assuming that technical regulations ensure the safety of consumers and the environment. We construct the Additional Compliance Requirement Indicator (ACRI) following Nabeshima et al. (2021) to examine the additional burden of the exporters. The indicator allows the research to adopt a bilateral index on technical regulations. As exporters may not necessarily feel burdensome for complying with similar regulations in both domestic and foreign markets, the number of NTMs or importer-oriented coverage ratios may not be adequate in explaining the impact of NTMs. Depending on the chapters, we define NTMs with SPS, TBT, and pre-shipment inspection.

Chapters 2 and 3 adopt all three information when constructing ACRI, and Chapter 4 adopt SPS and TBT when constructing ACRI.[5] Table 1.1 Explains the NTMs measurements of this research.

We first analyze the impact of technical regulations on the extensive and intensive margins of international trade. Past trade literature often focused on the total volume of trade. However, analysis on the total volume of exports does not consider whether the increase or decrease in exports results from growth in incumbent goods (intensive margin) or through product diversification (extensive margin). We follow Hummels and Klenow (2005)'s methodology on decomposing exports to extensive and intensive margin and empirically test the impact of ACRI on the two margins.

Unlike Fontagné et al. (2015) and Fontagné and Orefice (2018), we conduct our analysis with NTMs data from UNCTAD. While they transformed SPS and TBT dummy to take account of the multilateral characteristics of international trade (dummy variable takes the value of one if TBT or SPS are in force among any of the trade counterparts), we instead adopt bilaterally and multilaterally constructed NTMs from UNCTAD database. Moreover, we construct ACRI to focus on the additional burden of exporters. Mere existence of technical regulations between two trading partners may not be adequate to represent the burden of technical regulations. If the exporters are imposing identical or similar regulations at the time of exporting, the regulations may no longer be a barrier for exporters to enter the foreign market. The results indicate that additional regulations hamper international trade through product diversification (extensive margin) and the quantity margin of incumbent goods (intensive margin).[6]

Second, we discuss the impact of technical regulations on the Global Value Chains (GVCs) participation. As the current production network is highly fragmented, participating in GVCs is significant and inevitable. Developing nations may have a higher chance of achieving economic development through exports by participating in the GVCs network. Unlike bilateral trade, comparative advantage from developing nations may be a significant portion of anonymous trade partners taking part in the fragmented production network. We decompose GVCs participation into forward and backward participation to decompose the foreign value-added and domestic value-added content of exports from the GVCs framework. Korwatanasakul and

[5] Chapter 3 examine the impact of technical regulations on the quality of traded goods. We assumed that pre-shipment inspection could act as a unnecessary costs for improving quality.
[6] Chapter 2 is based on the original work by Nabeshima et al. (2021).

Baek (2020) utilized data from UNCTAD to measure regulatory burden. They argue that additional burden from NTMs discourage the participation in GVCs through backward participation. We deviate from their work by the followings: We employ recently updated panel NTMs data from UNCTAD, while they adopted the cross-section NTMs data prior to the recent updates. Second, our construction of ACRI is different from their research. Their construction mostly follows Nabeshima and Obashi (2020) which conducts cosine similarity between the exporter and importer vector of NTMs imposition. However, our research adopts Nabeshima et al. (2021) which conducts cosine similarity between the exporter and aggregate vector of NTMs imposition. This methodology allows us to assume that exporters need to comply with domestic technical regulations before entering the foreign market, which is more justifiable. Lastly, we conduct analysis for different sectors (i.e., manufacturing and agriculture). The results show that additional regulations overall hamper both forward and backward participation and the regulations seem to be more harmonized in agriculture sectors compared to manufacturing sectors.

Lastly, we consider the relationship between the quality of traded goods and additional technical regulations. Handful of research examined the theoretical and empirical impact of costs and quality. We incorporate NTMs as fixed costs to determine the impact of technical regulations on the quality of traded goods. Ghodsi and Stehrer (2021) empirically examine the positive role of NTMs on the quality of traded goods. They construct NTMs dummy variable and aggregate count of NTMs from WTO I-TIP database. NTMs dummy variable possesses the value of one when importers impose SPS or TBT measures on specific trading partners. Aggregate count of NTMs refer to the total number of NTMs imposed on importer-exporter-year-product level. They construct quality measure following Hallak and Schott (2011), decomposing pure price and quality index. The empirical results indicate that TBT and SPS incur higher quality of traded goods. We deviate from their work as the followings: We adopt UNCTAD NTMs data as explained above, instead of WTO I-TIP database. Then, we construct ACRI to capture the additional burden of exporters. Lastly, we construct price-controlled quality measure following Henn et al. (2020) instead of Hallak and Schott (2011). Indeed, conventional quality index, which is the unit value, may not capture quality appropriately due to its inevitable price-oriented characteristics. However, at the same time, quality may not be solely evaluated apart from price. In certain area and aspects, higher price does indicate higher quality. Therefore, we instead construct Quality Estimate from Henn et al. (2020) which

controls for price using series of empirical regressions. Unlike previous negative impacts on international trade, this chapter shows that additional regulations enhance the quality of traded goods.

As NTMs often refer to sound purposes to ensure the safety of consumers and the environment, mere eradication of NTMs may not always benefit the global economy. The analysis above found that NTMs hamper international trade through the extensive and intensive margin and GVCs participation. However, NTMs also contribute to higher-quality goods which could be critical for the consumers and environment. Chapters 2 to 4 empirically discuss the impact of technical regulations on international trade.

1.4. Contribution

Past literature often overlooked the impact of technical regulations on international trade flow. However, while the magnitude of tariff rates is decreasing, the magnitude of domestic regulations is enlarging. This study attempts to quantify technical regulations and empirically test its effect on international trade. Along with the objective of this research, this research originally contributes to the international trade literature as:

1. Understanding technical regulations. As shown in the previous sections, technical regulations are different from standards. The conformity, however, could act as a crucial and hidden barrier for exporters to comply with. Majority of the literature still use technical regulations and standards in the same context. We strictly distinguish technical regulations and standards.

2. Quantifying NTMs with ACRI. Quantification of qualitative NTMs information has been a crucial shortcoming. Past efforts to construct NTMs using coverage ratio and frequency index were not capable of taking account of the exporters' imposition of NTMs and their genuine burden between bilateral trade with trading partners. Employing cosine similarity index, ACRI bilaterally calibrates the additional burden of exporters which could overcome the shortcoming of conventional methodologies of quantifying NTMs: dummy variable, aggregate count, coverage ratio, and frequency index.

3. Decomposing international trade and empirically testing the role of technical regulations. We decompose international trade with the extensive and intensive margins of international trade, backward and forward participation in GVCs, and the quality of traded goods. Analysis on

aggregated trade may not be precise as they often show mixed results of trade nature. By decomposing international trade, we separately test the role of technical regulations on different nature of international trade.

The positive role of NTMs to support human and environment safety must not be overlooked. However, they may hamper international trade. Therefore, harmonization of NTMs between trading partners, among sectors, and in production network is necessary. Throughout this research, we define NTMs, evaluate its impact on international trade, and discuss the role of NTMs in current international trade literature.

Chapter 2. Technical Regulations and the Margins of International Trade

2.1. Background

In international trade, the issue of NTMs has gained greater importance in recent years, both academically and in policy discussions. Over the decades, trade liberalization through tariff reductions has played an important part in shaping the current global economy. The "East Asian Miracle" and the rise of the ASEAN are proof of the positive linkage between active participation in international trade, and economic and industrial growth. Nevertheless, the expected growth rate of global trade is slowing down, and with that, there are concerns that NTMs have been misused. In such a case, producers and consumers may suffer from higher production costs and prices due to the existence of NTMs and their regulatory requirements. Despite its impact on correcting the market failure, the majority of existing studies show a negative effect of NTMs on international trade flows.

In addition, while the main purpose of the NTMs is to protect domestic consumers in a variety of aspects such as health, safety, and environmental protections, in some cases, these NTMs may be utilized as a disguised form of protectionism. A study by Grundke and Moser (2019) examined the impact of port refusals in the US market on the subsequent bilateral trade relationships which failed to comply with food safety standards. They found that past port refusals led to reductions in the trade of the affected goods from the violating countries, and this disproportionately affected developing countries. They also found that during crises, such as the US subprime crisis in 2008, the impact was stronger, suggesting that NTMs may be used as a way for hidden protectionism.

Thus, NTMs seem to have a negative effect on international trade, especially for developing countries and smaller firms. In fact, for many sectors, the impact of NTMs is larger than that of tariffs. This is especially so if tariff rates and non-tariff measures are treated as substitutes, and lower tariff rates do not necessarily mean that market access is more liberalized. For instance, Herghelegiu (2018) finds that the likelihood of adopting NTMs is higher in the European Union (EU) and Japan if the initial tariff levels are higher. Especially for developing countries of relatively small economic size, continued reliance on external markets and the nurturing of vibrant exporting sectors will be key economic considerations to achieve high growth rates in order to avoid and escape from the middle-income trap.

Most previous studies examining trade and the economic effects of the existence of certain kinds of NTMs in importing countries do not take into account how different these regulations are from those of the exporters. In principle, exporters should meet all the domestic regulations in their country of origin. In most cases, countries tend to implement similar types of regulations for a given product. Therefore, it would be reasonable to assume that there are some overlaps in regulations for a pair of countries. Thus, the real impact of NTMs in importing countries should be additional requirements which are not imposed in the exporting country, with which exporters need to comply. Our study focuses on this additionality as the main explanatory variable to analyze the trade impact of NTMs, with particular focus on bilateral extensive and intensive margins of trade.

In this study, we narrow our focus on trade relationships that have positive trade flows. We first examine whether the additional requirements diminish trade values and then look into the different effects on the margins of trade. In other words, we are interested in analyzing which margin of trade accounts for the trade-diminishing effect of the regulatory burdens. Within the destination market of a particular industry, is a country facing more regulatory burdens likely to export a narrower set of goods and lower quantities at higher prices? The study builds on the literature looking at the margins of trade using finely disaggregated product-level trade data (e.g., Debaere and Mostashari, 2010; Hummels and Klenow, 2005; Kehoe and Ruhl, 2013).

Specifically, our methodology follows the work of Hummels and Klenow (2005), which decomposes the differences in export flows to a particular market among origin countries into the intensive margin and the extensive margin.[1] Bao and Chen (2013) examined the trade effect of the total number of notifications of TBT to the WTO by importing countries following Hummels and Klenow (2005). They looked into the margins of bilateral trade flows aggregated over sectors and found that TBT enhanced trade primarily by expanding the range of goods traded rather than by increasing the trade values of each good. In a similar vein, Shepherd (2015) studied the impact of EU product standards on the extensive margin of trade in the textile, clothing, and footwear sectors. Shepherd (2015) found that the international harmonization of standards was associated with an increase in product variety, particularly for the exports from developing economies. While our research interest is closely related to Bao and Chen (2013)

[1] Price as well as quantity components of the intensive margin. Extensive margin refers to the product variety.

and Shepherd (2015), this study contributes to the literature by quantifying regulatory burdens and analyzing their effects on different margins of trade at the sectoral level.

To quantify the regulatory burdens that an exporting firm may face when serving a foreign market, we construct the Additional Compliance Requirement Indicator (ACRI), revising the methodology from Nabeshima and Obashi (2020). The construction of the ACRI requires detailed information on technical regulations in many countries. This study uses a new database created by the UNCTAD in collaboration with many other entities. This database contains a description of each mandatory regulation, which is enforced by national legislation, along with the measure types coded according to the NTMs classification by UNCTAD, the affected products specified at the Harmonized Commodity Description and Coding System (HS) six-digit level, and the country codes for the imposing and affected countries[2]. Utilizing this detailed information, we construct the ACRI to estimate the impact of regulatory burdens on margins of trade. Furthermore, unlike Bao and Chen (2013) and Shepherd (2015), we differentiate the price and quantity components of the intensive margin and highlight the contrasting effects of the ACRI on prices and quantities traded.

Using the data for bilateral trade and associated margins calculated at the HS two-digit sector level for 98 x 97 country pairs as well as the constructed ACRI at the sector level, we find that regulatory burdens diminish trade values. To comply with additional requirements in the destination market, exporting firms incur fixed costs to establish the capacity and, subsequently, variable production costs (Bao and Chen, 2013; Chen et al., 2008; Ganslandt and Markusen, 2001). Such fixed costs of adapting products to foreign destination markets are thought to be associated with a narrow set of exported goods on the extensive margin. Meanwhile, higher marginal costs push up the unit price of exported goods, decreasing quantities traded on the intensive margin. Consistent with these predictions, we find that regulatory burdens influence the extensive and intensive margins of trade differently, beyond the overall trade-diminishing effect. Within a particular sector of the destination market country, a country facing more regulatory burdens exports a narrower set of goods on the extensive margin and exports lower quantities of each good at higher prices on the intensive margin.

[2] Depending on their nature, the regulations can apply to all countries or to a specific country or region.

Aside from the aforementioned literature on the margins of trade, our study is also related to the following two branches of literature analyzing the trade effect of NTMs[3]. The first branch of the literature computes the tariff equivalents of NTMs by looking at either the quantity traded or the prices of imported products. The quantity-based approach estimates the ad valorem equivalents (AVEs) of tariffs by comparing the estimated and actual trade values, determining at what tariff levels the actual trade value would be observed based on international trade data (e.g., Kee et al., 2009). The price-based approach utilizes extensive data on domestic prices, information on transportation costs, and international prices, and considers any price gap to be attributable to the impact of NTMs (e.g., Cadot and Gourdon, 2016; Cadot and Ing, 2015). In both approaches, the issue of NTMs is implied but not addressed specifically. The traditional approach of using tariff equivalents indicates only that there might be some overall trade restrictiveness with regard to imports of a given product, but it does not reveal where that restrictiveness might arise[4]. In essence, the tariff equivalent approach leaves the NTMs component as a black box. However, it was necessary to rely on this approach given the lack of a systematic database of NTMs.

The second branch of the literature analyzes the trade effect of NTMs at the firm level, paying more attention to firm heterogeneity. For instance, Fontagné et al. (2015) used the WTO database for specific trade concerns reported by exporters, which were then matched to the export data of French firms. The authors found that concerns regarding SPS standards in the destination market adversely affected the export participation of firms as well as the extensive and intensive margins of exports, with a dampening effect for the larger firms. They also detected a positive effect of SPS-related concerns on the unit value of exports due to possible incentives for firms to increase the price of exported goods. Studies like Fontagné et al. (2015), however, require firm-level export data, which is not available for many countries.

In the absence of firm-level data, Helpman et al. (2008) estimates the probability of exporting, and estimates the trade volume based on two-step procedures. They take into accounts for the selection bias and firm heterogeneity. Following their methodology, Shepotylo (2016) and Bao (2014) examined the trade effect of NTMs. Alternatively, Crivelli and Groeschl (2016), Disdier

[3] There are also a large number of studies that include NTMs (or a subset of them) in a gravity framework.
[4] In addition, the quantity-based approach is based on the assumption that the model (often a gravity-type model) is specified correctly. Any misspecification could turn up as the ad valorem equivalent. For the price-based approach, the question remains as to how much market structures in each country differ. Higher domestic prices could be the result of a more concentrated market structure, which may or may not be the result of NTMs.

and Marette (2010), and Xiong and Beghin (2014) apply a Heckman selection model, controlling for sample selection bias but not for firm heterogeneity bias. Given that this research focus on the cross-section data of NTMs, we also refrain from examining the probability of trade. Instead, we focus on positive trade flows and examine whether regulatory burdens diminish trade values and investigate their different effects on the margins of trade.

The remainder of this paper is organized as follows. After describing the NTM, trade value, and quantity data in the next section, Section 2.3 presents the methodologies used to construct the ACRI and measures the bilateral extensive and intensive margins of international trade. Section 2.4 uses the ACRI to estimate its effects on the bilateral margins of trade, and Section 2.5 provides concluding remarks.

2.2. Data Description

This section describes the two main types of data we use in our analysis. First, we make use of detailed NTMs information to quantify the additional requirements imposed by importing countries. We also use the NTMs data to construct a coverage ratio of hard measures that is controlled for in the estimating equation. Second, we use the finely disaggregated product-level data of bilateral trade values and quantities to analyze the effects of regulatory burdens on the bilateral margins of trade.

2.2.1. Data for NTMs

We use the researcher file from the NTMs Trade Analysis Information System (TRAINS) database, publicly available at the webpage from UNCTAD, and the Stata statistical software package, version 12. This new database provides a snapshot of the NTMs affecting imports and exports for 85 countries at the time of data collection.[5] Although the year of data collection varies across countries, ranging from 2012 to 2017, the data collection year for three-quarters of the countries is 2015 or 2016. In the current study, we aim to examine the implementation pattern of regulations effective in the 2015-2016 period. Using the NTMs data collected in 2015

[5] We extracted the data in December 2019. UNCTAD TRAINS recently updated the database with multiple years, albeit highly unbalanced. Chapters 3 and 4 utilize the updated panel data when quantifying NTMs.

and later years, we narrow our focus down to the recorded measures whose starting years are before 2017 and ending years are after 2016[6].

Scrutinizing national legal documents, the database systematically records the mandatory measures that are implemented against merchandise products imported from abroad in a non-tariff form. For each measure, we have information on the implementing country, the type of measure, the affected product, and the affected country.

For the measure types, recorded measures are categorized into chapters based on their purpose following MAST 3 version of NTMs classification (UNCTAD, 2015)[7]: A (SPS measures); B (TBT); C (pre-shipment inspection and other formalities); E (non-automatic licensing, quotas, prohibitions, and quantity control measures other than SPS or TBT reasons); F (price control measures including additional taxes and charges); G (finance measures); H (measures affecting competition); or I (trade-related investment measures). Each of the eight chapters is divided into groupings with depth up to three levels or three-digit numerical codes in a hierarchical tree structure.

The corresponding HS codes of the affected products are reported based on national tariff lines at the most disaggregated level following either the H3 or H4 version of the HS classification. We convert all product information to the 5,224 six-digit codes of the H2 (HS2002) version to ensure consistent matching with the bilateral trade data at the six-digit level[8].

Focusing on the effective measures in 2015-2016 as described above, we eliminate 17 out of 85 implementing (reporting) countries. Among the 17 excluded countries, we manually re-include India, Republic of Korea, and United States (hereafter US) using the latest data

[6] The information on starting and ending dates contained in the NTMs database from UNCTAD is subject to inconsistencies across the reporting countries (Disdier et al., 2020), which might be a result of having different national legislative systems. Instead, we look at the measures that are recorded as being effective during the two-year period so as to better capture the full set of effective regulations at the time of interest.

[7] Although the MAST 3 classification includes 16 chapters, the scope of the worldwide data collection under the UNCTAD initiative has been limited to Chapters A to I and P so far. Among them, Chapter P is reserved for export-related measures and is outside the scope of our study. We also exclude Chapter D (contingent trade protective measures) from our data analysis due to data incompleteness. They are also referred to as M3 classification. See https://unctad.org/topic/trade-analysis/non-tariff-measures/MAST-Group for more details on the MAST classification.

[8] We employ the H2 version of the HS classification because the Philippines reports its trade statistics based on the H2 during the period of interest. The conversion tables from the newer to the older HS version are obtained from the webpage of the Trade Statistics Branch of the United Nations Statistics Division: https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp.

available[9] from a detailed query of the UNCTAD TRAINS website. In addition, while the EU is included as a single statistical reporting unit in the UNCTAD TRAINS NTMs database, we consider the 28 individual EU member countries separately in our analysis of bilateral regulatory burdens and their effects on bilateral trade. Ultimately, we reorganize the NTMs data set on a bilateral basis by looking at the affected country information for each of the implementing countries as well as expanding the EU to the individual member countries. Our data set includes 98 x 97 country pairs (85-17+2+1-1+28=98)[10].

2.2.2. Data for Trade Values and Quantities

We obtain bilateral trade data at the HS six-digit product level of the H2 version for 2015 and 2016 from the United Nations Commodity Trade Statistics Database (UN Comtrade). We primarily use import statistics and complement the missing import values and quantities with "mirror data;" the corresponding figures reported by the trading partner country in its export statistics[11]. When the missing import values are replaced by the mirror data, we adjust for the cost of insurance and freight (CIF) by multiplying a conventional CIF/FOB ratio of 1.1, where FOB refers to Free on Board. In addition, we ignore product-level bilateral trade values less than US$1, which appear to be unrealistic and negligible[12].

To compute the price margin as a part of the intensive margin of trade, we first need to calculate the unit values using the trade quantity as well as the value data. In the product-level bilateral trade data set described above, one-tenth of the observations are either zero or missing. We exclude those observations from our data set. In addition, regarding data reliability, we refine the data set by excluding the following observations. We exclude quantity figures with i) no unit information, ii) number of items, number of pairs, and number of packages less than one which are unrealistic, and iii) data inconsistency that utilize different units of quantity for a particular product among reporter-partner groupings, based on the information from quantity tokens.[13]

[9] They were not incorporated into the researcher file at the time of data collection.
[10] See Appendix A for the list of 98 sample countries.
[11] See Appendix B for the availability of import statistics for the sample countries.
[12] Employing different threshold values did not change the estimation results qualitatively.
[13] For the details of the quantity classification, see the webpage of the World Bank: https://wits.worldbank.org/wits/wits/witshelp/Content/Codes/Quantity_Tokens.htm.

For the purpose of matching with the NTM data, we take an average of trade values and quantities between 2015 and 2016 as long as the data is available, after complemented by the mirror data, in both years; otherwise, we ignore missing figures and adopt the figures reported in either year. In doing so, we smooth out yearly fluctuations and minimize the number of missing observations.

2.3. Methodology

In this section, we begin my arguing that technical regulations do not necessarily restrict trade. It is not the mere presence of technical regulations in the export destination countries that is trade-restrictive, but the additional requirement faced by exporters upon entering the destination markets. Approximating such additionality, we construct the ACRI in Section 2.3.2. To analyze the trade effects of the ACRI, section 2.3.3. demonstrates how to measure the bilateral extensive and intensive margins of trade. Section 2.3.4. derives a set of reduced form equations to be estimated, which is followed by the descriptive statistics in Section 2.3.5.

2.3.1. Trade-diminishing Effect of Technical Measures

To quantify the regulatory burdens faced by an exporter in serving a foreign market, our focus is on the mandatory measures of technical regulations, such as SPS measures and TBT recorded in the UNCTAD TRAINS NTMs database. According to the measure definitions in the M3 classification, we consider NTMs classified under Chapters A, B, or C as technical measures. However, we exclude A11 (temporary geographic prohibitions for SPS reasons), A12 (geographical restrictions on eligibility), and B11 (prohibition for TBT reasons) because imports are, by definition, explicitly prohibited upon the implementation of these measures, unlike other technical measures of interest[14].

The presence of technical measures is not necessarily trade-restrictive, unlike other non-technical NTMs (barriers)[15]. Technical measures can be barriers to trade if countries enforce

[14] Although the manually collected NTM data for India, Korea, and the US is recorded based on the newer M4 classification, there are no significant differences in the technical measure codes of interest that interrupt with the research sample groupings.

[15] NTMs coded under Chapters E, F, G, H, or I are different from technical measures in terms of their impact on international trade. Chapters E and F are quantity- and price-control measures, or the "hard" group of measures, implemented at the border, which have a discriminatory intent and are expected to always decrease trade. Chapters G, H, and I contain behind-the-border measures restricting the payments of imports, market

different regulations, but they can also enhance trade if countries impose technical requirements in an internationally harmonized manner or streamline conformity assessment procedures through mutual recognition agreements. What is trade-restrictive is not simply the presence of technical regulations in the export destination but substantially effective measures at the destination relative to the origin country. As a thought experiment, suppose that Measure A is enforced in the home country, while Measures A and B are enforced in the foreign country. As domestic firms operating in the home country already comply with Measure A, only Measure B requires additional compliance actions to expand operations to include exporting to the foreign country.

Thus, to identify the trade-diminishing effect of technical measures, we need to approximate the additional compliance requirements of effectual measures at the export destination. Following Nabeshima and Obashi (2020), we construct the ACRI, based on the proximity measure called cosine similarity, described in detail in the following subsection[16].

2.3.2. Constructing Additional Compliance Requirement Indicator

We first construct a vector representing a regulatory pattern of technical measures regarding product *p* implemented domestically in the origin country *i* as:

$$F_{ip}^{D} = \left(F_{ip1}^{D},\ \ldots,\ F_{ipk}^{D},\ \ldots,\ F_{ipK}^{D}\right), \tag{1}$$

where F_{ipk}^{D} is the number of technical measures in force within a measure type grouping *k*. Superscript *D* refers to the domestic market in terms of exporters. This domestic regulatory pattern vector is approximated by a set of technical measures implemented in the origin country *i* against imports from all countries with no discrimination among trade partners, which are also expected to be applicable to domestic production and sales.

We consider 18 groupings (i.e. $K = 18$) of technical measure types, as listed in Appendix C. We create groups at the one-digit numerical level for technical measures classified under Chapters A and B. Meanwhile, we divide measures classified under Chapter C into two groups based on their purposes. One group consists of measures affecting both domestic and imported

competition, and investments, which might adversely affect trade.

[16] Cosine similarity is often used to compare the content between documents, such as the frequency of a particular keyword. In the economics field, patent literature (e.g., Branstetter, 2006; Jaffe, 1986) uses cosine similarity to measure the proximity of one firm to another in terms of patenting patterns.

products, such as pre-shipment inspection requirements coded as C1. The other group consists of those affecting imports only, namely, C2 (direct consignment requirement), C3 (requirement to pass through specified port of customs), and C4 (import-monitoring and -surveillance requirements and other automatic licensing measures)[17].

To count the number of technical measures by type grouping, we take into consideration the unbalanced tree-like structure of the NTMs classification. For technical measures classified under Chapters A and B, although there exist several three-digit numerical codes under A85 and B85, we check the incidence at the two-digit numerical level and count the number of measures by group. The measure of Chapter C, on the other hand, is recorded with a one-digit numerical code, and we also count its number by group[18]. Each element of the vector (F_{ipk}^{D}) therefore takes an integer value between 0 and the maximum possible number shown in Appendix C[19].

The count of technical measures may be affected by the potential number of measures enforced in combination, depending on the different legislative systems across countries. Nevertheless, the cumulative burden of multiple forms and types of similar measures, even if imposed to achieve equivalent policy objectives, can be burdensome for exporting firms. Thus, we count the number of technical measures by measure type groupings rather than using binary variables to represent the regulatory pattern. In addition, when calculating cosine similarity to gauge the proximity between a pair of regulatory pattern vectors, a relative frequency of technical measures of each grouping (i.e. a proportion in the overall number of observations for the country), as opposed to a nominal frequency, will be relevant.

We construct another vector representing a regulatory pattern in the destination country j against imports of a certain product p from the origin country i as:

$$F_{ijp}^{F} = \left(F_{ijp1}^{F}, \dots, F_{ijpk}^{F}, \dots, F_{ijpK}^{F}\right), \tag{2}$$

[17] Technical measures of Chapters A and B, except import prohibitions for SPS and TBT reasons (i.e. A11, A12, B11), are thought to affect both domestic and imported products.

[18] If a relevant legal document does not provide enough information to assign the measure to a disaggregated level, a technical measure is coded at a higher level even though more disaggregated codes exist. Such cases are rare exceptions and account for 3% of the technical measures recorded in our data set. Also, if a requirement is precisely defined in a legal document but does not match any of the existing codes, the "not elsewhere specified (n.e.s.)" code is used. For the sake of simplicity, we merge the higher-level codes into the corresponding n.e.s. codes. See UNCTAD (2014) for more details on when the higher-level and n.e.s. codes are used in constructing the original database.

[19] To consider the relatedness among measure codes, we could alternatively use the Mahalanobis distance with the "revealed" relatedness matrix among the vector elements (Bloom et al., 2013).

where vector F_{ijp}^{F} is the number of technical measures in force within a type grouping k. Superscript F indicates foreign market for the exporters i.

Using a pair of domestic and foreign regulatory pattern vectors (F_{ip}^{D} and F_{ijp}^{F}), we next approximate the additional compliance requirements of effectual measures on product p, implemented in the destination country j, relative to the domestic regulatory regime in the origin country i. We assume that the greater the degree of effectual measures, the greater the additional compliance requirements. To quantify the degree of effectual measures, we apply cosine similarity to measure the proximity of the domestic regulation vector to the other vector for a set of domestic and foreign regulations faced by firms exporting to a foreign country. The former domestic regulation vector is F_{ip}^{D} as explained above. The latter vector is constructed by aggregating each pair of elements of the domestic and foreign vectors as:

$$F_{ijp} = \left(F_{ip1}^{D} + F_{ijp1}^{F}, \dots, F_{ipk}^{D} + F_{ijpk}^{F}, \dots, F_{ipK}^{D} + F_{ijpK}^{F}\right), \tag{3}$$

where we assume that firms exporting to a foreign country are always serving the domestic market as well and thereby are required to comply with both domestic and foreign regulations.

The cosine similarity of F_{ip}^{D} to F_{ijp} is calculated as:

$$\mathrm{Cos}(\theta)_{ijp} = \frac{F_{ip}^{D} \cdot F_{ijp}{}'}{\|F_{ip}^{D}\| \|F_{ijp}\|} = \frac{\sum_{k=1}^{K} F_{ipk}^{D} F_{ijpk}}{\sqrt{\sum_{k=1}^{K} \left(F_{ipk}^{D}\right)^{2}} \sqrt{\sum_{k=1}^{K} \left(F_{ijpk}\right)^{2}}}, \tag{4}$$

where $\mathrm{Cos}(\theta)_{ijp}$ is represented using an inner product of the two regulatory pattern vectors and their magnitudes. θ is the measure of angle between the vectors, and takes a value between 0 degrees (identical) and 90 degrees (orthogonal) because both vectors are composed only of elements with positive integer values. The lower the cosine similarity, the more the combined vector is de-correlated with the domestic regulation vector (i.e., the greater the degree of effectual measures in the destination country j). We implicitly assume that the degree of effectual measures is mainly attributable to the complexity due to the differences of the foreign regulatory pattern with respect to the domestic regulations.

Using the cosine similarity, we define the ACRI for the destination country j with respect to the origin country i for product p as:

$$\mathrm{ACRI}_{ijp} = 1 - \mathrm{Cos}(\theta)_{ijp}, \tag{5}$$

which takes a higher value when the degree of effectual measures in the destination country *j*, or their additional compliance requirements, is calculated to be greater. The ACRI is bilateral and direction-specific: the ACRI from country A to country B can be different from the ACRI from country B to country A.

Notice that by construction, it always holds that $\text{Cos}(\theta)_{ijp} \in (0,1]$, and as long as both the destination and origin countries implement some regulation against product *p*, $\text{ACRI}_{ijp} \in [0,1)$. As a special case, when the domestic and foreign regulation vectors are identical to each other, $\text{Cos}(\theta)_{ijp} = 1$ and $\text{ACRI}_{ijp} = 0$, implying no additional compliance requirement. When no regulation is implemented against product p in the destination country j while some domestic regulation is enforced in the origin country i, $\text{Cos}(\theta)_{ijp} = 1$ and $\text{ACRI}_{ijp} = 0$. When there is no domestic regulation against product p in the origin country i, we cannot calculate $\text{Cos}(\theta)_{ijp}$; instead, we set $\text{ACRI}_{ijp} = 1$ if there is some regulation implemented against the same product in the destination, and otherwise, $\text{ACRI}_{ijp} = 0$.

Lastly, we construct the sector-level ACRI by taking a weighted average of ACRI_{ijp} across products $p \in P_{ij}^{s}$ within sector s using the worldwide trade share as a weight:

$$\text{ACRI}_{ij}^{s} = \sum_{\text{p}\in P_{ij}^{s}} \frac{V_p}{V^s} \text{ACRI}_{ijp}. \tag{6}$$

V_p is the world total trade value of product p, and V^s is the world total trade value of products in sector *s*.

The ACRI originally proposed by Nabeshima and Obashi (2020) is related but different than the summary indicators aimed at evaluating the dissimilarity or relative stringency of a series of technical requirements based on quantitative information of the maximum residue levels (MRLs) of pesticides and other toxic chemicals (e.g., Drogué and DeMaria, 2012; Winchester et al., 2012). The ACRI is intended to quantify the overall degree of regulatory burdens implied by the qualitative information on the list of technical measures described in various legal documents.

Related to the current study, Cadot et al. (2015) and Cadot and Ing (2015) also evaluate regulatory differences between countries based on the product-level qualitative information of technical measures. The regulatory distance measure proposed by these authors is intended to capture differences in the overall regulatory regime between a certain pair of countries and are

calculated to be symmetric by nature for the pair of countries. In contrast, ACRI is bilateral and direction-specific. Note, also, that the conventional count variable and frequency index of technical measures can be constructed on a bilateral basis, considering the set of measures implemented in the importing country against a particular origin country. These indicators, however, are destination country-specific in a substantial sense, given the fact that discriminatory implementations of technical measures differentiating between trading partner countries are rare (Nabeshima and Obashi, 2020). In contrast, the calculated ACRI of a certain destination country varies across its trading partners.

2.3.3. Decomposing Bilateral Trade Values to Extensive and Intensive Margins

To measure the extensive and intensive margins of trade, we follow the decomposition methodology originally proposed by Feenstra (1994) and further developed by Hummels and Klenow (2005), Broda and Weinstein (2006), and Feenstra and Kee (2008). Although we could simply count the number of products exported within a certain group or sector as a measure of the extensive margin, we adapt the approach by Feenstra (1994) because it is theoretically grounded and considers the different economic weights of different products.

Specifically, we define the bilateral extensive and intensive margins in line with Hummels and Klenow (2005), but we consider the margins by sectors. Let P_{ij}^{s} denote the set of (observable) product categories (in our empirical implementation, at the HS six-digit level) in which origin country *i* has a positive value of exports to destination country *j* within sector *s* (at the HS two-digit level). For the case when country *i*'s shipments to country *j* are a subset of a reference country *k*'s shipments to country *j*, the extensive margin is defined as:

$$\mathrm{EM}_{ij}^{s} = \frac{\sum_{\mathrm{p}\in P_{ij}^{s}} r_{kjp} q_{kjp}}{\sum_{\mathrm{p}\in P_{kj}^{s}} r_{kjp} q_{kjp}}, \tag{7}$$

where *r* and *q*, respectively, denote the export price and quantity. The extensive margin (EM_{ij}^{s}) equals country *k*'s exports of P_{ij}^{s} to country *j* relative to country *k*'s exports of P_{kj}^{s} to country *j*. The corresponding intensive margin is given by:

$$\mathrm{IM}_{ij}^{s} = \frac{\sum_{\mathrm{p}\in P_{ij}^{s}} r_{ijp} q_{ijp}}{\sum_{\mathrm{p}\in P_{ij}^{s}} r_{kjp} q_{kjp}}, \tag{8}$$

which compares nominal shipments from countries *i* and *k* in a common set of products.

In what follows, for each destination market *j*, we choose k to represent all exporters around the world (i.e. the rest of the world other than destination market *j*). Let $P_j^s \equiv \cup_{i \neq j} P_{ij}^s$ be the total set of products imported by country *j* in sector s across the origin countries, and let $V_{jp} \equiv \sum_{i \neq j} r_{ijp}\, q_{ijp}$ be the world total export value of product p to destination market *j*. (7) and (8) can be rewritten as:

$$\mathrm{EM}_{ij}^s = \frac{\sum_{\mathrm{p} \in P_{ij}^s} V_{jp}}{\sum_{\mathrm{p} \in P_j^s} V_{jp}}, \text{ and } \mathrm{IM}_{ij}^s = \frac{\sum_{\mathrm{p} \in P_{ij}^s} r_{ijp} q_{ijp}}{\sum_{\mathrm{p} \in P_{ij}^s} V_{jp}}. \tag{9}$$

The extensive margin can be thought of a weighted count of country *i*'s exported products to destination market *j* relative to the world average. The intensive margin is country *i*'s nominal exports to destination market *j* relative to the worldwide exports to destination market *j* for those products in which country *i* actually exports to destination market *j*. It follows from equation (9) that the proportion of country *i*'s nominal exports in the worldwide exports to destination market *j* equals the product of the two margins:

$$\frac{\sum_{\mathrm{p} \in P_{ij}^s} r_{ijp} q_{ijp}}{\sum_{\mathrm{p} \in P_j^s} V_{jp}} = \mathrm{EM}_{ij}^s \mathrm{IM}_{ij}^s. \tag{10}$$

The intensive margin is then decomposed into the price index and an implicit quantity index as:

$$\mathrm{IM}_{ij}^s = R_{ij}^s Q_{ij}^s. \tag{11}$$

For the price index, we employ a variant of exact price index for the intensive margin following Feenstra (1994). Using the worldwide exports to destination market *j* as a comparison, the price index is given by:

$$R_{ij}^s = \prod_{\mathrm{p} \in P_{ij}^s} \left(\frac{r_{ijp}}{\overline{r}_{jp}} \right)^{w_{ijp}^s}, \tag{12}$$

where $\overline{r}_{jp} \equiv \frac{V_{jp}}{\sum_{i \neq j} q_{ijp}}$. The weight w_{ijp}^s is the logarithmic mean of the share of product p in country *i*'s exports to destination market *j* within sector *s* (denoted by s_{ijp}^s), and share of product p in the worldwide exports of P_{ij}^s to destination market *j* within sector s (denoted by $\overline{s}_{jp}^s$). Specifically, the weight refers to:

$$w_{ijp}^{s} = \frac{\frac{s_{ijp} - \overline{s}_{jp}}{\ln s_{ijp} - \ln \overline{s}_{jp}}}{\sum_{p \in P_{ij}^{s}} \frac{s_{ijp} - \overline{s}_{jp}}{\ln s_{ijp} - \ln \overline{s}_{jp}}}, \tag{13}$$

with $s_{ijp}^{s} \equiv \frac{r_{ijp} q_{ijp}}{\sum_{p \in P_{ij}^{s}} p_{ijp} q_{ijp}}$ and $\overline{s}_{jp}^{s} \equiv \frac{V_{jp}}{\sum_{p \in P_{ij}^{s}} V_{jp}}$. Once the price index R_{ij}^{s} is computed through equation (12), the quantity index Q_{ij}^{s} can be implicitly obtained from equations (9) and (11).

2.3.4. Estimating Equations

Defining $\sum_{p \in P_{ij}^{s}} r_{ijp}\, q_{ijp} \equiv v_{ij}^{s}$ and $\sum_{p \in P_{j}^{s}} V_{jp} \equiv V_{j}^{s}$, it follows from equations (10) and (11) that:

$$\frac{v_{ij}^{s}}{V_{j}^{s}} = \mathrm{EM}_{ij}^{s} R_{ij}^{s} Q_{ij}^{s}. \tag{14}$$

By taking the natural logarithms of both sides on equation (14), we have:

$$\ln v_{ij}^{s} = \ln V_{j}^{s} + \ln \mathrm{EM}_{ij}^{s} + \ln R_{ij}^{s} + \ln Q_{ij}^{s}, \tag{15}$$

where the logged bilateral export value is additively separable in each of the logged, extensive, price and quantity margins at the sector level.

We regress the logged bilateral export value ($\ln v_{ij}^{s}$) as well as the decomposed respective margins, against the additional compliance requirement indicator of interest (ACRI_{ij}^{s}) at the sector level. To do so, we employ a standard cross-sectional gravity equation with a set of origin-sector and destination-sector dummy variables. Our baseline estimating equation is:

$$\ln v_{ij}^{s} = \alpha + \beta \ln C_{ij}^{s} + F_{i}^{s} + F_{j}^{s} + \varepsilon_{ij}^{s}, \tag{16}$$

where F_{i}^{s} and F_{j}^{s}, respectively, denote origin-sector and destination-sector individual effects. These country-sector-specific effects control for multilateral resistance terms and capture the characteristics of technical regulations in individual countries at the sector level (e.g., the number of technical measures implemented in each country, without discrimination among trading partners in most cases). Note that, in practice, before aggregating product-level bilateral trade data into sectoral figures, we exclude origin-destination-product-specific observations subject to import prohibitions for SPS or TBT reasons (i.e., A11, A12, or B11 imposed by the destination country) or for other reasons (E3).

We consider the ACRI as a part of sector-specific bilateral trade costs (C_{ij}^{s}). Specifically, we assume that trade costs take the following form:

$$C_{ij}^{s} = \left(\text{dist}_{ij}\right)^{\gamma_1} \times \exp\left(\gamma_2 \text{contig}_{ij} + \gamma_3 \text{lang}_{ij} + \gamma_4 \text{colony}_{ij} + \gamma_5 \text{deep}_{ij}\right) \times \left(1 + \text{tariff}_{ij}^{s}\right)^{\gamma_6} \times \exp\left(\gamma_7 \text{HM}_{ij}^{s} + \gamma_8 \text{ACRI}_{ij}^{s}\right) \quad (17)$$

where dist_{ij} is the (population-weighted) bilateral distance between the two countries (in kilometers) and contig_{ij}, lang_{ij}, and colony_{ij} are dummy variables indicating whether the two countries have a common border, common official or primary language, and (post-1945) colonial relationship, respectively. These four variables are included as a proxy for country pair-wise cross-border transportation and telecommunication costs, as in Silva and Tenreyro (2006). We obtain these data from Centre d'Études Prospectives et d'Informations Internationales (CEPII) gravity database.[20]

In addition, we control for country pair-wise policy cooperation in SPS and TBT, using the data set of Hofmann et al. (2017) on the content of preferential trade agreements (PTAs). The data set includes information on whether 279 PTAs reported to the WTO and signed in 2015 or earlier contain-provisions regarding SPS (e.g., affirmation of rights and obligations under the WTO Agreement on SPS; harmonization of SPS measures) and TBT (e.g., affirmation of rights and obligations under the WTO Agreement on TBT; provision of information; harmonization of regulations; mutual recognition agreements). Given this information, we construct an indicator variable (deep_{ij}) for a deep trade agreement including SPS or TBT-related provisions between a pair of countries.

As a proxy for bilateral, direction-specific trade costs, we include variables representing the trade policies of destination country against the origin country at the sector level: tariff_{ij}^{s}, HM_{ij}^{s}, and ACRI_{ij}^{s}. First, tariff_{ij}^{s} is a trade-weighted average of AVE bilateral tariffs across products within a sector[21]. We use the worldwide trade share as a weight as in the construction of ACRI_{ij}^{s}. Second, HM_{ij}^{s} is a coverage ratio of the hard measures classified under Chapters E or F.

[20] See http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8 for more details.
[21] Bilateral tariff data at the HS six-digit level is obtained from the World Bank's WITS https://wits.worldbank.org/. If the tariff data is missing in certain years, we replace them with the mean values of the years before and after the period of interest to mitigate abrupt increase or decrease in tariffs. We employ effective tariff rates in the sense that we use the MFN tariff rate unless there is a preferential tariff that is lower than the MFN rate.

Following UNCTAD (2018, p.92), we calculate the sector-level coverage ratio using the worldwide trade share as a weight.

Given (15), we are able to run the same regression as (16) for each of the extensive, price, and quantity margins and examine different effects of the ACRI on different margins. To be more precise, we estimate the following set of equations using the OLS[22]:

$$\ln v_{ij}^{s} = \alpha + \cdots + \delta_6 ln\left(1 + \text{tariff}_{ij}^{s}\right) + \delta_7 \text{HM}_{ij}^{s} + \delta_8 \text{ACRI}_{ij}^{s} + F_i^s + F_j^s + \varepsilon_{ij}^{s} \qquad (18)$$

associated with,

$$\ln \text{EM}_{ij}^{s} = \alpha^{\text{EM}} + \cdots + \delta_6^{\text{EM}} ln\left(1 + \text{tariff}_{ij}^{s}\right) + \delta_7^{\text{EM}} \text{HM}_{ij}^{s} + \delta_8^{\text{EM}} \text{ACRI}_{ij}^{s} + F_i^s + F_j^s + \varepsilon_{ij}^{s,\text{EM}};$$

$$\ln R_{od}^{s} = \alpha^{R} + \cdots + \delta_6^{R} ln\left(1 + \text{tariff}_{ij}^{s}\right) + \delta_7^{R} \text{HM}_{ij}^{s} + \delta_8^{R} \text{ACRI}_{ij}^{s} + F_i^s + F_j^s + \varepsilon_{ij}^{s,R}; \text{ and}$$

$$\ln Q_{ij}^{s} = \alpha^{Q} + \cdots + \delta_6^{Q} ln\left(1 + \text{tariff}_{ij}^{s}\right) + \delta_7^{Q} \text{HM}_{ij}^{s} + \delta_8^{Q} \text{ACRI}_{ij}^{s} + F_i^s + F_j^s + \varepsilon_{ij}^{s,Q},$$

where, given the linearity of OLS, the estimated coefficients always satisfy $\delta_n \equiv \delta_n^{\text{EM}} + \delta_n^{R} + \delta_n^{Q}, \forall n = 1, \ldots, 8$.[23]

By employing the ACRI, we aim to capture the compliance cost-raising effect of technical regulations. To meet the additional requirements in the destination market, exporting firms incur fixed costs to establish capacity and, subsequently, variable production costs (Bao and Chen, 2013; Chen et al. 2008; Ganslandt and Markusen, 2001). The fixed costs of adapting products to foreign destination markets are thought to be associated with a narrow set of exported goods on the extensive margin, as smaller or less productive firms cannot afford such fixed costs. Meanwhile, higher marginal costs due to the foreign regulatory burdens push up the unit price of exported goods, decreasing the quantities of each traded good on the intensive margin. Therefore, we expect to obtain estimated ACRI coefficients with the following signs: $\delta_8^{\text{EM}} < 0$; $\delta_8^{R} > 0$; and $\delta_8^{Q} < 0$.

In what follows, we mainly focus our analysis on the export flows from developing nations to advanced economies. It is a common perception that technical regulations in advanced economies are more stringent than those in developing nations. With this in mind, the same degree of effectual measures (i.e. the same value of the calculated ACRI) implies a greater cost

[22] We use δ for $\beta \times \gamma$ for the ease of notation.
[23] Notice that variations in $\ln V_j^s$ are perfectly accounted for by F_j^s.

burden of compliance for the exporting firms based in developing nations that serve the markets in advanced economies, compared to the firms exporting to developing nations from advanced economies. To better highlight the compliance cost-raising effect of technical regulations, we focus on examining the export flows from developing nations to advanced economies.

To do so, we group the 98 sample countries into advanced economies and developing nations based on the World Bank Country and Lending Group classification, in which countries are divided into Low Income (L), Lower Middle Income (LM), Upper Middle Income (UM), and High Income (H) groups, as shown in Appendix A[24]. We aggregate the first three groups into a single group of less-developed nations while considering high-income countries as advanced economies. We are mainly interested in examining export flows from developing nations to advanced economies' markets, and for comparative purposes, we also show the corresponding figures and estimation results for export flows from advanced economies to developing nations' markets, trade flows among developing nations, and trade flows among advanced economies.

2.3.5. Preliminary Data Observations

Descriptive statistics for all the variables used in our analysis are summarized in Table 2.1 The top table shows the statistics for the full sample, while the bottom table shows the statistics for the subsample of our main focus: export flows from developing nations to advanced economies.

Table 2.1. Summary Statistics

Full Sample

[24] For the details of the country classification, see https://datahelpdesk.worldbank.org/knowledgebase/articles/906519.

	Number of observations	Mean	Standard deviation	Minimum	Median	Maximum
Trade value (thousand dollar)	418,265	21,609	363,163	0.001	102	1.43E+08
Extensive margin	418,265	0.440	0.349	1.04E-08	0.377	1
Intensive margin	418,265	0.041	0.114	3.94E-10	0.004	1
Price index	418,265	170.371	102,584	4.82E-06	1.402	6.63E+07
Quantity index	418,265	0.039	0.115	7.55E-12	0.002	0.9999999
Distance	418,265	6,769	4,854	115	6,235	19,650
Contiguity dummy	418,265	0.046	0.209	0	0	1
Common-language dummy	418,265	0.136	0.343	0	0	1
Colonial-tie dummy	418,265	0.016	0.124	0	0	1
Deep PTA dummy	418,265	0.390	0.488	0	0	1
Tariff	418,265	7.187	10.900	0	4.714	318.207
Hard measure	418,265	0.143	0.313	0	0	1
ACRI	418,265	0.204	0.314	0	0.042	1

Exports from Developing to Advanced Economies

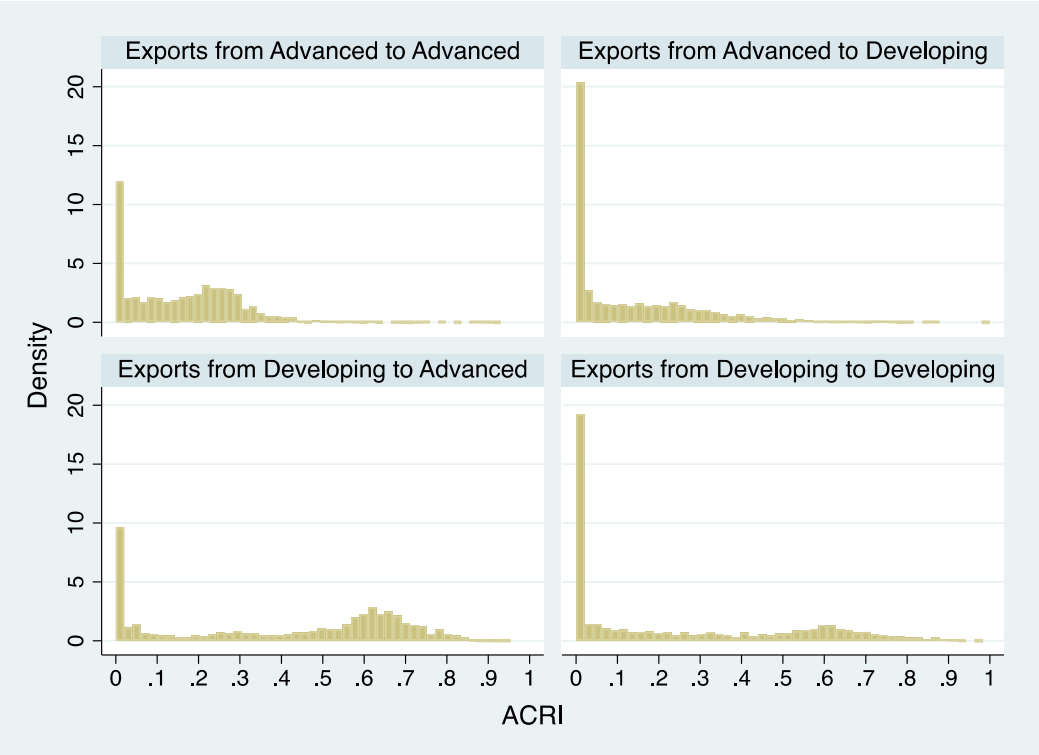
	Number of observations	Mean	Standard deviation	Minimum	Median	Maximum
Trade value (thousand dollar)	88,913	19,385	567,437	0.001	47	1.43E+08
Extensive margin	88,913	0.366	0.322	1.04E-08	0.271	1
Intensive margin	88,913	0.029	0.095	1.48E-09	0.001	1
Price index	88,913	8.572	293	4.82E-06	1.241	49,219
Quantity index	88,913	0.031	0.103	8.47E-12	0.001	0.9999999
Distance	88,913	7,534	4,473	115	7,854	19,650
Contiguity dummy	88,913	0.017	0.131	0	0	1
Common-language dummy	88,913	0.121	0.327	0	0	1
Colonial-tie dummy	88,913	0.016	0.126	0	0	1
Deep PTA dummy	88,913	0.305	0.461	0	0	1
Tariff	88,913	5.222	11.143	0	3.384	318.207
Hard measure	88,913	0.153	0.324	0	0	1
ACRI	88,913	0.367	0.375	0	0.198	1

*Source: Authors' calculation. Raw values before transforming using natural logarithm.

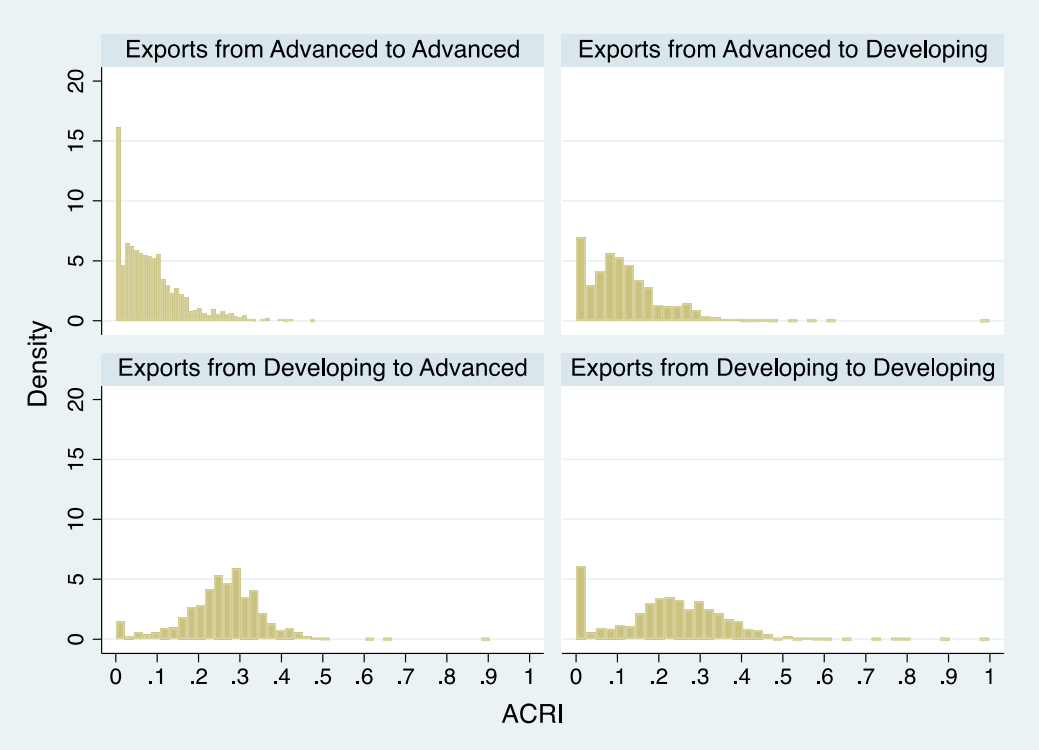
Table 2.1 indicates that the ACRI of interest is on average relatively high in our subsample for the export flows from developing nations to advanced economies, compared to the central tendency figures in the full sample. Figure 2.1 complements this point by showing histograms of ACRI, which are depicted based on the data for exports of manufacturing and agricultural goods, separately for the four types of trade flows by country group. For both the manufacturing and agricultural exports, the histogram for the exports from developing nations to advanced economies tends to be located on the right, followed by the exports among developing nations. These tendencies indicate that exporting firms based in developing nations face a greater degree of effectual measures in the export destination markets, in particular, in the advanced economies' markets, compared to the firms exporting from advanced economies.

Figure 2.1. Distribution of ACRI

Manufacturing Sectors



Agricultural Sectors



*Source: Authors' calculation

Some may suspect that there is an underlying correlation between the ACRI and certain other trade policy variables: deep PTA dummy, tariff, and hard measure. The box plots in Figure 2.2 show the central tendency of the ACRI for origin and destination country pairs with and without the deep trade agreements with SPS or TBT-related provisions. These are shown separately for the four types of trade flows by country group. The box plots are depicted based on the data for exports of manufacturing and agricultural goods, ignoring the outliers beyond either whisker of each box plot. For both the manufacturing and agricultural exports, the red box representing the interquartile range of the ACRI for country pairs with deep trade agreements tends to be located on the left, compared to the corresponding blue box for those without deep trade agreements.

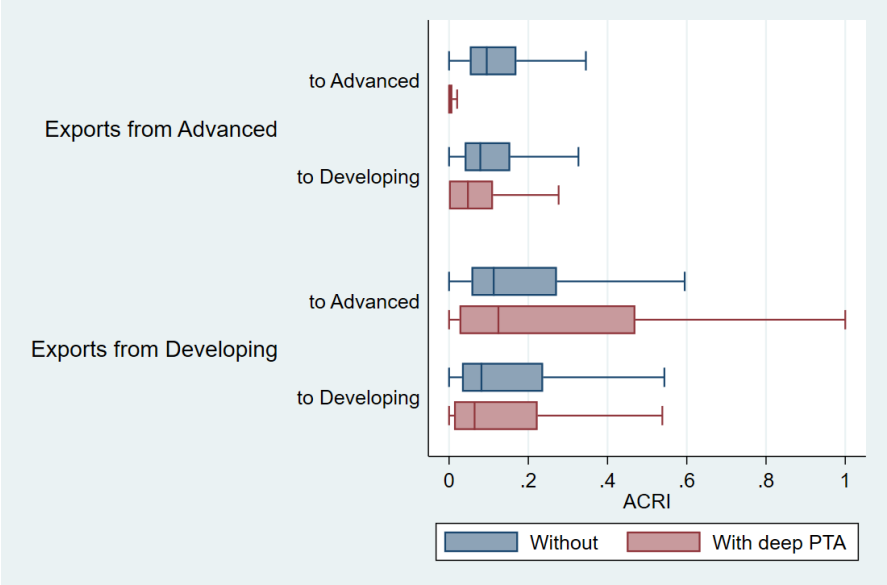
An exception, however, is found in our subsample for the export flows from developing nations to advanced economies. The red box shows a relatively wide distribution toward both ends for manufacturing as well as agricultural exports, indicating that the ACRI is relatively high even for country pairs with policy cooperation regarding technical regulations. Note that the existence of SPS or TBT-related provisions in trade agreements does not necessarily mean that the regulatory regime of a member country is similar to that of the others. Rather, in most cases, they are in the form of the provision of regulatory information and mutual recognition agreements as well as the affirmation of rights and obligations under the relevant WTO agreements, which are not interrelated with the international regulatory differences that is quantified by the ACRI.

Figures 2.3 and 2.4 show correlation plots between the ACRI and the other two import-restrictive measures implemented in the destination country against the origin country at the sector level. Figure 2.3 shows the correlation between the ACRI and the trade-weighted average of ad valorem equivalent tariffs, while Figure 2.4 focuses on the correlation with the coverage ratio of hard measures. For the correlation plots, we take an average of each variable (originally defined at the origin-destination-sector level) across the origin countries. The plots in Figures 2.3 and 2.4 do not show any clear positive (complementary) or negative (substitute) relationship between the ACRI and tariffs and between the ACRI and hard measures, respectively.

Figure 2.2. ACRI for Country Pairs with and without Deep PTA with SPS or TBT-related Provisions

Manufacturing Sectors

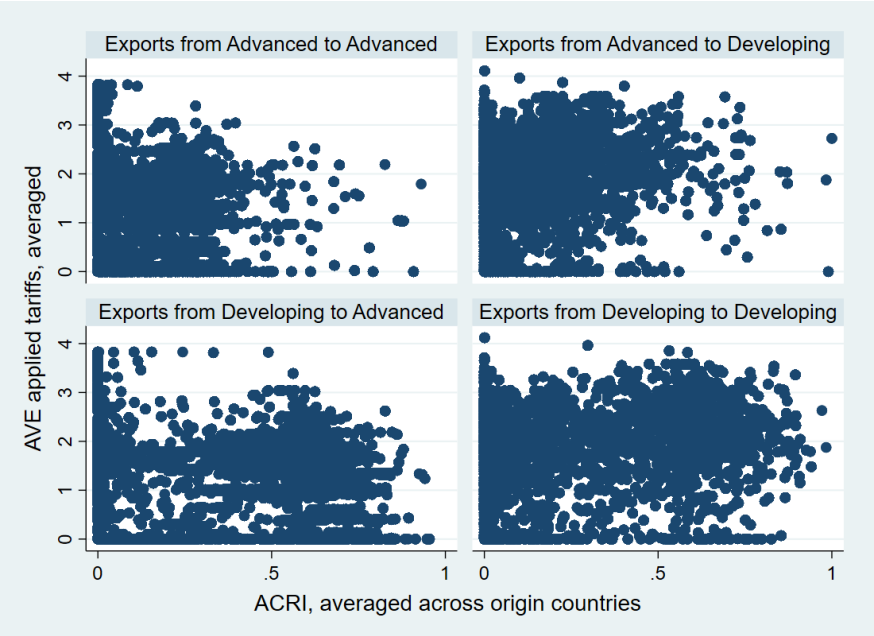
Agricultural Sectors



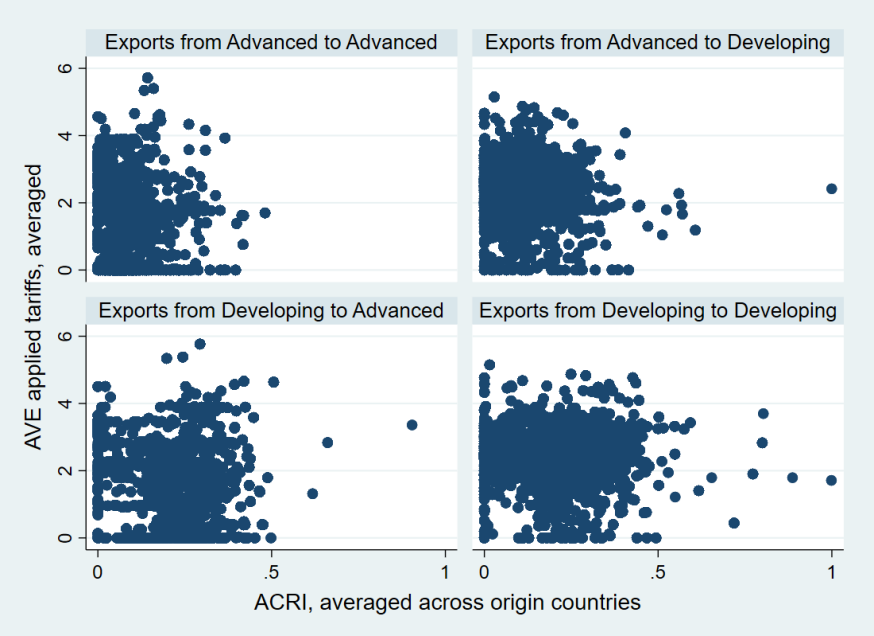
*Note: Outliers (beyond either whisker of each box plot) are omitted.
*Source: Authors' calculation.

Figure 2.3. Sector-level Relationships between ACRI and Tariffs

Manufacturing Sectors



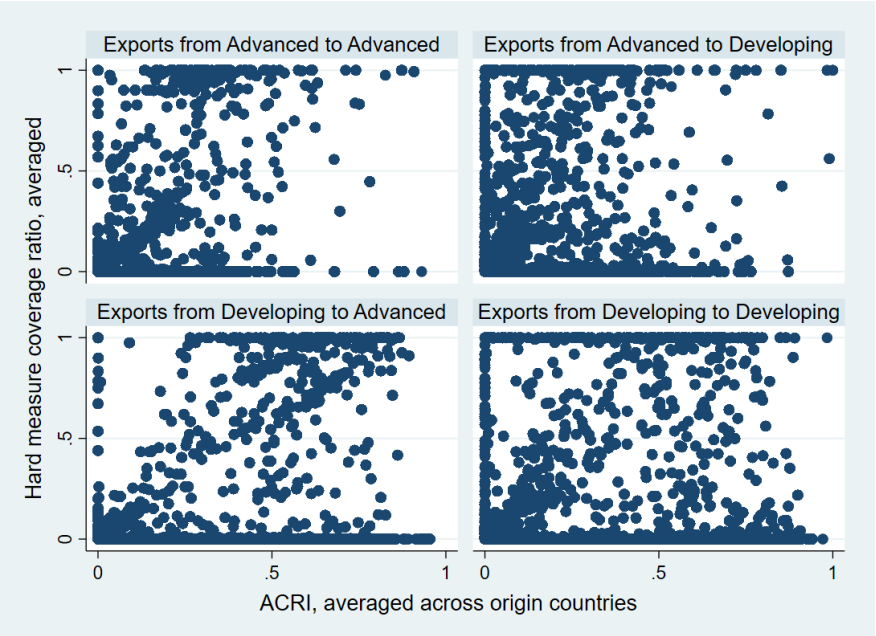
Agricultural Sectors



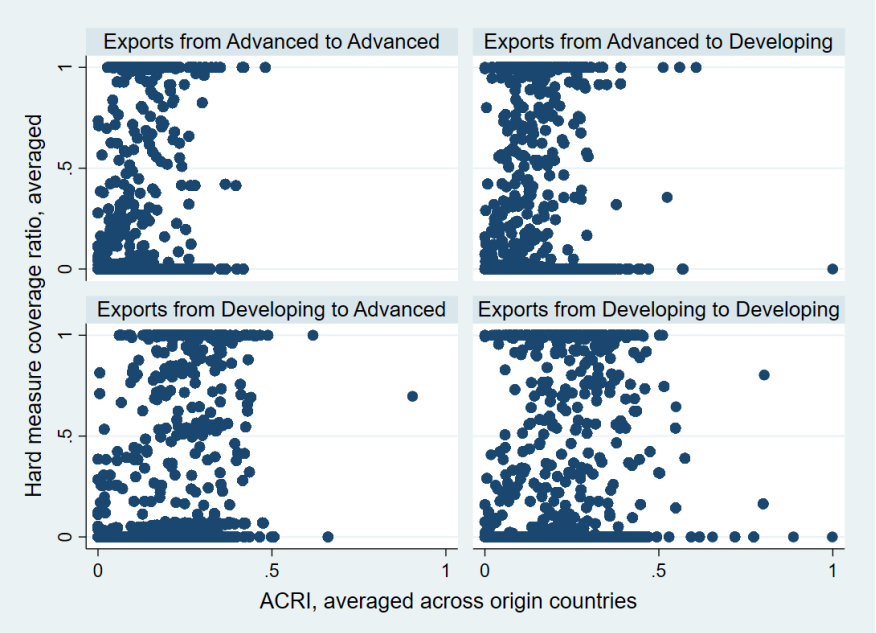
*Notes: Although the policy variables of interest are defined at the origin-destination-sector level, we take the average of each variable across the origin countries to depict the plots in a concise manner. The tariff variable on the vertical axis is the natural logarithmic value.
*Source: Authors' calculation.

Figure 2.4. Sector-level Relationship between ACRI and Hard Measures

Manufacturing Sectors



Agricultural Sectors



*Note: Although the policy variables of interest are defined at the origin-destination-sector level as explained in the main text, we take the average of each variable across the origin countries to depict the plots in a concise manner.
*Source: Authors' calculation.

2.4. Estimation Results

For export flows from developing nations to advanced economies, our baseline estimation results for a set of equations (18) using the data for all merchandise trade are summarized in Table 2.2. Column (1) of the table shows the estimates of the equation with the sector-level

bilateral trade values (in natural logarithms) as the dependent variable. Columns (2) and (3) show the decomposed estimates for the extensive margin and the intensive margin (in natural logarithms) of the sector-level bilateral trade, respectively. For each covariate as well as the ACRI, the sum of the estimated coefficients shown in Columns (2) and (3) is equal to the coefficient in Column (1) by construction. The intensive margin is further decomposed into price and quantity components; the sum of the estimated coefficients shown in Columns (4) and (5) is equal to the coefficient in Column (3).

In Column (1) of Table 2.2, all the coefficients are estimated as expected with statistical significance. The only exception is the dummy variable, indicating the existence of a deep trade agreement including SPS or TBT-related provisions between a pair of countries; the coefficient is estimated to be positive, as expected, but is statistically insignificant. The estimated coefficient for the ACRI indicates that sector-level bilateral trade values decrease by 10.2% if the sector-level ACRI is increased by 0.1 points with all other things unchanged. The estimated trade-diminishing effect of the ACRI is comparable to the effects of import-restrictive measures implemented in the destination country; trade values decrease by 5.2% if the trade-weighted average of AVE tariffs increases by 10%. Also, trade values decrease by 21.7% if the coverage ratio of hard measures (i.e. price controls or quantity-restrictive measures) is increased by 0.1 points, ceteris paribus.

Columns (2) and (3) of Table 2.2 indicate that the directions of the effects of the ACRI and covariates on both the extensive and intensive margins are the same as those on the trade values. Comparing Columns (2) and (3), the magnitude of the estimated coefficient is uniformly larger on the intensive margin than on the extensive margin, except for the deep PTA dummy. Note that the level of aggregation at which we measure the extensive margin affects the estimates, as discussed in Hummels and Klenow (2005). If product variety differences exist at more disaggregated levels (e.g., eight-digit or ten-digit levels), then we will only be able to capture some of the variety differences in the extensive margin using the six-digit level product data within the four-digit sector. The rest of the variety differences are included in the intensive margin instead. Given the possible underestimation of the effects on the extensive margin, we interpret the current estimation results of the extensive margin as the lower bound[25].

[25] Note that we can calculate the extensive and intensive margins as defined in equation (9) using trade values only, without referring to trade quantities. Even when expanding the sample by including those without (reliable) quantity data, estimation results for trade values, extensive margin, and intensive margin do not differ

Looking into the intensive margin, Columns (4) and (5) of Table 2.2 show contrasting patterns in the signs of the estimated coefficients between the price and quantity margins. In particular, a higher ACRI is associated with smaller quantities of each exported good to a large degree on the quantity margin, as well as with higher prices of exported goods. This is consistent with our prediction that higher marginal costs due to the additional compliance requirements push up the exported prices, thereby decreasing quantities. To be more precise, the estimates for the ACRI indicate that if the ACRI were 0.1 points higher, with all other things unchanged, the quantities of each traded good would decrease by 9.4%, while prices would increase by 1.5%.

A related noteworthy result is for the deep PTA dummy, which captures international policy cooperation in SPS and TBT, such as the provision of regulatory information and mutual recognition agreements. In this regard, the deep PTA dummy can be seen as (at least partially) capturing the effect that exporting firms can save the costs of collecting information on technical requirements in the destination markets[26]. The estimated coefficient for the deep PTA dummy on the price margin indicates that the exported prices would decrease by 3.6% if a pair of countries were to have a SPS or TBT-related trade agreement provision. A similar positive effect of the deep PTA dummy is found on the extensive margin as well. SPS or TBT-related deep trade agreements may mitigate the trade impact of the ACRI, at least to some extent, through the information cost-saving effect.

Table 2.2. Baseline Results: All Merchandise Exports from Developing to Advanced

substantially.

[26] The information cost-saving effect of technical regulations has been pointed out in the related literature (Portugal-Perez et al., 2010; Bao and Chen, 2013). Although the ACRI may partially reflect the information cost-saving effect in addition to the compliance cost-raising effect of interest, the existence of SPS or TBT-related provisions of deep trade agreements is a more direct indicator for measuring the information cost-saving effect.

	(1) ln(Trade value)	(2) ln(EM)	(3) ln(IM)	(4) ln(P)	(5) ln(Q)
ln(distance)	-1.422***	-0.509***	-0.913***	0.171***	-1.083***
	(0.044)	(0.021)	(0.033)	(0.012)	(0.039)
Contiguity dummy	0.969***	0.236*	0.732***	-0.150**	0.882***
	(0.256)	(0.124)	(0.160)	(0.067)	(0.200)
Common-language dummy	0.588***	0.230***	0.358***	-0.008	0.366***
	(0.081)	(0.033)	(0.062)	(0.022)	(0.073)
Colonial-tie dummy	0.598***	0.134	0.463**	-0.125**	0.589***
	(0.228)	(0.090)	(0.187)	(0.061)	(0.211)
Deep PTA dummy	0.106	0.077**	0.029	-0.036**	0.066
	(0.067)	(0.030)	(0.052)	(0.018)	(0.059)
ln(1+Tariff)	-0.518**	-0.161	-0.358*	0.087	-0.445**
	(0.209)	(0.120)	(0.189)	(0.098)	(0.213)
Hard measure	-2.167***	-0.798***	-1.369***	0.357***	-1.726***
	(0.350)	(0.133)	(0.280)	(0.128)	(0.349)
ACRI	-1.024***	-0.231***	-0.793***	0.147***	-0.940***
	(0.101)	(0.050)	(0.086)	(0.035)	(0.097)
Origin-sector dummies Destination-sector dummies	YES	YES	YES	YES	YES
Number of observations	88,913	88,913	88,913	88,913	88,913
Adjusted R-squared	0.680	0.534	0.609	0.248	0.594

*Notes: Dependent variables, as well as the ACRI of interest, are defined at the origin-destination-sector level. We omit from the table coefficients for the constant term, origin-sector-specific effects, and destination-sector-specific effects. Robust standard errors clustered by origin and destination country pair are in parentheses. Asterisks denote statistical significance: *** p< 0.01, ** p< 0.05, * p< 0.1. We group the 98 sample countries into 48 advanced economies and 50 developing economies, based on the World Bank's country classification by income group, as explained in the main text. The estimates shown in this table are obtained using the export data for all merchandise goods from 50 developing nations to 48 advanced economies.
*Source: Authors' calculation.

Continuing to focus on the export flows from developing nations to advanced economies, Table 2.3 summarizes the estimates separately for manufacturing sectors and agricultural sectors. There are some noticeable differences by sector. First, the overall trade-diminishing effect of the ACRI is twice as large in magnitude for agricultural sectors as it is for manufacturing sectors. The decomposed effects through the extensive margin and the quantity margin also show relatively large adverse effects of the ACRI for agricultural sectors.

Agricultural exporters from developing nations appear to face a greater cost burden to comply with the additional regulatory requirements in the advanced economies' markets, compared to the manufacturing exporters.

Second, the positive impact of the ACRI on the price margin is statistically significant in manufacturing exports as well as in all merchandise exports, but it is not significant in agricultural exports. This would indicate that agricultural exporters are not differentiating export prices across destination countries with respect to the regulatory burdens imposed by those countries, which can be interpreted as suggesting that the law of one price holds.

Third, the coefficients for the deep PTA dummy are estimated to be statistically significant in all the equations for the agricultural exports, in stark contrast to the manufacturing exports. The adverse effects of the ACRI appear to be mitigated by the international policy cooperation on SPS and TBT regarding agricultural goods, unlike in the case of manufacturing goods.

Fourth, tariffs lose statistical significance in all the equations for agricultural exports, unlike the ACRI and hard measures. This is consistent with the general perception that non-tariff barriers, rather than tariffs, are substantial obstacles faced by the agricultural exporters of developing nations when serving advanced economies' markets.

Table 2.3. Manufacturing and Agricultural Exports from Developing to Advanced

Manufacturing sectors

	(1) ln(Trade value)	(2) ln(EM)	(3) ln(IM)	(4) ln(P)	(5) ln(Q)
Deep PTA dummy	-0.029	0.011	-0.039	-0.004	-0.035
	(0.071)	(0.032)	(0.055)	(0.021)	(0.063)
ln(1+Tariff)	-0.550**	-0.220*	-0.330	0.136	-0.466*
	(0.262)	(0.125)	(0.250)	(0.126)	(0.279)
Hard measure	-2.564***	-0.921***	-1.644***	0.388**	-2.031***
	(0.410)	(0.167)	(0.323)	(0.191)	(0.431)
ACRI	-0.914***	-0.212***	-0.703***	0.155***	-0.857***
	(0.103)	(0.051)	(0.088)	(0.037)	(0.100)
Origin-sector dummies Destination-sector dummies	YES	YES	YES	YES	YES
Number of observations	61,522	61,522	61,522	61,522	61,522
Adjusted R-squared	0.712	0.558	0.635	0.235	0.624

Agricultural sectors

	(1) ln(Trade value)	(2) ln(EM)	(3) ln(IM)	(4) ln(P)	(5) ln(Q)
Deep PTA dummy	0.589***	0.268***	0.321***	-0.111***	0.432***
	(0.095)	(0.040)	(0.081)	(0.023)	(0.089)
ln(1+Tariff)	-0.479	-0.039	-0.440	0.014	-0.453
	(0.389)	(0.260)	(0.326)	(0.139)	(0.368)
Hard measure	-1.468***	-0.615***	-0.853*	0.360***	-1.213**
	(0.561)	(0.226)	(0.462)	(0.118)	(0.500)
ACRI	-1.924***	-0.391***	-1.533***	0.081	-1.614***
	(0.318)	(0.146)	(0.283)	(0.109)	(0.325)
Origin-sector dummies Destination-sector dummies	YES	YES	YES	YES	YES
Number of observations	19,470	19,470	19,470	19,470	19,470
Adjusted R-squared	0.572	0.489	0.522	0.266	0.505

*Notes: Dependent variables, as well as the ACRI of interest, are defined at the origin-destination-sector level. We omit from the table coefficients for the constant term, origin-sector-specific effects, destination-sector-specific effects, and country pair-wise variables (except the deep PTA dummy). Robust standard errors clustered by origin and destination country pair are in parentheses. Asterisks denote statistical significance: *** p< 0.01, ** p< 0.05, * p< 0.1. We group the 98 sample countries into 48 advanced economies and 50 developing economies, based on the World Bank's country classification by income group, as explained in the main text. The estimates shown in the top and bottom table are obtained, respectively, using the data for exports of manufacturing goods (HS28 to 92) and agricultural goods (HS1 to 24) from 50 developing nations to 48 advanced economies.
*Source: Authors' calculation.

Next, Table 2.4 compares the estimated effects of the ACRI on the respective margins of all the merchandise exports from developing nations to advanced economies with those for the other three types of trade flows by origin and destination country groups. The estimated effect of the ACRI on the trade value for the exports from developing nations to advanced economies is almost the same in magnitude as that for the exports from advanced economies to developing nations. This similarity indicates that a unit increase of the calculated ACRI, or the same degree of effectual measure, leads to, on average, a similar percentage decline in the export values of the two trade flows.

Table 2.4. Trade effects of ACRI: Comparison of Trade Flows by Country-Group

(1) ln(Trade value)	(2) ln(EM)	(3) ln(IM)	(4) ln(P)	(5) ln(Q)	Number of observations
Developing to Advanced					
-1.024***	-0.231***	-0.793***	0.147***	-0.940***	88,913
(0.101)	(0.050)	(0.086)	(0.035)	(0.097)	
Advanced to Developing					
-1.028***	-0.315***	-0.713***	0.122***	-0.835***	111,562
(0.131)	(0.057)	(0.100)	(0.043)	(0.120)	
Advanced to Advanced					
-0.703***	-0.138***	-0.565***	0.278***	-0.843***	142,342
(0.116)	(0.048)	(0.089)	(0.036)	(0.102)	
Developing to Developing					
-0.519***	-0.141**	-0.378***	0.053	-0.431***	75,448
(0.123)	(0.056)	(0.095)	(0.036)	(0.107)	

*Notes: Dependent variables, as well as the ACRI of interest, are defined at the origin-destination-sector level. We omit from the table coefficients for the constant term, origin-sector-specific effects, destination-sector-specific effects, and covariates other than the ACRI. Robust standard errors clustered by origin and destination country pair are in parentheses. Asterisks denote statistical significance: *** p< 0.01, ** p< 0.05, * p< 0.1. We group the 98 sample countries into 48 advanced economies and 50 developing economies, based on the World Bank's country classification by income group, as explained in the main text. The estimates shown in this table are obtained using the export data for all merchandise goods.
*Source: Authors' calculation.

Note, however, that regulatory burdens would prohibit bilateral trade, resulting in zero trade values even at the sector level, especially in the case of developing nations' exports. Since we focus on examining trade relationships with positive trade values so as to decompose the trade effects of the ACRI into different margins in the current study, the estimates for the developing nations' exports might be underestimated[27]. Indeed, the estimated coefficients of the trade flows among developing nations are relatively small in magnitude compared to the other three trade flows.

However, the estimates on the quantity margin show that the same degree of effectual measures reduces the quantities exported from developing nations to advanced economies the most. This result is consistent with the common belief that technical regulations are more stringent in advanced economies than in developing economies. Relatedly, the estimate on the quantity margin of the trade flows among advanced economies is the second largest in magnitude, while the estimates of the exports destined for developing nations tend to be smaller.

[27] Examining the effects of the ACRI on the probability of exports is beyond the scope of the current paper. Future studies are awaited.

More importantly, we highlight the differences in the pattern of the decomposed effects of the ACRI on the respective margins by trade flow. Decomposing trade flows into extensive and intensive margins and analyzing how the regulatory burdens affect different margins have important welfare implications. While a narrower range of exported goods would imply lower producer surplus in the exporting country, a higher unit price might adversely affect consumer surplus in the importing country. Smaller quantities of exported goods would deteriorate both producer surplus in the exporting country and consumer surplus in the importing country.

In the case of exports from developing nations to advanced economies, the overall trade-diminishing effect of the ACRI is attributed mainly to the quantity margin. On the other hand, in the case of exports from advanced economies to developing nations, the extensive margin is relatively important. It appears that advanced economies' exporters tend to be forced away from the markets of developing nations with more regulatory burdens. The technical regulations implemented in developing nations, even though they are thought to be less stringent, may deteriorate producer surplus in the exporting, advanced economies.

In contrast, in the case of trade flows among advanced economies, foreign regulatory burdens push up the price of exported goods to a relatively large extent. This would indicate that advanced economies' exporters tend to differentiate export prices among the destination advanced economies based on their regulatory burdens. In this case, technical regulations may adversely affect consumer surplus due to the higher prices of imported goods, even if the regulations are enforced to protect the consumer.

2.5. Chapter Conclusion

In this research, we studied the trade impact of NTMs, focusing on how regulatory burdens imposed by importing countries influence the extensive and intensive margins of bilateral trade. To quantify the extra technical requirements that an exporter firm may face when serving a foreign country's market, we constructed the ACRI indicator, making use of the new UNCTAD NTM data set of the detailed information on technical regulations. To measure the bilateral margins of trade, we used finely disaggregated, product-level bilateral trade values and quantity data for 98 countries. We first showed that the regulatory burdens diminish trade values. Beyond this overall trade-diminishing effect of regulatory burdens, we looked into the different effects on the margins of trade. Our major finding is that a country facing more regulatory

burdens within a particular sector of a destination market country exports a narrower set of goods and lower quantities of each good at higher prices.

We inevitably face some limitations due to data unavailability. Although ACRI measures the additional burden from qualitative information of government documents, the magnitude of technical regulations on each product or on each partner are ambiguous. For example, NTMs measure A13 on product 010111 may have larger negative effect on international trade compared to A14 on the identical product, in terms of magnitude. We leave this data concerns for future research anticipating for updates on the magnitude of the NTMs measure.

Regardless of the limitations, however, this study contributes to international trade literature with the followings. First, we constructed a new measure to calibrate additional burden for the exporters. Mere number of NTMs imposed by importers may not capture the burden of exporters as exporters may not need to comply with such regulations. ACRI enables the research on the impact of technical regulations on the bilateral international trade. Second, we attempted to examine the impact of additional burden on the extensive and intensive margins of international trade by decomposing international trade. Traditional analysis on trade often focuses on the total value of trade. However, these literatures may not differentiate whether the volume of incumbent goods (intensive margin) or the new entrants (extensive margin) are affected more by additional costs. We adopted Hummels and Klenow (2005)'s decomposition methodology to test the impact of technical regulations on two different measurements of international trade. At last, we showed that technical regulations serve as original costs for international trade.

Appendices

Appendix A. 98 Sample Countries

Country Name	ISO3	Group	Country Name	ISO3	Group	Country Name	ISO3	Group
United Arab Emirates	ARE	H	United Kingdom	GBR	H	Malaysia	MYS	UM
Argentina	ARG	UM	Greece	GRC	H	Nicaragua	NIC	LM
Antigua and Barbuda	ATG	H	Grenada	GRD	UM	Netherlands	NLD	H
Australia	AUS	H	Guatemala	GTM	LM	New Zealand	NZL	H
Austria	AUT	H	Guyana	GUY	UM	Oman	OMN	H
Belgium	BEL	H	Hong Kong	HKG	H	Pakistan	PAK	LM
Bulgaria	BGR	UM	Honduras	HND	LM	Panama	PAN	UM
Bahrain	BHR	H	Croatia	HRV	H	Peru	PER	UM

Bahamas	BHS	H	Hungary	HUN	H	Philippines	PHL	LM
Bolivia	BOL	LM	Indonesia	IDN	LM	Papua New Guinea	PNG	LM
Brazil	BRA	UM	India	IND	LM	Poland	POL	H
Barbados	BRB	H	Ireland	IRL	H	Portugal	PRT	H
Brunei	BRN	H	Israel	ISR	H	Paraguay	PRY	UM
Canada	CAN	H	Italy	ITA	H	Qatar	QAT	H
Switzerland	CHE	H	Jamaica	JAM	UM	Romania	ROU	UM
Chile	CHL	H	Jordan	JOR	UM	Russian Federation	RUS	UM
China (Republic of)	CHN	UM	Japan	JPN	H	Saudi Arabia	SAU	H
Cameroon	CMR	LM	Kazakhstan	KAZ	UM	Singapore	SGP	H
Colombia	COL	UM	Kyrgyzstan	KGZ	LM	El Salvador	SLV	LM
Costa Rica	CRI	UM	Cambodia	KHM	LM	Suriname	SUR	UM
Cuba	CUB	UM	Korea, Republic of	KOR	H	Slovakia	SVK	H
Cyprus	CYP	H	Kuwait	KWT	H	Slovenia	SVN	H
Czech Republic	CZE	H	Lao People's Democratic Republic	LAO	LM	Sweden	SWE	H
Germany	DEU	H	Lebanon	LBN	UM	Thailand	THA	UM
Dominica	DMA	UM	Sri Lanka	LKA	LM	Tajikistan	TJK	LM
Denmark	DNK	H	Lithuania	LTU	H	Trinidad and Tobago	TTO	H
Algeria	DZA	UM	Luxembourg	LUX	H	Tunisia	TUN	LM
Ecuador	ECU	UM	Latvia	LVA	LM	Turkey	TUR	UM
Spain	ESP	H	Morocco	MAR	LM	Uruguay	URY	H
Estonia	EST	H	Mexico	MEX	UM	United States	USA	H
Ethiopia	ETH	L	Malta	MLT	H	Venezuela, Bolivarian Republic of	VEN	UM
Finland	FIN	H	Myanmar	MMR	LM	Viet Nam	VNM	LM
France	FRA	H	Mauritania	MRT	LM			

*Notes: The "ISO3" column shows the International Organization for Standardization (ISO) 3166-1 alpha-3 country codes. The "Group" column shows the World Bank Country and Lending Groups: Low Income (L); Lower Middle Income (LM); Upper Middle Income (UM); and High Income (H).
*Source: World Bank Country and Lending Groups. See https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups for more details.

Appendix B. Availability of Import Statistics for 98 Sample Countries in 2015-2016

ISO3	2015	2016	ISO3	2015	2016	ISO3	2015	2016
ARE	v	v	GBR	v	v	MYS	v	v
ARG	v	v	GRC	v	v	NIC	v	v
ATG	v	v	GRD	.	.	NLD	v	v
AUS	v	v	GTM	v	v	NZL	v	v
AUT	v	v	GUY	v	v	OMN	v	v
BEL	v	v	HKG	v	v	PAK	v	v
BGR	v	v	HND	v	v	PAN	v	v
BHR	v	v	HRV	v	v	PER	v	v
BHS	v	.	HUN	v	v	PHL	v	v
BOL	v	.	IDN	v	v	PNG	.	.
BRA	v	v	IND	v	v	POL	v	v
BRB	v	v	IRL	v	v	PRT	v	v

BRN	v	v	ISR	v	v	PRY	v	v
CAN	v	v	ITA	v	v	QAT	v	v
CHE	v	v	JAM	v	v	ROM	v	v
CHL	v	v	JOR	v	v	RUS	v	v
CHN	v	v	JPN	v	v	SAU	v	v
CMR	v	v	KAZ	v	v	SGP	v	v
COL	v	v	KGZ	v	v	SLV	v	v
CRI	v	v	KHM	v	v	SUR	v	v
CUB	.	.	KOR	v	v	SVK	v	v
CYP	v	v	KWT	v	v	SVN	v	v
CZE	v	v	LAO	v	v	SWE	v	v
DEU	v	v	LBN	v	v	THA	v	v
DMA	.	.	LKA	v	v	TJK	.	.
DNK	v	v	LTU	v	v	TTO	v	.
DZA	v	v	LUX	v	v	TUN	v	v
ECU	v	v	LVA	v	v	TUR	v	v
ESP	v	v	MAR	v	v	URY	v	v
EST	v	v	MEX	v	v	USA	v	v
ETH	v	v	MLT	v	v	VEN	.	.
FIN	v	v	MMR	v	v	VNM	v	v
FRA	v	v	MRT	.	v			

*Notes: The “ISO3” column shows the ISO 3166-1 alpha-3 country codes published by the International Organization for Standardization (ISO). “v” indicates that import statistics reported by a country of concern are available for a given year. “.” means that the import statistics are not available; mirror export data are used instead, if applicable.
*Source: UN Comtrade.

Appendix C. Groupings of Technical Measures Considered in Constructing the Regulatory Pattern Vector

Group of technical measures	Maximum possible number of measures within group
A13, A14, A15, A19	4
A20, A21, A22	3
A30, A31, A32, A33	4
A41, A42, A49	3
A51, A52, A53, A59	4
A61, A62, A63, A64, A69	5
A81, A82, A83, A84, A85, A86, A89	7
A9	1
B14, B15, B19	3
B20, B21, B22	3
B30, B31, B32, B33	4
B41, B42, B49	3
B6	1
B7	1
B81, B82, B83, B84, B85, B89	6
B9	1
C1, C9	2
C 2, C3, C4	3

*Note: We count the number of technical measure codes at the two-digit level for the groupings of Chapters A and B and at the one-digit level for the Chapter C grouping.
*Source: Authors' calculation.

Chapter 3. Technical Regulations and the Global Value Chains Participation

3.1. Background

GVCs transformed the nature of production. Traditionally, literature on international trade supposed each country's imports to reflect the domestic demand. However, with the current fragmented production network, domestic and foreign inputs traverse country borders relatively easier than in the past. Participating in the global production networks lets economies increase efficiency by mass production of comparative advantage. Developing nations significantly proliferated and were given a chance to catch up with the global economy. Participating in GVCs requires fewer thresholds than direct trade between the two nations; unknown primary or intermediate goods from developing nations that direct trade partners may not demand could be an integral portion of constructing final goods for another country in the value chains. According to World Bank (2019), Almost 50% of international trade is in the form of GVCs, and the production network enhanced the economy of developing nations through international trade participation. They also urged the necessity of significant reforms for the prosperity of GVCs from ongoing trade conflicts.

As technical regulations inhibited international trade activity both through extensive and intensive margins, shown in Chapter 2, they may also act as obstacles for GVCs participation in the global economy. While tariffs have drastically decreased, international trade has not grown proportionately. In reality, technical regulations such as SPS and TBT shape the necessary protection to ensure the safety of consumers and the environment. According to UNCTAD (2019, p. 6), unlike Non-tariff Barriers (NTBs), which serve as direct trade costs that hamper international trade, NTMs often refer to "policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade." Prevention of hazardous pesticides, certifications on the methodology of production processes, and restrictions on the usage of chemical substances contribute to incrementation of imports via reductions on the fixed transaction costs and enhancements on the quality of imported goods (Beghin et al., 2015a; Grübler et al., 2016; Rindayati and Kristriana, 2018; Xiong and Beghin, 2011).

This research addresses two research questions. First, what are the impacts of NTMs on participating in GVCs? The imposition of technical regulations may be independent of GVCs participation. However, domestic regulations may deter exporters from taking part in different value chains that maximize their profit. Unlike the sound purposes of the NTMs to shape the

necessary protection to ensure consumers' and environmental safety, the majority of the past literature often addressed the adverse impact of NTMs on international trade. El-Enaby et al. (2016) examined Egyptian firm-level data and the NTMs data from the WTO to show that NTMs negatively affect the new goods margin of the Egyptian exporters. Ghodsi et al. (2017) amended and utilized the information on NTMs from the WTO I-TIP database showing that NTMs stimulate the trade-impeding effect. They focused on TBT measures to reflect NTMs.

Along with the unintended repercussions of NTMs on international trade, however, only a handful of research examined the relationship between NTMs and GVCs participation. As the current production networks are highly fragmented, the impact of additional NTMs that exporters need to comply with before entering the foreign market may act as a hidden burden that could result in the renunciation of the exports. We construct the ACRI as shown in Chapter 2 to compare disparate policy measures between exporters and importers. The conventional methodologies on calibrating NTMs include a simple count of an aggregate number of regulations, coverage ratio, and frequency index. These measurements, however, are inadequate as they do not take account of the policy measures that exporters impose in the domestic market. Suppose a government of specific exporters imposes specific NTMs on certain products in the domestic market. In this case, the exporters may not need to or may have fewer efforts to comply with the identical measures that the importers impose. As the conventional calibration of NTMs does not consider the policy measures that exporters impose domestically, the magnitude of the index may show biased results; the number of foreign NTMs that exporters need to follow consecutively increase. ACRI allows the research to capture the additional regulatory burden between the exporters and importers.

Second, does the impact of NTMs differ across the sectors? The magnitude of NTMs in the manufacturing sector may deviate from the agriculture sector. A specific sector may be highly involved in the GVCs networks, whereas the other sector may not. We empirically analyze the effect of policy measures on the fragmented production network employing NTMs data from the UNCTAD TRAINS database.

We distinguish the participation in GVCs as backward and forward participation through analysis. The current fragmented production networks urge the significance of GVCs. Economies involved in the GVCs framework may import inputs from their trade partners to construct and sell intermediate or final goods (foreign value-added). On the other hand, they may sell domestic goods, explicitly engaging in the upstream process (domestic value-added).

As the impact of regulations toward the participation in GVCs may show discrepancy on the foreign value-added content of the total exports and the domestic value-added content of the total exports, we distinguish the backward and forward participation in GVCs to conduct a detailed investigation on the leverage of the NTMs.

We interchangeably use regulations, technical regulations, and technical measures to denote NTMs throughout this chapter. Among the broad classification of NTMs, we focus on the technical measures of NTMs, which include SPS, TBT, and pre-shipment inspections. Non-technical measures include trade-related measures, subsidies, government procurement restrictions, intellectual property, and rule of origin, which may explicitly sabotage international trade compared to technical measures. We also strictly distinguish standards and technical regulations in this research, where regulations conform with applicable rules and enforced with laws. Technical regulations fall under regulations as government documents describing production processing and methods.

The rest of the chapter is constructed as follows. We present related literature on the relationship between technical regulations and participation in GVCs in Section 3.2. We then describe our research data sources and the empirical methodology in Sections 3.3 and 3.4, respectively. Section 3.5 presents the regression results of our analysis. We employ Pooled Ordinary Least Squares (POLS) estimation as the sample is highly unbalanced. To minimize the heteroskedasticity among variables and adjust for zero value observations of the dependent variables, we employ Poisson Pseudo Maximum Likelihood (PPML) estimation following Silva and Tenreyro (2006) as robustness checks for the empirical results. The results indicate that additional regulatory burden for exporters hampers GVCs participation in the manufacturing sector for forward and backward participation. We conclude our paper with the conclusion in Section 3.6.

3.2. Literature Review

Before examining the past literature regarding the relationship between technical regulations and GVCs participation, we first discuss the past efforts to quantify technical regulations utilizing NTMs. As the systematically documented data for NTMs are scarce, it is challenging to examine NTMs. NTMs database often reports NTMs data with binary values. The data indicate whether the reporter imposes specific NTMs on the imported goods from the trading

partners. Bora et al. (2002) and Ferrantino (2006) suggested the inventory approach to construct NTMs: the coverage ratio and frequency index. Coverage ratio and frequency index capture NTMs on total imports and the presence of NTMs-applied products, respectively. Accordingly, they are not effective in taking account of the reporter-partner-specific impositions of NTMs. Subsequently, Cadot et al. (2015) developed regulatory dissimilarity which captures the disharmony of NTMs' consent between importers and exporters. They construct absolute value by subtracting the dummy variable between the domestic NTMs imposed by the importers and exporters. This indicator calibrates the repercussions of different regulations policies between the importers and exporters. However, regulatory dissimilarity is weak in distinguishing which country imposed the regulations. For example, the value of one could be the outcome of NTMs imposed by importers but not exporters, or vice versa. To grasp the additional burdens that the exporters need to follow when entering the import market, we construct ACRI following Nabeshima et al. (2021).[1]

The majority of the past literature adopted the coverage ratio and frequency index when examining the impact of NTMs on the participation in GVCs (Beghin et al., 2015b; Ghodsi et al., 2017; Grübler et al., 2016; Rindayati and Kristriana 2018; WTO Secretariat 2012). Cheng et al. (2015), Ghodsi and Stehrer (2016), and Liu et al. (2019) constructed AVE tariffs as a proxy for NTMs. Cheng et al. (2015) and Liu et al. (2019) showed a more significant negative impact of AVE tariffs on the backward GVCs participation. Ghodsi and Stehrer (2016) showed the mixed impact of regulations on GVCs participation. They extracted trade data from the World Input-Output Database (WIOD) to construct the backward participation in GVCs. Franssen and Solleder (2016) also showed mixed results on the relationship between the NTMs and the GVCs participation by using the data from ITC. Recently, Korwatanasakul and Baek (2020) conducted a cross-section analysis on the impact of NTMs on the participation in GVCs employing the NTMs data from the UNCTAD TRAINS and the backward and forward participation in GVCs data from the Organization for Economic Cooperation and Development (OECD) – Inter-country Input-output (ICIO) tables. The authors constructed a regulatory distance following Nabeshima and Obashi (2019). The results showed a negative and statistically significant relationship between ACRI and backward participation in GVCs.

[1] Chapter 2 is based on the original work from Nabeshima et al. (2021).

This research contributes to the international trade literature with the following. First, albeit highly unbalanced, we employ more updated NTMs data from the UNCTAD TRAINS and conduct panel analysis, whereas Korwatanasakul and Baek (2020) employed the past cross-section data from UNCTAD TRAINS. The database recently updated more observations for each country, and the database now contains multiple years for each country. We incorporate panel technical regulations into the production network framework. Second, we construct empirical analysis using ACRI on the GVCs participation, focusing on the additional burden of exporters from the technical regulations imposed by the importers, where the conventional quantification of NTMs often only considered the characteristics of the NTMs imposed by importers. Third, we conduct an empirical analysis on each sector, namely manufacturing and agriculture, to thoroughly investigate the different impacts of technical regulations on different sectors.

3.3. Data Description

This section explains the data sources of this research. We employ panel NTMs data from the UNCTAD TRAINS database collaborated by UNCTAD and regional think tanks, including ERIA. The data includes trade regulations for 92 reporters at the reporter-partner-year-product-NTMs classification level. Reporter and partner indicate importer and exporter, respectively. Product refers to HS six-digit products, and NTMs classification level follows MAST classification. UNCTAD (2019) explains the objectives of the MAST group as developing a concise definition and classifying a system of NTMs to construct a favorable environment for analysis regarding technical regulations. Unlike the first-round data of UNCTAD TRAINS, the current version of NTMs data from the UNCTAD-TRAINS uniformly adopts the 2019 version of MAST classification (M4). Henceforth, we do not need to concord different MAST classifications for the current analysis.

We extract 24 economies and 25 industries from the raw data to concord with the sample countries from GVCs data and other variables. Appendix A describes the 24 sample countries for this analysis, including three-letter alphabetical codes from ISO3. We then convert HS six-digit product-level NTMs data to the International Standard Industrial Classification of All Economic Activities (ISIC) Rev.4 classification. To meet with aggregated sector-level observations in GVCs data, we use the simple mean of NTMs observations over the industry.

Appendix B describes the 25 industries for this research. When conducting sector-level analysis for manufacturing and agriculture sectors, we define the industry codes as follows: ISIC Rev.4 10 to 33 as manufacturing, and 01 to 09 as agriculture sector. As participating in production networks often occurs in the agriculture and manufacturing sectors, we also present empirical results using non-service sectors, excluding sectors from 35 to 96 and sector 09.

Among NTMs classification, we adopt import-related NTMs chapters A, B, and C as technical measures and chapters E, F, G, H, and I as non-technical measures, as defined by UNCTAD (2019). Chapters A and B respectively define SPS and TBT measures. Chapter C refers to pre-shipment inspection. We adopt all four-digit NTMs classification in Table 1 when constructing ACRI; one-digit alphabetical letter and two-digit numbers. We exclude A11, A12, E31, and E32 when quantifying NTMs as they represent explicit trade prohibitions, where A11 represents prohibitions for SPS reasons, and A12 implies geographical restrictions on eligibility in technical regulations. Therefore, we construct two ACRI using technical regulations and non-technical regulations.

Table 3.1. List of NTMs classification Type

	NTMs chapters	Contents	Classification
Technical measures	A	Sanitary and Phytosanitary Measures	A13 A14 A15 A19 A20 A21 A22 A30 A31 A32 A33 A41 A42 A49 A51 A52 A53 A59 A61 A62 A63 A64 A69 A81 A82 A83 A84 A85 A86 A89 A90
	B	Technical Barriers to Trade	B14 B15 B19 B20 B21 B22 B31 B32 B33 B41 B42 B49 B60 B70 B81 B82 B83 B84 B85 B89 B90
	C	Pre-shipment Inspection and other Formalities	C10 C20 C30 C40 C90
Non-technical measures	D	Contingent Trade-protective Measures	N/A
	E	Restrictions other than SPS and TBT	E11 E12 E20 E21 E22 E23 E31 E32 E51 E60 E61 E62 E90
	F	Price-control Measures	F11 F12 F19 F31 F32 F39 F40 F50 F61 F62 F64 F65 F69 F71 F72 F73 F79 F90
	G	Financial Measures	G11 G13 G19 G32 G39 G40 G90
	H	Measures Affecting Competition	H11 H19 H21 H22 H29 H90
	I	Trade-related Investment Measures	I10 I20 I90
	J	Distribution Restrictions	N/A
	K	Restrictions on Post-sales Services	N/A
	L	Subsidies and other Forms of Support	N/A
	M	Government Procurement Restrictions	N/A
	N	Intellectual Property	N/A
	O	Rules of Origin	N/A
Exporters' measures	P	Export-related Measures	N/A

*Note: NTMs classification A11, A12, B11, E31, and E32 are excluded as they refer to explicit prohibition measures for international trade. We present NTMs classification codes that are adopted in this research. Please

refer to UNCTAD (2019) for more details on the prohibition measures and more detailed NTMs classification codes.
*Source: Authors based on UNCTAD (2019).

We deviate from Chapter 2 when constructing ACRI as the following. First, we do not distinguish the groups in Chapter C of NTMs classification. While Chapter 2 focused on the bilateral difference between origin countries (exporters) and destination countries (importers), we analyze reporter (importers)-industry-year levels on the world as partners (exporters). Therefore, while Chapter 2 dissected measures affecting domestic and imported products (C1) and measures affecting only imports (C2, C3, and C4) from Chapter C of NTMs classification, this chapter does not need to distinguish such measurement information. Furthermore, we define "World" as the entire sample countries presented in Appendix A.

Second, we construct ACRI using non-technical measures, namely Chapters E, F, G, H, and I. They typically represent other restrictions than SPS and TBT, price-control, financial measures, competition measures, and trade-related investments, which may hamper international trade relatively higher than technical measures. We distinguish the effect of the additional burden from technical and non-technical regulations to compare the different effects of regulations on GVCs participation.

We extract the backward and forward participation in GVCs from OECD ICIO tables. The data covers 35 OECD countries and 29 non-OECD economies from 1995 to 2015 at the reporter-partner-industry-year level. Among them, we extract 24 economies from 2012 to 2015. Total participation in GVCs refers to the sum of backward and forward participation. We present the construction of GVCs participation in Section 3.4.

According to Fernandes et al. (2020), the determinants of GVCs participation include factor endowments, domestic industrial capacity, trade policies, foreign investment, institutional quality, and macroeconomic factors. Factor endowments refer to natural resources, labor, or capital, which often showed positive results on GVCs participation in their analysis. Trade policy such as tariff showed negative results on GVCs participation. Foreign investment, such as FDI and institutional quality, showed a positive relationship with GVCs participation. Macroeconomic factors showed mixed results. Following their work on the determinants of GVCs participation, we include Gross Domestic Products (GDP), Foreign Direct Investment (FDI), trade openness, and a series of fixed effects as control variables. We use GDP as a proxy for factor endowments and domestic industrial capacity, FDI as foreign investment,

trade openness as a measure for international transactions (macroeconomic factors), and industry fixed effects to control for institutional quality.

We extract and construct the control variables as the following. We extract the MFN tariff from World Integrated Trade Solution (WITS) for the reporter-partner-product-year level. We then aggregate the ratio using a simple mean over reporter-industry-year level. The GDP is from World Development Indicators (WDI) to capture country-year effects. The value is 100 billion constant 2015 US dollars. Trade openness refers to the total trade (sum of exports and imports) on GDP for each reporter-industry-year level. The variable captures how much the economy is engaged in international transactions. We further extract FDI share information from WDI and OECD Structural Analysis (STAN) databases. FDI share refers to the share of FDI net inflows on GDP. As WDI only reports the total inflow of FDI, we adopt industry-level FDI share from the OECD STAN database. However, we conduct empirical regressions on manufacturing and agriculture sectors using only 11 countries from the OECD STAN database due to data restrictions. The sample countries are marked with an asterisk (*) in Appendix A. In short, we conduct empirical regressions with 24 reporters, 25 industry, and through four years (2012 to 2015).

3.4. Methodology

3.4.1. Construction of Additional Compliance Requirement Indicator

We follow the construction methodology of ACRI in Section 2.3.2 of Chapter 2. We construct the weighted average of ACRI for each year from 2012 to 2015. By including time subscript *t* to the equation (6) from Section 2.3.2, we get[2]:

$$\text{ACRI}_{ijt}^{d} = \sum_{\text{p}\in P_{ijt}^{d}} \frac{V_p}{V^d} \text{ACRI}_{ijpt}. \quad (1)$$

where ACRI_{ijt}^{d} refers to ACRI from exporter *i*, to importer *j*, in industry *d*, at time *t*. We aggregate ACRI_{ijpt} using trade share $\frac{V_p}{V^d}$, where V^d is the world total trade value for industry *d*, and V_p is the world total trade value for product *p*. To concord GVCs data, we correspond HS six-digit level product to ISIC Rev.4 products using WITS concordance table.[3] As shown in

[2] Note that equation (6) refers to $\text{ACRI}_{ij}^{s} = \sum_{\text{p}\in P_{ij}^{s}} \frac{V_p}{V^s} \text{ACRI}_{ijp}$ from Section 2.3.2. The equation differs from the equation (6) of Chapter 3.

[3] See https://wits.worldbank.org/product_concordance.html for more details. Appendix B describes the industry

Section 2.3.2, the ACRI quantifies the regulatory burden with the qualitative information of NTMs on legal documents.

As long as both the exporters and importers implement some regulations, $ACRI_{ijt}^{d} \in [0,1)$. When the regulations are identical in both the domestic and foreign market, no additional compliance is required for the exporters ($ACRI_{ijt}^{d}$=0). Furthermore, ACRI remains zero when only the domestic market of exporters enforces some technical regulations. When only the importers impose any regulations on their market, exporters face $ACRI_{ijt}^{d}$=1.

3.4.2. Construction of Global Value Chains Participation

Economies participate in GVCs through upstream and downstream linkages. When the economy exports domestically produced goods or services to trade partners which re-exports to other economies with further processing, they participate in the forward GVCs participation. We define the forward participation in GVCs as the share of domestic value-added of the exporters embodied in the third economy's exports. According to WTO (2015), forward participation in GVCs refer to "Domestic value-added sent to third economies to the economy's total gross exports." (Explanatory notes, p.2). To be concise, it is the seller's perspective or the supply side of GVCs participation. We adopt the information from OECD, which constructs the forward participation in GVCs from country *i*, in industry *d*, at time *t* as:

$$Forward_{it}^{d} = \frac{DVX_{it}^{d}}{GE_{it}^{d}}, \tag{2}$$

where DVX and GE refers to the domestic value-added in exports and gross exports, respectively. Note that unlike domestic value-added (DVA), DVX is the domestic value-added portion of the exports.

Economies can also participate in GVCs through downstream linkages. We define backward participation in GVCs as follows. An economy first imports foreign inputs. They then produce intermediate or final goods which are exported to another country. According to WTO (2015), backward participation in GVCs refers to "Foreign value-added content of exports to the economy's total gross exports." It is the buyer's perspective of the GVCs participation. Similar

used for this research.

to the information of forward participation in GVCs, we adopt the information on backward participation from OECD, which is:

$$Backward_{it}^{d} = \frac{FVA_{it}^{d}}{GE_{it}^{d}}. \quad (3)$$

$Backward_{it}^{d}$ indicates the backward participation in GVCs from country *i*, in industry *d*, at time *t*. FVA refers to the foreign value-added.

We further construct the total GVCs participation index as the sum of $Forward_{it}^{d}$ and $Backward_{it}^{d}$ which is calculated as:

$$Total_{it}^{d} = \frac{FVA_{it}^{d} + DVX_{it}^{d}}{GE_{it}^{d}}. \quad (4)$$

$Total_{it}^{d}$ indicates the overall participation in GVCs from country *i*, in industry *j*, at time *t*.

3.4.3. Estimating Equation

We estimate the impact of NTMs on GVCs participation using the following reduced form equation.

$$GVC_{it}^{d} = \beta_0 + \beta_1 Regu_{it}^{d} + \beta_2 ln\left(1 + \text{tariff}_{it}^{d}\right) + \beta_3 ln(GDP_{it}) + \beta_4 ln\left(1 + open_{it}^{d}\right) + \beta_5 ln(FDI_{it}) + F^{d} + F_t + \varepsilon_{ijt}^{d} \quad (5)$$

GVC_{it}^{d} indicates the vector of GVCs participation, including $ln\,(1 + Forward_{it}^{d})$, $\ln\,(1 + Backward_{it}^{d})$, and $\ln\,(1 + Total_{it}^{d})$ from equations (2), (3), and (4) from Section 3.4.2. $Regu_{it}^{d}$ refers to the vector of ACRI including both technical regulations ACRI and non-technical regulations ACRI: $ln\,(1 + ACRI_{it}^{d})$. $ACRI_{it}^{d}$ refers to the average value of $ACRI_{ijt}^{d}$ on the destination market *j*, indicating the world average of ACRI. GDP_{it} refers to the GDP of country *i* at time *t*. $open_{it}^{d}$ and FDI_{it} indicate industry-level trade openness and net FDI inflows per GDP. As we conduct empirical analysis not only for the total sample but for manufacturing and agriculture sectors, we use industry-level FDI from OECD STAN for sector-level analysis to take account of FDI for each sector, where FDI for the total sample is from WDI. F^{d} and F_t indicate industry fixed effect and year fixed effect.[4] Furthermore, we use the raw value for the

[4] We assumed that the reporter fixed effects are already taken account through GDP.

dependent variables ($ln\ (1 + Forward_{it}^{d})$, $\ln\ (1 + Backward_{it}^{d})$, and $\ln\ (1 + Total_{it}^{d})$) when conducting PPML estimation for robustness check.

As the countries of interest (reporter) are the exporters for forward participation in GVCs, we input ACRI and tariff in the opposite direction. Specifically, when conducting empirical analysis on forward participation in GVCs, the imposition of technical or non-technical regulations from the world average becomes the foreign vector. Therefore, we test the impact of additional regulations that the world imposes on the forward participation of reporters. Likewise, tariffs are the world average MFN rates in this case. When conducting empirical analysis on total participation in GVCs, we use the mean value for ACRI and tariff used for forward and backward participation in GVCs.

3.4.4. Preliminary Data Visualization

Table 3.2 shows the summary statistics of our variables. The table indicates that forward participation is relatively lower than backward participation in GVCs. We may also infer that the pattern of total participation in GVCs will be similar to backward participation as they show similar summary information: mean, standard deviation, minimum value, and maximum value.

Table 3.2. Summary Statistics

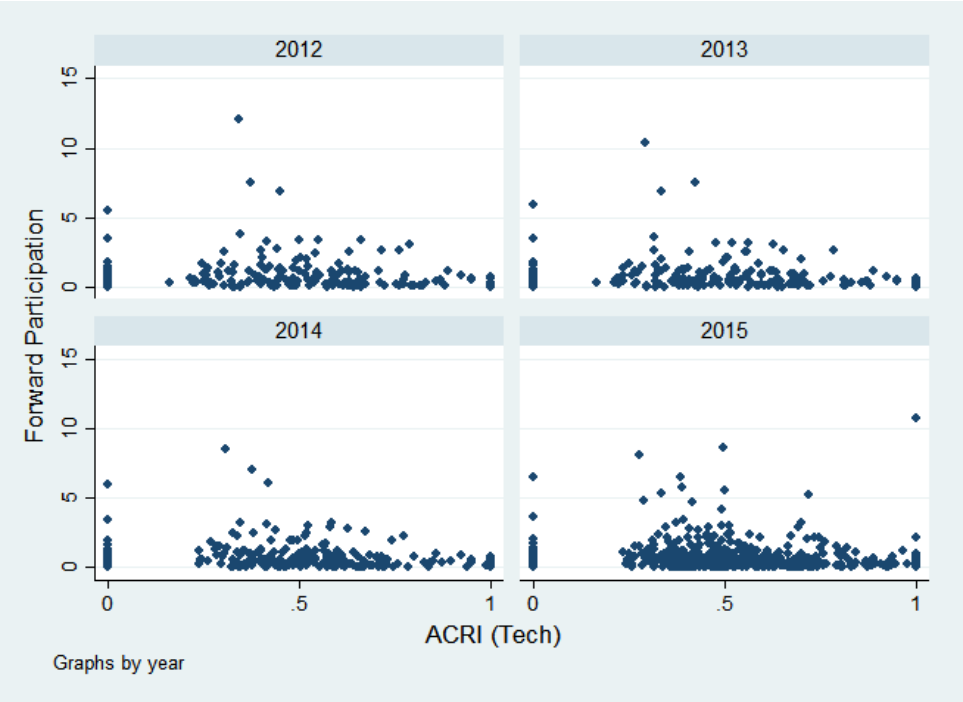
VARIABLES	(1) N	(2) Mean	(3) SD	(4) Min	(5) Max
Forward	1,164	0.759	1.148	0	12.07
Backward	1,164	20.842	13.505	0	81.49
Total	1,164	21.6	13.667	0	81.73
ACRI	1,164	0.457	0.274	0	1
ACRI (Non)	1,164	0.826	0.376	0	1
Tariff (%)	1,164	7.114	8.572	0	97.838
GDP	1,164	31.524	51.611	0.129	176.941
Openness	1,164	0.001	0.002	0	0.027
FDI share	1,164	4.936	4.782	-0.041	22.654

*Note: See https://wits.worldbank.org/wits/wits/witshelp/content/codes/country_codes.htm for more details. SD, min, and max refer to standard deviation, minimum value, and maximum value. The variables in summary statistics are raw values.
*Source: Authors based on WITS country codes.

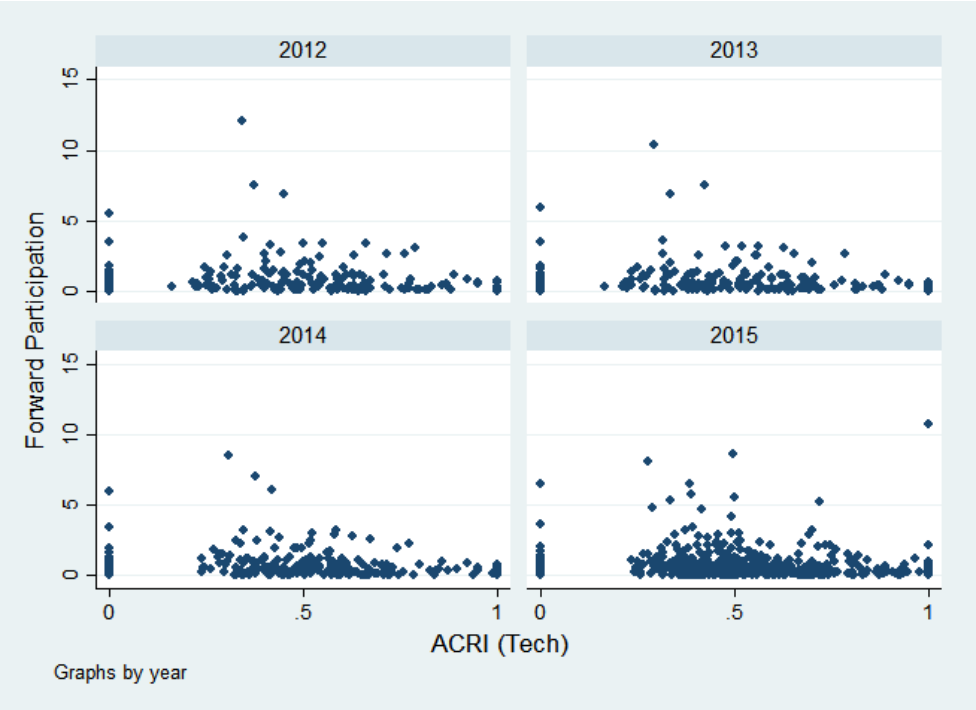
To take account of the different magnitude between forward and backward participation in GVCs, as shown in Table 3.2, we compare the effect of ACRI (technical regulations-oriented) to see if they have different or noticeable distribution patterns. Figure 3.1 depicts the ostensible relationship between GVCs participation and ACRI. Across the years, they show similar patterns: observations primarily located in the average range. Furthermore, regardless of forward and backward GVCs participation, the patterns are similar to ACRI.

Figure 3.1. GVCs participation and ACRI

Forward Participation and ACRI



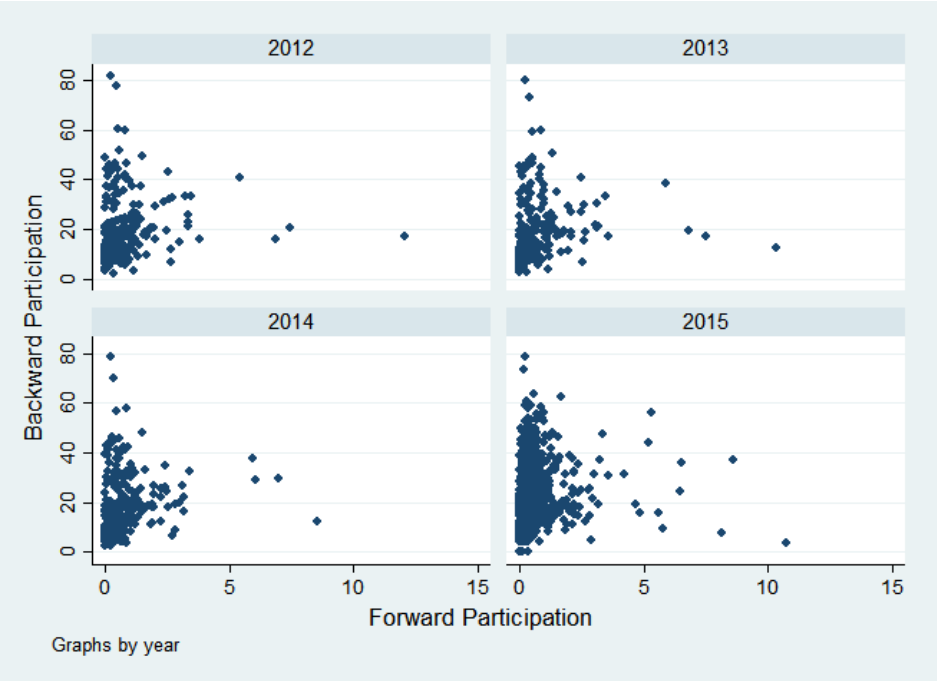
Backward Participation and ACRI



*Source: Author's calculation

We further test whether forward and backward participation has specific patterns. Countries involved in importing primary or intermediate goods from other countries (FVA) may also export more primary goods to other countries. Figure 3.2 depicts the ostensible scatter plot between forward and backward participation in GVCs. The figure shows that the magnitude of backward participation is larger than forward participation, as shown in the summary statistics (Table 3.2), and no specific trends or patterns between the two GVCs participation.

Figure 3.2. Forward and Backward Participation



*Source: Author's calculation

3.5. Estimation Results

This section presents the empirical results following the methodology from the previous section. Tables 3.3 to 3.5 present POLS results on forward, backward, and total participation in GVCs. For each Table 3.3, 3.4, and 3.5, rows (1) to (4) represents the empirical results with total samples, including service sectors such as ISIC Rev. 4 industry 09, and 35 to 96. Rows (5) to (8) show the empirical results without such service sectors, focusing mainly on manufacturing and agriculture sectors. ACRI and ACRI (non) refer to additional technical and non-technical regulations that countries need to follow when participating in the production networks. The results show identical signs with and without service sectors, and the patterns for backward and total participation in GVCS show similar results as mentioned in Section 3.4.4.

Additional technical regulations burden discourages each country from participating in all GVCs participation. If ACRI increase by one percent, forward participation decreases by 0.1 percent, backward participation decreases by 0.66 percent, and total participation diminishes by 0.65 percent. Regardless of the domestic value-added of exporters or foreign value-added, reporters suffer from participating in production networks when additional NTMs to follow increase. Noticing that all GVCs participation are calibrated using world average, a decrease in 0.1 percent may even be significant for each country. On the other hand, additional non-

technical regulations that reporters need to comply with before entering the foreign market only show negative and statistically significant results on backward and total participation in GVCs. Explicit trade costs primarily hamper foreign value-added portion of exports to the gross exports. Although statistically insignificant, ACRI (non) shows positive coefficients on forward participation in GVCs. Positing that regulations act as fixed costs for exporters, they may trade more volume to the destinations they originally had trade relationships with to compensate for increased costs (Lawless and Whelan 2007).

Tariff rates hamper forward participation in GVCs but show statistically insignificant results on both backward and total participation. The results indicate that tariff rates negatively affect the upstream goods, specifically domestic value-added sent to other economies. The magnitude of costs from tariff rates is approximately seven times larger than additional technical regulations. On the other hand, tariff rates on backward participation often show positive coefficients, albeit statistically insignificant. This may imply that costs from tariff rates are relatively lower for importers of foreign value-added but higher for exporters of upstream products. Despite the low tariff rates, as shown in Figure 3.3, they still act as a significant barrier for taking part in the forward participation in GVCs.

GDP shows negative linkages with all GVCs participation. Small countries may rely more on trade activities and participate in production networks for products of comparative advantage. Furthermore, larger countries have more capacity for producing and exporting different products. Their virtuous cycle fortifies as diversification of exported goods leads to diversification of imported goods when assuming the presence of fixed costs. Additionally, the large market size allows the economy to take advantage of the domestic market before participating in foreign production networks. Additionally, as World Bank (2019) addressed, developing nations have a higher chance of participating in international trade through GVCs participation. The complex nature of GVCs increase the participation of developing nations in the current trade nature, relatively larger than developed nations. Therefore, the larger the economy's size, the GVCs participation ratio decreases.

Openness and FDI show similar trends for each participation in GVCs. They both show the negative but statistically insignificant result on forward participation, whereas positive and statistically significant results on backward and total participation. The results indicate that as the economy weighs more international transactions than domestic transactions, and as the economy receives more FDI, the foreign value-added content of exports increases. They import

more primary goods or intermediate goods as they are more open to trade and receive more investments.

Table 3.3. Pooled OLS Results on Forward Participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Forward Participation							
VARIABLES	Including Service Sectors				Excluding Service Sectors			
ACRI	-0.100**		-0.099**		-0.124**		-0.121**	
	(0.040)		(0.043)		(0.049)		(0.052)	
ACRI (Non)		0.023		0.033		0.023		0.036
		(0.029)		(0.031)		(0.034)		(0.036)
Tariff	-0.731***	-0.684***	-0.732***	-0.701***	-0.786***	-0.733***	-0.791***	-0.755***
	(0.123)	(0.126)	(0.127)	(0.130)	(0.141)	(0.144)	(0.146)	(0.150)
GDP	-0.037***	-0.030***	-0.037***	-0.029***	-0.043***	-0.035***	-0.043***	-0.034***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)
Openness	-2.174	-0.735	-2.154	-0.342	-2.383	-0.813	-2.316	-0.328
	(7.818)	(7.854)	(7.791)	(7.796)	(7.823)	(7.858)	(7.788)	(7.788)
FDI			-0.012	-0.172			-0.041	-0.222
			(0.181)	(0.179)			(0.212)	(0.209)
Constant	0.526***	0.470***	0.526***	0.472***	0.557***	0.494***	0.559***	0.497***
	(0.036)	(0.039)	(0.036)	(0.039)	(0.040)	(0.044)	(0.041)	(0.044)
Observations	1,164	1,164	1,164	1,164	983	983	983	983
R-squared	0.650	0.648	0.650	0.648	0.590	0.588	0.590	0.588
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

*Note: All variables are transformed using the natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.4. Pooled OLS Results on Backward Participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Backward Participation							
VARIABLES	Including Service Sectors				Excluding Service Sectors			
ACRI	-0.661***		-0.758***		-0.630***		-0.701***	
	(0.078)		(0.087)		(0.086)		(0.096)	
ACRI (Non)		-0.556***		-0.679***		-0.531***		-0.628***
		(0.050)		(0.060)		(0.052)		(0.063)
Tariff	0.162	-0.082	0.361	0.114	0.015	-0.195	0.162	-0.035
	(0.241)	(0.230)	(0.243)	(0.226)	(0.238)	(0.227)	(0.240)	(0.222)

GDP	-0.091***	-0.096***	-0.098***	-0.108***	-0.088***	-0.095***	-0.094***	-0.105***
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Openness	31.579***	27.604***	28.950***	23.102***	32.936***	29.023***	31.104***	25.624***
	(7.776)	(7.392)	(7.827)	(7.376)	(7.743)	(7.343)	(7.807)	(7.357)
FDI			1.522***	1.969***			1.123**	1.558***
			(0.482)	(0.494)			(0.534)	(0.548)
Constant	2.770***	2.975***	2.706***	2.945***	2.769***	2.966***	2.722***	2.943***
	(0.081)	(0.085)	(0.080)	(0.081)	(0.083)	(0.087)	(0.084)	(0.085)
Observations	1,164	1,164	1,164	1,164	983	983	983	983
R-squared	0.487	0.495	0.496	0.510	0.450	0.460	0.456	0.471
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

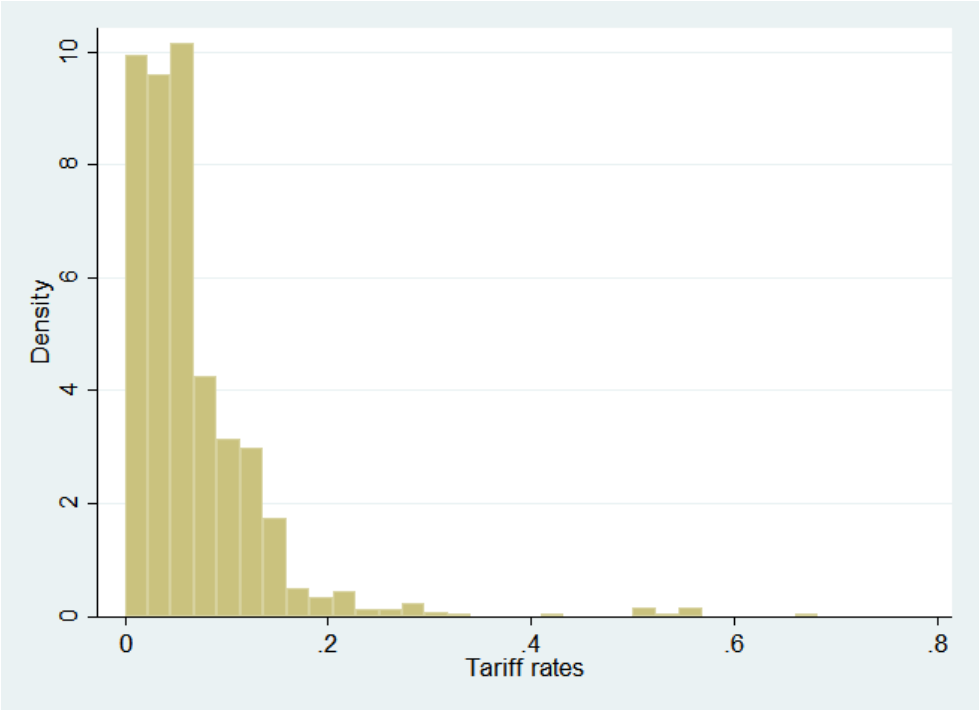
*Note: All variables are transformed using the natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.5. Pooled OLS Results on Total Participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total Participation							
VARIABLES	Including Service Sectors				Excluding Service Sectors			
ACRI	-0.653***		-0.746***		-0.623***		-0.690***	
	(0.075)		(0.083)		(0.081)		(0.090)	
ACRI (Non)		-0.540***		-0.657***		-0.514***		-0.604***
		(0.047)		(0.057)		(0.050)		(0.060)
Tariff	0.063	-0.171	0.252	0.015	-0.092	-0.292	0.044	-0.143
	(0.230)	(0.219)	(0.230)	(0.213)	(0.224)	(0.213)	(0.224)	(0.206)
GDP	-0.095***	-0.099***	-0.102***	-0.110***	-0.093***	-0.099***	-0.098***	-0.108***
	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.010)	(0.010)
Openness	29.379***	25.631***	26.872***	21.352***	30.705***	27.044***	28.997***	23.879***
	(7.275)	(6.908)	(7.310)	(6.882)	(7.220)	(6.835)	(7.266)	(6.835)
FDI			1.451***	1.872***			1.047**	1.451***
			(0.460)	(0.473)			(0.506)	(0.522)
Constant	2.830***	3.025***	2.769***	2.997***	2.833***	3.019***	2.789***	2.997***
	(0.076)	(0.080)	(0.076)	(0.077)	(0.078)	(0.082)	(0.079)	(0.080)
Observations	1,164	1,164	1,164	1,164	983	983	983	983
R-squared	0.526	0.533	0.535	0.547	0.492	0.500	0.497	0.510
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

*Note: All variables are transformed using the natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Figure 3.3. Tariff Rates for the Sample Countries



Tables 3.6 and 3.7 show POLS results in the manufacturing and agriculture sectors. Results on manufacturing sectors are similar to those of the total sample, as shown in Tables 3.3 to 3.5. Additional technical regulations hamper GVCs participation, and additional non-technical regulations hamper backward and total participation in GVCs. However, tariffs show positive and statistically significant coefficients on backward and total participation in GVCs. As mentioned above, on the one hand, tariffs may already be trivial. Moreover, exporters may increase the volume of importing primary products to produce a larger volume of exporting goods, as they need to compensate for additional tariffs. Trade openness shows statistically insignificant results, whereas FDI shares show positive and statistically significant results on backward and total participation in GVCs. This may imply that FDI incurs higher backward GVCs participation in the manufacturing sector.

Table 3.7 shows the empirical results in the agriculture sector. Unlike previous results, additional technical regulations show statistically insignificant results on GVCs participation. Regardless of the additional regulations, exporters engage in production networks in the agriculture sector. The results imply that agricultural goods are inflexible regardless of the additional costs compared to manufacturing goods. This could also indicate that regulations in the agriculture sectors act well in terms of filtering unsuitable goods for consumer and environmental safety relative to regulations in the manufacturing sector. Albeit statistically

insignificant, the coefficient on forward participation also shows positive results for both technical and non-technical ACRI. Regardless of the regulations, upstream exporters may engage in GVCs participation as complying with additional costs are lower than anticipated profits that they can gain from participating in the production networks. Moreover, unlike the manufacturing sector, trade openness induces backward and total participation compared to inward FDI in terms of statistical significance. As the economy weighs more on international transactions compared to domestic transactions, agriculture exporters engage more in importing foreign value-added and exporting processed goods. The results also conform to the role of FDI effectiveness in the agriculture sector. When an economy receives investments in the agriculture sector, the profits may shift back to the owner country, and the food price in the local market would inevitably increase.[5] On the other hand, trade openness shows positive and statistically significant coefficients. Therefore, trade openness is more effective in backward participation for agriculture goods, and FDI seems to be more focused on the manufacturing sector.

Notice also that, ACRI constructed from non-technical regulations lose statistical significance in the regression results on forward participation, regardless of the sectors. As non-technical regulations often include price-control measures, such as chapter F (Price-control measures from additional taxes), and chapter H (Measures affecting competition), they often directly hamper international trade. Both FVA and DVX may be vulnerable to additional burden from non-technical regulations as the price of imported goods and domestic goods are highly related to additional costs from non-technical regulations. However, the results indicate that additional costs from non-technical regulations show statistically insignificant results on the domestic value-added portion of the exports embodied in the third economy's exports. Products, sectors, or even countries involved in the GVCs position through foreign value-added to the economy's total gross exports are located in the downstream stage of the value-chains. They import goods from other countries and export again after adding value-added to the goods. As additional non-technical regulations increase the price of imported goods, they inevitably have to import the goods to be involved in the backward linkage of GVCs. Less information on the price of imported goods, such as information asymmetry stemming from less knowledge on different trading partners, could be a reason as well. On the other hand, if they are in the upstream stage of the value-chains, they may export their upstream goods to a more lucrative

[5] Some also concern that investments in agriculture sector correspond with selling land to foreign countries or firms.

or cost-effective market. In other words, price-control measures may less likely to affect forward participation in GVCs, compared to backward participation in GVCs. In this case, unexpected costs stemming from additional technical regulations exert larger negative effects on GVCs participation as they hamper both forward and backward participation. The hidden barriers from non-technical regulations hamper GVCs participation both through forward and backward participation. Therefore, forward participation in GVCs is less sensitive to the additional burden stemming from price-control measures, compared to the additional costs from non-technical measures.

Table 3.6. Pooled OLS Results on the GVCs participation in Manufacturing Sector

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Forward Participation		Backward Participation		Total Participation	
ACRI	-0.267***		-0.465***		-0.477***	
	(0.098)		(0.106)		(0.100)	
ACRI (Non)		0.031		-0.546***		-0.525***
		(0.074)		(0.056)		(0.052)
Tariff	-1.290***	-1.108***	2.265***	1.797***	2.098***	1.664***
	(0.195)	(0.223)	(0.467)	(0.492)	(0.444)	(0.467)
GDP	-0.060***	-0.058***	-0.088***	-0.088***	-0.091***	-0.092***
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)
Openness	-28.690	-37.839	83.150	76.311	77.231	69.676
	(52.987)	(53.366)	(51.275)	(48.849)	(47.844)	(44.937)
FDI	-0.082	-0.150	0.725***	0.677**	0.700***	0.647***
	(0.181)	(0.180)	(0.271)	(0.266)	(0.250)	(0.245)
Constant	1.088***	0.941***	2.716***	3.044***	2.818***	3.120***
	(0.080)	(0.095)	(0.127)	(0.131)	(0.118)	(0.122)
Observations	400	400	400	400	400	400
R-squared	0.551	0.542	0.412	0.452	0.458	0.493
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

*Note: All variables are transformed using the natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.7. Pooled OLS Results on the GVCs participation in Agriculture Sector

	(1)	(2)	(3)	(4)	(5)	(6)

VARIABLES	Forward Participation		Backward Participation		Total Participation	
ACRI	0.058		-0.512		-0.503	
	(0.069)		(0.365)		(0.356)	
ACRI (Non)		0.024		-0.703*		-0.697*
		(0.053)		(0.369)		(0.362)
Tariff	-0.323***	-0.317***	0.467	-0.192	0.408	-0.249
	(0.100)	(0.110)	(0.437)	(0.601)	(0.420)	(0.582)
GDP	-0.003	-0.004	0.011	0.016	0.009	0.014
	(0.010)	(0.010)	(0.025)	(0.025)	(0.024)	(0.024)
Openness	-4.382	-4.387	48.257***	34.527**	44.077***	30.385**
	(3.681)	(3.897)	(12.352)	(14.572)	(11.750)	(13.862)
FDI	41.028	46.028*	99.735	122.930	95.199	119.042
	(25.829)	(25.760)	(96.197)	(95.187)	(92.018)	(91.841)
Constant	0.358***	0.359***	2.419***	2.808***	2.474***	2.862***
	(0.058)	(0.069)	(0.213)	(0.337)	(0.205)	(0.327)
Observations	96	96	96	96	96	96
R-squared	0.696	0.694	0.325	0.350	0.306	0.334
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

*Note: All variables are transformed using the natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

We further estimate the impact of NTMs on GVCs participation using PPML as a robustness check. PPML takes account of the zero values of dependent variables and potential heteroskedasticity, as proposed by Silva and Tenreyro (2006). Tables 3.8 to 3.10 present the PPML results. They show similar results to the POLS estimation for the coefficients signs and directions.

Table 3.8. Robustness Check: PPML Results on GVCs participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Including Service Sectors				Excluding Service Sectors			
VARIABLES	Forward		Backward		Forward		Backward	
ACRI	-0.621***		-0.758***		-0.654***		-0.691***	
	(0.205)		(0.097)		(0.211)		(0.104)	
ACRI (Non)		-0.004		-0.719***		-0.017		-0.665***
		(0.146)		(0.060)		(0.149)		(0.062)

Tariff	-2.469***	-2.491***	0.567**	0.370	-2.462***	-2.475***	0.311	0.157
	(0.536)	(0.556)	(0.256)	(0.237)	(0.539)	(0.559)	(0.243)	(0.226)
GDP	-0.165***	-0.131***	-0.120***	-0.136***	-0.168***	-0.133***	-0.117***	-0.132***
	(0.027)	(0.026)	(0.010)	(0.010)	(0.028)	(0.027)	(0.011)	(0.011)
Openness	-4.338	1.159	15.717*	10.403	-4.493	0.945	17.488**	12.367
	(27.770)	(27.542)	(8.495)	(8.106)	(27.771)	(27.583)	(8.525)	(8.166)
FDI	0.112	-0.388	1.813***	2.336***	0.074	-0.425	1.472***	1.982***
	(0.734)	(0.716)	(0.323)	(0.308)	(0.751)	(0.733)	(0.339)	(0.322)
Constant	145.238***	158.569***	-95.964***	-101.210***	149.364***	162.418***	-93.175***	-97.741***
	(56.316)	(58.891)	(26.433)	(25.371)	(57.045)	(59.639)	(27.910)	(26.780)
Observations	1,164	1,164	1,164	1,164	983	983	983	983
R-squared	0.476	0.456	0.445	0.474	0.440	0.419	0.398	0.428
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

*Note: All variables are transformed using natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.9. Robustness Check: PPML Results on GVCS participation in Specific Sectors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Manufacturing Sector				Agriculture Sector			
VARIABLES	Forward		Backward		Forward		Backward	
ACRI	-1.038***		-0.385***		0.312		-0.491	
	(0.279)		(0.110)		(0.344)		(0.359)	
ACRI (Non)		-0.064		-0.477***		0.109		-0.743**
		(0.261)		(0.057)		(0.328)		(0.322)
Tariff	-3.187***	-2.717***	2.421***	1.877***	-2.014***	-1.991***	0.215	-0.508
	(0.704)	(0.767)	(0.441)	(0.439)	(0.601)	(0.685)	(0.382)	(0.528)
GDP	-0.200***	-0.178***	-0.069***	-0.072***	0.005	-0.002	-0.027	-0.024
	(0.034)	(0.032)	(0.012)	(0.012)	(0.040)	(0.039)	(0.026)	(0.026)
Openness	-70.488	-93.033	73.921	68.506	-14.837	-15.138	36.979***	21.808
	(106.233)	(102.442)	(46.168)	(44.473)	(11.372)	(13.271)	(10.635)	(13.410)
FDI	-0.001	-0.271	0.725*	0.727*	249.148**	270.915**	-45.212	-2.190
	(0.655)	(0.617)	(0.379)	(0.391)	(105.111)	(107.253)	(96.730)	(89.875)
Constant	149.568*	122.224	3.414	10.567	475.233***	465.175***	-182.312**	-154.825*
	(86.014)	(88.544)	(37.543)	(37.009)	(99.372)	(102.560)	(83.382)	(86.718)
Observations	400	400	400	400	81	81	96	96
R-squared	0.442	0.394	0.369	0.415	0.640	0.637	0.218	0.264
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

*Note: All variables are transformed using the natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, *

p<0.1. Some observations in the analysis on forward participation in the agriculture sector using PPML analysis are dropped due to multicollinearity with year Fixed Effect.

Table 3.10. Robustness Check: PPML Results on Total Participation

Robustness Check: PPML results on Total Participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total Participation							
VARIABLES	Total Sample		Without Service		Manufacturing		Agriculture	
ACRI	-0.753***		-0.688***		-0.405***		-0.479	
	(0.092)		(0.098)		(0.103)		(0.350)	
ACRI (Non)		-0.696***		-0.643***		-0.464***		-0.738**
		(0.057)		(0.059)		(0.052)		(0.316)
Tariff	0.472*	0.284	0.217	0.070	2.255***	1.747***	0.184	-0.539
	(0.241)	(0.224)	(0.227)	(0.212)	(0.422)	(0.419)	(0.369)	(0.515)
GDP	-0.122***	-0.136***	-0.119***	-0.132***	-0.074***	-0.076***	-0.026	-0.023
	(0.010)	(0.010)	(0.010)	(0.010)	(0.012)	(0.011)	(0.025)	(0.025)
Openness	15.029*	10.012	16.763**	11.955	68.801	62.147	34.619***	19.407
	(8.189)	(7.849)	(8.198)	(7.887)	(43.266)	(41.100)	(10.112)	(12.801)
FDI	1.754***	2.246***	1.420***	1.895***	0.701**	0.693*	-38.973	4.246
	(0.306)	(0.293)	(0.320)	(0.304)	(0.354)	(0.364)	(92.887)	(86.513)
Constant	-87.092***	-91.884***	-83.619***	-87.676***	8.377	14.543	-164.985**	-137.584*
	(24.824)	(23.852)	(26.089)	(25.055)	(34.891)	(34.409)	(80.323)	(83.596)
Observations	1,164	1,164	983	983	400	400	96	96
R-squared	0.483	0.509	0.436	0.463	0.408	0.451	0.211	0.261
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

*Note: All variables are transformed using the natural logarithm. See Section 3.4.3. for more details. ACRI and ACRI (Non) refer to ACRI using technical regulations and non-technical regulations. Openness refers to trade openness. FDI is the net inflow FDI per GDP. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.6. Chapter Conclusion

We focused on the impact of technical regulations on the GVCs participation in this chapter. To quantify the additional costs from regulations, we constructed ACRI using both technical measures and non-technical measures. We decomposed GVCs participation as forward, and backward participation using domestic value-added portion of exports (DVX) and foreign value added (FVA). In general, ACRI (both using technical and non-technical regulations) hampered both forward and backward participation in GVCs. When looking into specific sectors, the agriculture sector seemed to be not affected much by additional regulations.

Future research may improve the trade literature by the following: First, as Fernandes et al. (2020) addressed, the distance may play a critical role in GVCs participation. Distance often appears as fixed or variable costs depending on the methodology of trade literature; fixed costs in empirical studies, and variable costs in theoretical studies. As this research estimated the GVCs participation of reporters in the world, we excluded distance. Second, future research may incorporate the aid effectiveness of FDI. Although FDI showed positive and statistically significant results for backward participation in GVCs, indicating that FDI contributes to participating in the fragmented production network, this may also implicate that investment recipients could increase trade activities to the donors. Future research may construct international trade with three or more directions, including the impact of distance on GVCs participation, and incorporate aid effectiveness of FDI.

This chapter contributes to international trade as the following. First, this chapter also constructed ACRI to examine the additional costs that exporters need to comply with. As the conventional methodology of quantifying NTMs either increase serially (NTM count) or do not take account of the domestic regulations that exporters impose. This research deviates from the past literature on NTMs by taking account of the additional burden that exporters need to follow. Second, we examined the impact of additional regulations on decomposed GVCs participation. As the current fragmented production networks emphasize the role of GVCs, analysis of GVCs is vital in international trade literature. We showed that technical regulations also serve as a hidden barrier for participating in the fragmented production network.

Appendices

Appendix A. Sample Country List

ISO3	Country	Year	ISO3	Country	Year
ARG	Argentina	2012-2015	JPN*	Japan	2015
AUS*	Australia	2015	KHM	Cambodia	2015
BRA	Brazil	2012-2015	KOR*	Korea, Republic of	2012-2015
BRN	Brunei	2015	MEX*	Mexico	2012-2015
CAN*	Canada	2015	MYS	Malaysia	2015
CHE*	Switzerland	2015	NZL*	New Zealand	2015
CHL*	Chile	2012-2015	PER	Peru	2012-2015
CHN	China, Republic of	2012-2015	PHL	Philippines	2015
COL*	Colombia	2012-2015	SGP	Singapore	2015

CRI	Costa Rica	2014-2015	THA	Thailand	2015
EUN*	European Union	2012-2015	USA*	United States	2014
IDN	Indonesia	2015	VNM	Viet Nam	2015

*Note: See https://wits.worldbank.org/wits/wits/witshelp/content/codes/country_codes.htm for more details.
*Source: Authors based on WITS country codes.

Appendix B. Industry List

ISIC Rev.4	Industry	ISIC Rev.4	Industry
From 01 to 03	Agriculture; forestry and fishing	25	Fabricated metal products
From 05 to 06	Mining and energy producing products	26	Computer and electronic products
From 07 to 08	Mining of metal ores and quarrying	27	Electrical equipment products
09	Mining support service activities	28	Machinery and equipment products
From 10 to 12	Food, beverages and tobacco products	29	Motor vehicles
From 13 to 15	Textiles, apparel, and leather products	30	Other transport equipment products
16	Wood and articles of straw products	From 31 to 33	Furniture and other manufacturing products
From 17 to 18	Paper products and printing	From 35 to 39	Electricity and water supply
19	Coke and refined petroleum products	From 58 to 60	Information and communication
From 20 to 21	Chemicals and pharmaceuticals products	From 69 to 82	Service activities
22	Rubber and plastic products	85	Education
23	Other non-metallic mineral products	From 90 to 96	Arts and entertainment
24	Basic Metals		

*Note: Statistics. See https://ilostat.ilo.org/resources/concepts-and-definitions/classification-economic-activities/ for more details.
*Source: Authors based on International Labour Organization (ILO).

Chapter 4. Technical Regulations and the Quality of Traded Goods

4.1. Background

While the past literature on international trade primarily focused on the observable aspects of international transactions, research regarding the quality of traded goods is scarce. A Series of papers positively links developed countries with higher-quality goods exports than those of developing nations (Hallak, 2006; Schott, 2004). The impact of conventional trade costs on the quality of exported goods is not yet theoretically grounded. Amiti and Khandelwal (2013) examined the impact of import tariffs on the quality of goods by revising the conventional estimator of quality, which is the unit value, using percentiles. They showed that import tariffs have mixed results on the quality of goods traded: products closer to the frontier take advantage of low tariffs whereas vice versa for products distant from the frontier. The determinants of the quality of traded goods remain vague.

This chapter fills this missing gap by examining the relationship between NTMs application and the quality of traded products. We focus on technical and regulatory NTMs on both exports and imports. The hypothesis tests whether additional regulations cause higher quality or lower quality goods. As regulations often sophisticate the traded goods with additional safety measures, they may enhance their quality.

We address two questions. First, do countries export higher quality products when importers impose more regulations or additional regulations on the imported products? Second, does the impact of complying with additional regulations differ by sectors, including south-north trade (From developing economies to developed economies, or vice versa)? Since one major purpose of NTMs is to ensure the health and safety of consumers, well-designed technical regulations can keep substandard and fraudulent products out of the market (Movchan et al., 2019). Consequently, conformity with technical regulations can signal product quality upgrading, thus enhancing the competitiveness of products on the market (Hudson and Jones, 2003; Navaretti et al., 2018; Olper et al., 2014). Furthermore, regulations reduce information asymmetry, enhance the observability of product quality, and generate higher demand for better-quality products (Disdier et al., 2020; Leland, 1979; Yang et al., 2019). By shifting demand, NTMs may encourage the quality upgrading of firms.

On the other hand, technical measures may not generate the expected positive effects. This is particularly the case if the regulations incur high compliance costs for producers. To meet the

new product quality requirements, firms may need to adopt product and process innovation, which, in turn, implies an increase in capital investment. Specifically, quality upgrading could involve a switch to a new and more costly source of intermediate inputs (Chakraborty, 2017). Rising adjustment costs discourage firms from trading. This burden falls disproportionately on small firms that face resource constraints. Consequently, firms may divert their trade to less restrictive markets or stop exporting (Beestermöller et al., 2018; Fontagne and Orefice, 2018; Fugazza et al., 2018; Melitz, 2003; Melo et al., 2014). Moreover, regulations designed with protectionist intent could further impede competition and discourage the innovation of firms (Swinnen and Vandermoortele, 2011). Ghodsi (2020b) and Ghodsi and Stehrer (2021) analyzed the quality impact of NTMs (i.e., TBTs and SPS measures) notified to the WTO during the period 1995-2011 on the globally traded products. Ghodsi (2020b) showed both positive and negative impacts of regulations on the imports; negative on the flows to the EU and China (Republic of), and positive on the flows to the US. Furthermore, Ghodsi and Stehrer (2021) pointed out that although TBTs and SPS measures both induce higher quality of goods, accumulated flows of TBTs and the existence of SPS measures affect the quality of traded goods the most.

This chapter contributes to the literature on the impact of regulations on trade and literature on the quality of traded goods as follows. First, we employ newly released NTMs data developed and collected by the UNCTAD-TRAINS from 2012 to 2018 to estimate the quality effects of NTMs. The cross-sectional version of this data has been used widely for studies on the trade impact of NTMs (Bratt, 2017; Cadot et al., 2015; Cadot and Gourdon, 2016; Kee et al., 2009). Although Niu et al. (2018) utilized the panel data of NTMs collected by UNCTAD TRAINS, we employed the most recent version of the database which was publicly distributed in the last quarter of 2019.

Our framework on measuring quality deviates from the past literature as we construct ACRI to examine the additional burden of exporters. More precisely, our study is closely related to Olper et al. (2014); they place more weight on the diffusion of food standards on imports by the EU. This database overcomes two of the significant constraints of studies on NTMs-comprehensiveness and time dimension: the database covers all regulations in force which is the prerequisite for the measurement of regulatory distance, and covers the 2010-2018 period, which allows us to observe the changes in NTMs pattern and its potential impact on quality

upgrading.[1] While the past literature adopted NTMs data from the WTO I-TIP database such as Bao (2014), Bao and Qiu (2012), Fontagné and Orefice (2018), Fontagné et al. (2015), Ghodsi (2020a), Ghodsi et al. (2017), and Navaretti et al. (2018), this research employ the NTMs data from UNCTAD-TRAINS database which correspond to analyzing the official documents of each country. Professionals and specialists from each country accumulated and reported the information of NTMs based on the government documents to construct the NTMs database of UNCTAD-TRAINS. Incorporating the documented information of NTMs, the UNCTAD-TRAINS database presents detailed, comprehensive, and relatively more observations at reporter-partner-product-NTMs imposition-year level. Reporters and partners represent the regulations-imposing country (importers) and their corresponding trading partners (exporters), respectively.

Second, to mitigate problems with aggregation, we conduct the analysis at the most detailed HS level. Our data cover 4951 products at HS six-digit level using the H3 version (HS 2007). Unlike tariffs, aggregation of NTMs is not straightforward. First, differences in NTMs intensity partly arise from the characteristics of products. For example, SPS measures are more likely to regulate agricultural products. TBT, on the contrary, accounts for the majority of technical regulations on manufactured goods, machinery, and electronics. Without proper aggregation methods, NTMs indicators may simply reflect the heterogeneity in trade patterns rather than the stringency of NTMs (Melo and Nicita, 2018). Moreover, a single regulation can affect only one HS 6-digit product, such as a fumigation requirement on imported car seats, or hundreds of products, as in the case of a generic import licensing. Accordingly, summing up the number of regulations across products poses the risks of overestimating the prevalence of NTMs. Therefore, we construct NTMs at the most disaggregated level of HS six-digit level.

Third, to link regulations to quality upgrading and to overcome the risks of overestimating the prevalence of NTMs via summation of the number of regulations across products possessed, we utilize a novel indicator to measure the heterogeneity in regulatory structure between trading partners following Nabeshima et al., (2021), similar to those of Chapter 2. In particular, we consider whether or not two trade partners impose a requirement on the same product. NTMs cover a wide array of policy instruments with diverse designs and objectives, and thus, they exert distinguished impacts on product quality. For example, a labeling requirement is not

[1] See Melo and Nicita (2018) for a detailed discussion on the advantages and weaknesses of existing NTMs databases.

directly comparable to a requirement on production processes. Then, what matters is not the mere presence of technical regulations in the foreign market but rather how different the regulations imposed on the foreign market are compared to the domestic market. Intuitively, additional regulations that are not in existence in the domestic markets are more likely to induce quality improvement of imported goods.

Lastly, we construct the Quality Estimate (QE) following Henn et al. (2020). They constructed a new indicator that controls for the price of conventional quality variable, unit value. Traditional literature on the quality of traded goods often adopted unit value as the quality. While unit value corresponds with the price of the goods, the price may not be adequate in explaining the quality of traded goods. In fact, the price may not be a suitable indicator to examine the quality of traded goods as higher prices do not always match quality. We compare the impact of technical regulations on both the conventional unit value and QE to see how these two quality indices show different results. Overall, the results show that the additional burden caused by technical regulations positively correlates with the quality of traded goods, indicating that, unlike observable trade values, technical regulations contribute to the quality of products traded. Additionally, NTMs in the agriculture sector seem to be more harmonized as additional regulations increase the quality of goods and have a negative or less impact on price.

The rest of the chapter is organized as follows. We present a brief literature review in section 4.2. Section 4.3 describes data sources, and Section 4.4 describes the construction of the quality index and the empirical specification. Section 4.5 discusses the essential findings and Section 4.5 concludes the chapter.

4.2. Literature Review

Unlike tariffs, NTMs are complex policy instruments that fulfill multiple purposes. Traditional NTMs such as quotas, anti-dumping, and voluntary export restraints are considered as NTBs that are commercial policy tools, aiming to restrict international trade. However, the majority of current NTMs are technical measures designed primarily to protect the health and safety of consumers, ensure the welfare of animals, preserve the environment, and address concerns about national security and violation of cultural values. These NTMs legitimately serve as a welfare-improving tool to correct information asymmetry-driven market failures.[2]

[2] See Akerlof (1970) for more details on the relationship between quality and uncertainty.

Leland (1979) and Ronnen (1991) suggested minimum quality constraints as a possible solution to adjust asymmetric information; minimum quality standards alleviate the price competition and generate positive externalities, improving social welfare. Leonardi and Meschi (2016) showed that NTMs alleviate the negative employment effect from import exposure.

However, the majority of empirical analyses found a significant trade-distorting impact of NTMs. From the producers' side, the procedural costs and compliance costs arising from NTMs application inevitably reduce both the varieties of traded goods and the number of foreign firms serving the domestic market. For consumers, by decreasing varieties and the price increment of remaining goods, NTMs may exert a negative welfare impact similar to that of ad valorem tariffs. Andriamananjara et al. (2004) and Vanzetti et al. (2018) implemented Computable General Equilibrium (CGE) model to evaluate the impact of NTMs; the former stresses the importance of NTMs removal for the global welfare gains, and the latter place weight on harmonization of NTMs for the benefit of ASEAN exporters. Hoekman and Nicita (2008) and Liu and Yue (2009) conducted country-level analyses to estimate the impact of NTMs on international trade. Hoeckman and Nicita (2008) reviewed the trade restrictiveness index developed by the World Bank and the overall trade restrictiveness index following Kee et al. (2009). Their results suggest that the adverse effect of both tariffs and NTMs on low-income countries is explicit. Liu and Yue (2009) suggested that removing Japanese NTMs on a cut flower will increase the Japanese imports of cut flowers. They employed the combined effects of SPS and administrative customs procedures as regulations to emphasize the significance of incorporating product quality changes when estimating the impact of SPS. Disdier et al. (2007), Essaji (2008), and Ghodsi et al. (2017) implemented both HS four- and six-digit level analysis to show the negative impact of NTMs on international trade. Disdier et al. (2007) measured the AVEs of tariffs as a proxy for SPS and TBT on agricultural trade under the gravity setting. The results indicated that NTMs negatively influence the exports of developing and least developed countries. Moreover, imports of the EU severely suffered from TBT and SPS measures relative to other OECD members. Essaji (2008) indicated that technical regulations exacerbate the situation in emerging countries. The weak capacities of firms in developing countries to meet the technical regulations of their export counterpart will eventually lead them to alienate from more regulated industries. Similarly, Ghodsi (2020b) found evidence that Chinese TBTs have stimulated imports of manufacturing products from advanced economies while least developed countries trade has been negatively affected.

Only a handful of studies examine the potentially positive role of regulations in shaping product quality. Utilizing the Heckman selection model, Blind et al. (2017) show that standards and regulation each have the opposite impact on innovation. Low market uncertainty standards incur lower innovation efficiency, and regulations induce higher innovation efficiency; vice versa for high market uncertainty. Amiti and Khandelwal (2013) analyzed the impact of import competition, proxied by tariffs, on the quality of the products traded. Lower tariffs contribute to quality upgrading of products closer to the frontier due to competition effects. On the other hand, the quality of products farther from the frontier downgraded; these products faced more protection to induce quality upgrading. Adopting a similar distance to the frontier framework, Olper et al. (2014) showed that diffusion of standards, on average, can enhance product quality upgrading rate. Disdier et al. (2020) developed a firm-heterogeneity model and trade that incorporates product quality. Utilizing French firm data, they found that adoption of quality standards drives low-quality firms out of the domestic markets. Facing higher competition among high-quality incumbents, low-productivity firms also exit from the market (Melitz, 2003). The enactment of quality standards assures minimum quality, but average quality improvement is not necessarily occurring. Ghodsi and Stehrer (2018) focused on Commoditization and Commodity Traps in economic development. They showed that compliance to NTMs reduces the commoditization impact on their terms of trade based on a gravity framework. Using the data on the quality of products estimated by Feenstra and Romalis (2014) and Ghodsi and Stehrer (2021) found evidence that depending on the sectors, TBTs and SPS measures have diverse effects on the quality of traded products. Using similar data, Ghodsi and Stehrer (2019) found that TBTs and SPS measures imposed by the EU on poultry imports affect the quality and prices of imports diversely from different exporters.

While the literature has gradually become abundant in analyzing the impact of regulative NTMs on trade flows, it still lacks conclusive evidence on the role of these NTMs in the quality of traded products. Thus, this paper contributes to the literature by utilizing a panel dataset of quality NTMs collected by UNCTAD and assessing their impact on the quality upgrading of traded products at the six-digit level of the harmonized system from 2012 to 2018.

4.3. Data Description

We utilize the newly released panel NTMs database developed by UNCTAD in collaboration with regional think tanks and universities covering the 2010-2018 period.[3] For ASEAN countries, the data source is the raw ERIA-UNCTAD NTMs in the ASEAN database, 2019 version (Doan and Rosenow, 2019). The combined database contains NTMs derived from all trade regulations in 92 countries at the reporter-year-partner-product-NTM level. The data reflect regulations that were in force at the time of data collection. Data include unilateral NTMs, recording measures applied to the world, and bilateral NTMs applied to selected countries. Depending on the time of data collection, products are defined at different HS six-digit versions. Conversely, NTMs are defined in the three-digit Multi-Agency Support Team (MAST) M4 (UNCTAD, 2019). For consistency, we convert all HS nomenclatures to HS 2007 classification using concordance tables from United Nations Trade Statistics.

Among the data, we employ 77 countries from 2012 to 2018 to concord with other data. As only EU reports NTMs for 2010 and 2012, we adopt periods from 2012 to 2018. Additionally, data of five Latin-America countries, including Costa Rica, Guatemala, Honduras, Panama, and El Salvador, show an abrupt increase in the number of products affected between 2015 and 2016.[4] To construct consistent data, we drop data years before the sudden increase in the number of NTM-product pairs and thus, drop these countries from our sample. EU members are grouped into one trade partner to follow the structure of UNCTAD's NTM database structure.

As noted earlier, NTMs cover a wide range of policy tools serving various purposes, some of which are unrelated to product regulations. Therefore, we focus on the technical NTMs, namely SPS and TBT, equivalent to NTM Chapters A and B by MAST version M4. A and B cover SPS and TBT on imports, respectively. We exclude A11 (prohibitions for SPS reasons) and A12 (geographical restrictions on eligibility) for Chapter A because imports are, by definition, explicitly prohibited upon the implementation of these measures.[5] Unlike previous chapters, we exclude information of Chapter C (Pre-shipment inspection) to solely focus on technical regulations such as SPS and TBT that may affect the quality of goods.

[3] The data can be downloaded from trains.unctad.org. Data collection time is different across countries.
[4] These countries have adopted different HS classifications to calculate the number of NTMs-product pair between 2015 and 2016.
[5] See Appendix A and B for more details. It provides a list of NTMs groupings, and countries and years with available data.

Furthermore, we use the information from Chapter P to construct exporters' imposition of regulations. Chapter P includes export-related measures. We construct export deterrent measure including P11 (Export authorization), P12 (Export registration requirements), P13 (Production requirements), P14 (Product quality requirements), P15 (Labelling requirements), P16 (Conformity assessments), and P19 (Not elsewhere specified). We drop P17 when constructing the export deterrent measure as it refers to the export prohibition for SPS reasons. Additionally, we calibrate export promotion measure using P6 (Export-support measures). All information on NTMs is from UNCTAD (2019). We aggregate the total number of reported NTMs for each export deterrent measure and export prohibition measure at the reporter-partner-product-year level.

To estimate product quality, we extract bilateral import data from UN Comtrade at the HS six-digit level (HS 2007), covering the period from 2012 to 2018. For members of the EU, extra-EU trade is constructed. In so doing, the sum of import statistics of 28 individual EU members with each of their non-EU trade counterparts is calculated to construct import value and quantity for the EU as a single unit.

In addition to import statistics, we also use data on income per capita of exporting and importing countries and other variables from the standard gravity model, including the dummy variable on the existence of a preferential trade agreement, distance, a common colonizer, a colonial relationship, a common language relationship, and contiguity, when constructing QE. We use the distance between capital cities. Brussel is considered as the capital of the EU, which is home to a number of important European institutions, including the European Parliament. For standard gravity determinants in the EU, such as contiguity and common language, the variable takes the value of one if any of the 28 EU members possessed the corresponding relationship with partner countries. We extract nominal GDP per capita (USD) from the WDI and standard gravity variables from CEPII.[6] FTA information is extracted separately from the RTA database.[7]

We include tariff rates to denote variable costs. We extract AVEs of both MFN and preferential tariff rates from the WITS database. Tariff is defined as the lowest value between MFN and preferential trade tariff rates, assuming that exporters use the lowest tariff rates

[6] See Mayer and Zignago (2011) for more details.
[7] FTA variable is constructed by the authors using the data from WTO RTA database. See https://rtais.wto.org/UI/PublicMaintainRTAHome.aspx for more details.

available when exporting. We detected the initial value of each tariff and filled the gaps for the missing value with the past value of tariffs. When the value of tariff for product p in country A is 20 percent for the year 2014, and the next reported tariff rate for product p in country A is 15 percent for the year 2016, we fill the tariff value for 2015 as 20 percent when tariffs for that product in 2015 is missing. We keep it as missing for missing tariff rates prior to the initial value reported.

4.4. Methodology

4.4.1. Quantification of NTMs indices

Due to its technical complexity, the quantification of NTMs is notoriously challenging. In this section, we calibrate ACRI to define NTMs. We construct the ACRI following Nabeshima and Obashi (2021) and Nabeshima et al. (2021), similar to Chapters 2 and 3. The estimator stem from the past efforts to measure the proximity of technical regulations implemented between the bilateral partners (Branstetter, 2006; Cadot et al., 2015; Jaffe, 1986; Nabeshima and Obashi, 2019). The index compares the bilateral product-type NTMs combinations in force by two trade partners. It might be the case that the exporter will be more likely to adopt quality upgrading if the destination country imposes a different set of NTMs than the home country. If the home and foreign countries apply the same NTMs on the product of interest, quality upgrading due to NTMs in foreign markets is less likely to happen. It may also be completely the opposite. For instance, assume that the country of an exporting firm imposes a maximum tolerance limit (i.e., SPS category A21), while it does not require another type of regulations like Hygienic practices during production (i.e., SPS category A42). Then, when the importing country imposes stricter regulations on A21 on that product, then the exporter is more likely to comply with the new maximum limit in its production as it already had some experience in that; thus, the exporter upgrades the quality of its product to that same market. However, if the importing country imposes technical regulations on A42 because the exporting firm has had no experience in that before, it completely stops exporting to that country, and the quality upgrading does never happen. These two opposing implications will be tested in our analysis. This is mainly because proximity or similarity is mainly in the type of the regulatory NTMs that is implemented by both trading partners, but not in the exact requirements in each type of the regulatory NTMs.

With equation (5) from Section 2.3.2 ($\text{ACRI}_{ijp} = 1 - \text{Cos}(\theta)_{ijp}$), we construct ACRI for each year *t* as:

$$\text{ACRI}_{ijpt} = 1 - \text{Cos}(\theta)_{ijpt}, \quad (1)$$

where ACRI_{ijpt} refers to the Additional Compliance Requirement Indicator for exporter *i* and importer *j*, for product *p*, at time *t*. We construct ACRI using the information from Chapters A and B, which are SPS and TBT measures, respectively. In principle, technical regulations should be applied without discrimination between domestic and imported products. In other words, regulations on imports are indicative of domestic regulations. As a result, exporters also have to comply with import regulations in their own countries aside from export measures.

Furthermore, we add NTMs count from Chapter P to incorporate the exporters' measurements of technical regulations (export deterrent measure and export promotion measure), as described in Section 4.3. While additional regulations to follow are small, the number of regulations that exporters need to follow may already be high in the domestic market.

4.4.2. Construction of Quality Indices

Product quality is not observed directly and thus needs to be estimated. Unit values, defined as the ratio of trade value over quantity for each product, are observable and often used in earlier studies (Hummels and Klenow, 2005; Schott, 2004). Notwithstanding its simplicity, the unit value may be driven by factors other than quality. For example, higher prices do not necessarily reflect better quality but can result from higher production costs. To control for this possibility, recent studies have introduced more sophisticated measurements of quality based on microeconomic foundations (Feenstra and Romalis, 2014; Khandelwal, 2010). However, due to demanding data requirements, these approaches do not offer data on traded quality at the six-digit level of the harmonized system. Therefore, this chapter uses two alternative proxies for product quality that are measurable at the HS six-digit level of products: unit value and QE. We analyze the unit value to compare the conventional and recently calibrated quality measurements.

We construct QE following Henn et al. (2020). They modified Hallak (2006) and assumed the bilateral unit value (u_{ijpt}) as a function of quality, GDP per capita, and distance between trade partners, as shown in equation (2).

$$\ln u_{ijpt} = \alpha_0 + \alpha_1 \ln Q_{ijpt} + \alpha_2 \ln y_{it} + \alpha_3 \ln Dist_{ij} + \varepsilon_{ijpt}, \quad (2)$$

Q_{ijpt} is the unobservable quality of product p exported from i to j on product time t, which is our core interest. y_{it} is the income per capita of exporter i at time t. $Dist_{ij}$ is the geographical distance between i and j on product p. u_{ijpt} is the bilateral unit value defined as trade value over quantity. Here, we use u_{ijpt} as a proxy for price. ε_{ijpt} is the error term vector including both time-variant and time-invariant error terms. Along with the bilateral unit value, the quality-augmented gravity equation is defined as:

$$\ln trade_{ijpt} = \beta \ln Dist_{ij} + \gamma Gravity_{ijt} + \delta \ln Q_{ijpt} \ln y_{jt} + FE_i + FE_j + \xi_{ijpt}, \quad (3)$$

where $Gravity_{ijt}$ is a set of vector that includes gravity determinants such as FTA relationship, contiguity, common language, common colony and colonial relationship. FE_i and FE_j are exporter and importer fixed effects, respectively. $trade_{ijpt}$ is the nominal value of import of j from i. The reason why the authors assumed quality and the importers' income per capita as interaction term is that income of importers is highly related with the quality of incoming goods. Therefore, if δ is positive, greater income increases the demand for quality.

To obtain product-specific quality estimates by country pair, we conduct Two-stage Least Squares (2SLS) estimations for each of 4,951 products. The estimation equation is:

$$\ln trade_{ijpt} = \beta \ln Dist_{ij} + \gamma Gravity_{ijt} + \frac{\delta}{\alpha_1} \ln u_{ijpt} \ln y_{jt} - \frac{\delta \alpha_2}{\alpha_1} \ln y_{it} \ln y_{jt} - \frac{\delta \alpha_3}{\alpha_1} \ln Dist_{ij} \ln y_{jt} + FE_i + FE_j - \frac{\delta \alpha_0 + \delta \varepsilon_{ijpt}}{\alpha_1} \ln y_{jt} + \xi_{ijpt}. \quad (4)$$

ε_{ijpt} is a component of $\ln u_{ijpt}$, indicating possible correlation between regressor $\ln u_{ijpt} \ln y_{jt}$ and the disturbance term $-\frac{\delta \alpha_0 + \delta \varepsilon_{ijpt}}{\alpha_1} \ln y_{jt} + \xi_{ijpt}$. To mitigate endogeneity issue, we use $\ln u_{ijp,t-1} \ln y_{j,t-1}$ as an instrument of $\ln u_{ijpt} \ln y_{jt}$.[8]

Multiplying δ and replacing parameters and the fitted value calculated from 2SLS equation (4), we get,

[8] While Henn et al. (2020) used $\ln u_{ijp,t-1} \ln y_{jt}$ as an instrument, we used the lagged value of the exporters' GDP as well.

$$\ln \hat{Q}_{ijpt} + \frac{\delta\alpha_0}{\alpha_1} = \frac{\delta}{\alpha_1} \ln \hat{u}_{ijpt} - \frac{\delta\alpha_2}{\alpha_1} \ln \hat{y}_{it} - \frac{\delta\alpha_3}{\alpha_1} \ln \widehat{Dist}_{ij}, \quad (5)$$

where ∧ refers to the fitted value.

We normalize the left-hand side quality index ($\ln \hat{Q}_{ijpt} + \frac{\delta\alpha_0}{\alpha_1}$) with the 90th percentile, which captures the mixed effect of quality ($\ln \hat{Q}_{ijpt}$) and the preference of importers (δ). High product prices may not genuinely reflect high quality but rather explain high production costs. The QE attempts to control for prices to extract the quality portion from goods traded and unit value. The high product price does not necessarily reflect better quality of goods. By controlling for price, the Quality Estimate captures the demand-side consideration of the quality of traded goods. The estimator also controls for selection bias; higher-priced goods to farther destinations. As Lawless and Whelan (2007) showed, fixed costs may increase the volume of trade for exporters to compensate for increased thresholds costs. The price growth of incumbent goods grows as exporters need to compensate for higher costs coming from longer distances. Henn et al. (2020) suggest that a series of steps that they have done control for price effects innated in the traditional quality indices; unit value.

The intuition for QE is that, through series of equations, we attempted to extract quality index that are relatively insensitive to the price. Equation (2) assumes unobservable quality index as a component of unit value. While the past literature often defined quality of goods traded using unit value, high price may not typically define high quality. By incorporating gravity-like equation (3), QE is a mixture of unobservable quality index and importers' preference (δ). As QE controls for price, QE is more effective in explaining quality than unit value as they are less vulnerable to price effects.

4.4.3. Estimating Equation

To examine the relationship between adoption of technical regulations and quality of traded products, we employ an NTM-augmented reduced form equation as:

$$Quality_{ijpt} = a_0 + a_1 ACRI_{ijpt} + a_2 \ln(1 + tariff_{ijpt}) + a_3 FTA_{ijt} + a_4 lndist_{ij} + a_5 lnX_{it} + a_6 lnX_{jt} + a_7 deter_{ijpt} + a_8 prom_{ijpt} + FE + \epsilon_{ijpt}. \quad (6)$$

Vector $Quality_{ijpt}$ includes normalized Quality Estimates and the natural logarithm of unit value. $tariff_{ijpt}$ indicates the tariff rates. We adopt the lowest tariff rates among the bilateral tariff rates and MFN tariff rates. FTA_{ijt} and $dist_{ij}$ refer to FTA relationship and distance. X_{it} and X_{jt} are respectively GDP per capita of exporters and importers. $deter_{ijpt}$ and $prom_{ijpt}$ refer to the count of exporters' imposition of NTMs. $deter_{ijpt}$ is the export deterrent measure and $prom_{ijpt}$ indicates export promotion measure. FE vector includes product fixed effect and sector*year fixed effect.[9] Note that we excluded gravity variables from the CEPII database (i.e., contiguity, common language) as QE already takes account of the variables when calibrating, and they show a high correlation with other variables. This may indicate a high probability of multicollinearity. As the information on NTMs imposition is highly unbalanced, we employ POLS estimation. Table 4.1 presents summary statistics.[10]

Table 4.1. Summary Statistics

VARIABLES	(1) N	(2) Mean	(3) SD	(4) Min	(5) Max
QE	5,018,937	0.380	6.329	-1,259	3,003
ACRI	5,018,937	0.348	0.463	0	1
Count	5,018,937	2.127	3.586	0	34
Tariff (%)	5,018,937	4.486	8.269	0	800
FTA	5,018,937	0.547	0.498	0	1
Distance	5,018,937	8,390	5,491	111	19,812
GDP per capita (i)	5,018,937	23,667	22,602	467	86,605
GDP per capita (j)	5,018,937	16,040	17,195	482	82,081
Export Deterrent	5,018,937	0.133	0.457	0	6
Export Promotion	5,018,937	0.021	0.142	0	1

*Source: Author's calculation

4.5. Estimation Results

Table 4.2 shows POLS results on regulations-product quality linkage following equation (6). Three features stand out. First, ACRI overall positively affects the unit value and QE. Additional

[9] Due to the size of data, the statistical software was not capable of handling product fixed effect. Instead, we control for HS six-digit product level, year fixed effect, and the interaction term of year and HS two-digit sector level.

[10] Variables do not show notable correlation. We provide the correlation table upon request.

regulations incur higher quality goods except for the agriculture sector. For instance, in the manufacturing sector, 0.1 increase in ACRI increase unit value by 0.4% and enhance QE by 0.007. This may indicate that, in the manufacturing sector, additionally required technical regulations increase not only the price (unit value) but quantity-side quality (QE) and contribute to more sophisticated quality goods. While technical regulations acted as a hidden barrier for the analysis on the margins of international trade and GVCs participation, NTMs improve the quality of goods traded.

On the other hand, additional regulations requirements in the agriculture sector show a negative but statistically insignificant result on unit value. Assuming that unit value has more price-oriented quality than QE, prices in the agriculture sector are relatively inflexible from the regulatory burden. This may imply that technical regulations in the agriculture sector are relatively harmonized than the manufacturing sector. The additional regulations improved the quality of traded goods but had less impact on the price of goods.

Second, tariff and distance show opposite signs on the total and manufacturing sample. When tariffs decrease, the price of the traded goods will decrease, and the quantity of the goods will increase. Trade flow would increase between the two countries, and at the same time, unproductive products will enter the market with cheap inputs. Overall, the quality of goods may deteriorate. On the other hand, when the two countries are located farther, trade value between them may increase as they want to compensate for higher threshold costs stemming from a distance (Lawless and Whelan, 2007). As long as they decide to pay the threshold costs, unproductive firms may also participate in the foreign market. Therefore, the quality of traded goods may decrease overall.

Furthermore, notice that export promotion measure increases both the unit value and the QE. The measurement improves the quality of goods traded, and exporters sell higher quality goods at a higher price at the foreign market. The results show similar results to those of ACRI. Export deterrent measures seem to affect the price of traded goods more than the quality. It increases the unit value of the total and manufacturing sample while decreasing the unit value of the agriculture sector. This could be another example of harmonized technical regulations relative to the manufacturing sector in the agriculture sector.

The GDP per capita of both exporters and importers shows a positive relationship with both unit value and QE. As larger countries export higher-quality goods, the results correspond with

Hallak (2006) and Schott (2004). However, agriculture goods for QE show negative coefficients from the GDP per capita of exporters (i). Developing nations may engage more with trade in agriculture sectors than developed nations, where products with a broad range of quality may be imported. This may result in a negative relationship between the GDP per capita of exporters and the quality of goods in the agriculture sector.

Table 4.2. Impact of NTMs on the Quality of Traded Goods

	(1)	(2)	(3)	(4)	(5)	(6)
		Unit Value			QE	
VARIABLES	Total	Manufacture	Agriculture	Total	Manufacture	Agriculture
ACRI	0.036***	0.040***	-0.005	0.011***	0.007*	0.029***
	(0.001)	(0.002)	(0.004)	(0.003)	(0.004)	(0.010)
Tariff	-0.416***	-0.457***	-0.020	0.167***	0.208***	0.172***
	(0.010)	(0.011)	(0.019)	(0.017)	(0.019)	(0.049)
FTA	0.133***	0.137***	0.102***	0.029***	0.033***	0.031***
	(0.001)	(0.001)	(0.004)	(0.003)	(0.003)	(0.010)
Distance	0.107***	0.102***	0.148***	-0.010***	-0.023***	0.089***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.005)
GDPPC (j)	0.077***	0.076***	0.068***	0.012***	0.013***	0.011***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
GDPPC (i)	0.133***	0.139***	0.083***	0.041***	0.047***	-0.007**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Deterrent	0.008***	0.017***	-0.007***	0.001	0.002	0.001
	(0.001)	(0.002)	(0.002)	(0.004)	(0.005)	(0.005)
Promotion	0.040***	0.071***	-0.014***	0.027***	0.014	0.048***
	(0.004)	(0.005)	(0.005)	(0.008)	(0.010)	(0.015)
Constant	5.648***	-2.466***	5.957***	-0.062	0.272***	-0.383***
	(0.118)	(0.077)	(0.120)	(0.047)	(0.101)	(0.073)
Observations	5,018,937	4,320,347	437,151	5,018,937	4,320,347	437,151
R-squared	0.706	0.698	0.526	0.807	0.769	0.726
Product FE	YES	YES	YES	YES	YES	YES
Sector##Year FE	YES	YES	YES	YES	YES	YES

*Note: Unit Value refers to the natural logarithm of unit value. Tariff refers to the natural logarithm of tariff rates ($\ln(1 + tariff)$). Distance refers to the natural logarithm of distance. GDPPC (j) and GDPPC (i) indicate GDP per capita of importers and exporters, respectively. Deterrent and Promotion refer to export deterrent measure and export promotion measure, respectively. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10

Table 4.3. shows the impact of additional regulations to follow in South-North trade. As developed nations often impose more regulations, additional regulations in the developed nations increase the quality of goods from the developing nations. 0.1 increase in additional regulations enhances QE by 0.18%. Enhancement in quality also occurs in intra-trade among developing nations. However, the unit value decreases as additional regulations increase by the developed nations on goods from developing nations. This may result from relatively unproductive goods from the developing nations compared to the similar domestic goods in the developed nations. Overall, the quality of products from developing nations enhances as the importing countries impose additional regulations.

Table 4.3. Impact of NTMs on Quality: South-North Trade

VARIABLES	(1) Unit Value	(2) QE
Developing to Developed		
ACRI	-0.005*	0.018***
	(0.003)	(0.006)
Developed to Developing		
ACRI	0.071***	0.010
	(0.003)	(0.007)
Developing to Developing		
ACRI	0.002	0.011*
	(0.002)	(0.006)
Developed to Developed		
ACRI	0.041***	-0.001
	(0.003)	(0.008)
Product FE	YES	YES
Sector##Year FE	YES	YES

*Note: Count indicates the count of NTMs. Coefficient of other variables are similar to the total sample in terms of signs and direction. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10

4.6. Chapter Conclusion

Utilizing a novel comprehensive panel dataset on NTMs, this chapter examines the impact of technical NTMs, namely SPS measures and TBTs, on the quality of traded products. To measure regulative divergence, we constructed ACRI, which indicates the extent of additional technical requirements that exporters of a six-digit product face in the foreign market relative to their domestic market.

Overall, by comparing the quality estimator following recently published Henn et al. (2020) with the conventional unit value approach, we find a positive correlation between the adoption of regulations by both exporters and importers on the quality of traded goods. The results also indicate that unit value incorporates more price-oriented quality patterns. Additional regulations for developing nations also improved the quality of products from the developing nations.

Particularly in the agriculture sector, technical regulations acted well, increasing the quality of traded goods and at the same time lowering the prices. This may indicate that harmonization of regulations is effective in the agriculture sector relative to the manufacturing sector. Although the quality of manufacturing goods increased with additional regulations to follow, increased production costs inevitably increased the price of the goods.

Our study has several shortcomings. First, current data on regulations is not capable of distinguishing trade costs arising from technical compliance with the regulations, and the procedural costs due to the implementation of the regulations. Indeed, measuring procedural cost is challenging, as implementation may include a lengthy and complex process involving various government agencies. Second, due to data availability, we were only able to capture the structure of NTMs, but not their stringency. For example, two trade partners may both apply tolerance limit requirements on a specific product, but the extent of strictness can be different. By counting the number of NTMs, we assume that all NTMs receive the same weight. These issues should be kept in mind when interpreting the results.

The proliferation of NTMs has raised the concerns that NTMs can be used as disguised trade barriers. In the new generation of free trade agreements, streamlining NTMs has become one of the key tasks to achieve deep integration. In this context, one common issue raised by policymakers is how to determine and eliminate NTBs. However, we would argue that elimination is not desirable in most cases since NTMs generally serve legitimate purposes. By

setting regulations, NTMs ensure the rights of consumers and enhance their confidence in traded products. The quality of traded goods is also one of them. As such, the rising number of quality and safety regulations reflects legitimate concerns about the rights of consumers. NTMs also incentivize firms to invest in product and process innovation since producers with better-quality products can gain better market share. Therefore, instead of the trade-concession approach aiming at NTMs reduction, harmonization of regulations should be the goal.

Appendices

Appendix A. Groupings of NTMs

NTM Measure Group (NTM 2-digit)	Maximum Possible no. of measures within the group	NTM Measure Sub-group
A1	4	A13, A14, A15, A19
A2	3	A20, A21, A22
A3	4	A30, A31, A32, A33
A4	3	A41, A42, A49
A5	4	A51, A52, A53, A59
A6	5	A61, A62, A63, A64, A69
A8	7	A81, A82, A83, A84, A85, A86, A89
A9	1	A9
B1	3	B14, B15, B19
B2	3	B21, B22, B29
B3	4	B31, B32, B33, B39
B4	3	B41, B42, B49
B6	1	B6
B7	1	B7
B8	6	B81, B82, B83, B84, B85 B89
B9	1	B9

*Note: NTM classification follows UNCTAD (2019). We drop NTMs Measure Sub-group A11 and A12 as they refer to explicit restrictions on trade.
*Source: Authors' calculation.

Appendix B. NTMs Data Availability

Reporter	2010	2011	2012	2013	2014	2015	2016	2017	2018
ARE	.	..	.	.	.	A	.	.	.
ARG	.	..	A	A	A	A	A	A	A
ATG	.	..	.	.	.	.	A	.	.
AUS	.	.	.	.	.	A	A	.	.
BEN	.	.	.	.	A	.	.	.	.

BFA	.	.	A	.	.	.	.	.	.
BHR	.	.	.	.	.	A	.	.	.
BHS	.	.	.	.	.	A	.	.	.
BLR	.	.	.	.	.	.	.	A	.
BOL	.	.	A	A	A	A	A	A	A
BRA	.	.	A	A	A	A	A	A	A
BRN	.	.	.	.	.	A	.	.	A
BWA	.	.	.	.	.	.	.	A	.
CAN	.	.	.	.	.	A	.	A	.
CHE	.	.	.	.	.	A	.	.	.
CHL	.	.	A	A	A	A	A	A	A
CHN	.	.	.	.	.	.	A	.	.
CIV	.	.	A	.	.	.	.	.	.
CMR	.	.	.	.	.	A	.	.	.
COL	.	.	A	A	A	A	A	A	A
CPV	.	.	.	.	A	.	.	.	.
CRI	.	.	.	.	.	.	.	A	A
DZA	.	.	.	.	.	A	.	.	.
ECU	.	.	A	A	A	A	A	A	A
ETH	.	.	.	.	.	A	.	.	.
EUN	A	A	A	A	A	A	A	.	A
GMB	.	.	.	A	.	.	.	.	.
GTM	.	.	.	.	.	.	.	A	A
GUY	.	.	.	.	.	A	.	.	.
HKG	.	.	.	.	.	.	A	.	.
HND	.	.	.	.	.	.	.	A	A
IDN	.	.	.	.	.	A	.	.	A
IND	.	.	.	.	.	.	.	A	.
ISR	.	.	.	.	.	.	A	.	.
JAM	.	.	.	.	.	A	.	.	.
JOR	.	.	.	.	.	.	A	.	.
JPN	.	.	.	.	.	A	A	.	.
KAZ	.	.	.	.	.	.	.	A	.
KGZ	.	.	.	.	.	.	.	A	.
KHM	.	.	.	.	.	A	.	.	A
KOR	.	.	.	.	.	.	A	.	.
KWT	.	.	.	.	.	A	.	.	.
LAO	.	.	.	.	.	A	.	.	A

LBN	.	.	.	.	.	.	A	.	.
LKA	.	.	.	.	.	.	A	.	.
MAR	.	.	.	.	.	.	A	.	.
MEX	.	.	A	A	A	A	A	A	A
MMR	.	.	.	.	.	A	.	.	A
MUS	.	.	.	.	.	.	.	A	.
MYS	.	.	.	.	.	A	.	.	A
NER	.	.	.	.	A	.	.	.	.
NGA	.	.	.	A	.	.	.	.	.
NIC	.	.	.	.	A	A	A	A	A
NPL	.	.	A	.	.	.	.	.	.
NZL	.	.	.	.	.	A	A	.	.
OMN	.	.	.	.	.	A	.	.	.
PAK	.	.	.	.	.	.	A	.	.
PAN	.	.	.	.	.	.	.	A	A
PER	.	.	A	A	A	A	A	A	A
PHL	.	.	.	.	.	A	.	.	A
PRY	.	.	A	A	A	A	A	A	A
QAT	.	.	.	.	.	.	A	.	.
RUS	.	.	.	.	.	.	A	.	.
SAU	.	.	.	.	.	.	A	.	.
SEN	.	.	A	.	.	.	.	.	.
SGP	.	.	.	.	.	A	.	.	A
SLV	.	.	.	.	.	.	.	A	A
SUR	.	.	.	.	.	A	.	.	.
TGO	.	.	.	.	A	.	.	.	.
THA	.	.	.	.	.	A	.	.	A
TTO	.	.	.	.	.	A	.	.	.
TUN	.	.	.	.	.	.	A	.	.
TUR	.	.	.	.	.	.	A	.	.
URY	.	.	A	A	A	A	A	A	A
USA	.	.	.	.	A	.	.	A	A
VNM	.	.	.	.	.	A	.	.	A
ZWE	.	.	.	.	.	.	.	A	.

*Note: “A (Available)” indicates that NTM data for chapters A, B, and P are available for the reporter in a given year. “.” indicates missing NTM data. Highlighted countries represent sample countries for this research. Country codes follow United Nations’ “ISO3.”
*Source: Author’s calculation.

Chapter 5. Conclusion

Through Chapters 2 to 4, we analyzed the impact of technical regulations, defined as NTMs, on international trade. We quantified technical regulations using the most recent and comprehensive NTMs data from UNCTAD by constructing ACRI following Nabeshima et al. (2021). ACRI captures the additional burden for the exporters when entering the foreign market. We then decomposed international trade into the extensive and intensive margins of international trade, GVCs, and the quality of traded goods to thoroughly examine the impact of NTMs on the nature of international trade. We followed Feenstra (1994), and Hummels and Klenow (2005) to construct the extensive and intensive margins of international trade as they are theoretically grounded in defining product diversity (extensive margin) and volume of incumbent goods (intensive margin). For GVCs participation, we decomposed the global production network as the backward participation and forward participation. The backward participation in GVCs refers to the ratio of foreign value-added on total gross exports and the forward participation indicates the ratio of domestic value-added content of exports on total gross exports. Particularly, they depict the downstream and upstream engagements, respectively. Finally, we constructed the quality of traded goods adopting both the conventional unit value, and price-controlled quality estimates following Henn et al. (2020). Overall, technical regulations hampered the margins of international trade and participation in GVCs network. However, they were effective in enhancing the quality of goods traded.

First, ACRI hampers international trade through both the extensive and intensive margins of international trade. Additional burden for technical regulations discourages exporters to diversify the goods (extensive margin) and sell larger volume of incumbent goods (intensive margin). Noticeably, ACRI decreased the quantity margin and increased the price margin of the intensive margin of international trade. Additional costs stem higher marginal costs. The costs push the export price up and the quantity of the products will decrease. This may affect consumer welfare adversely; deteriorating producer surplus in exporting country and consumer surplus in importing country. Furthermore, the magnitude of NTMs is comparable to tariffs. Therefore, NTMs serve as a hidden barrier for international trade.

Additionally, developing countries and agriculture sectors were more vulnerable to the regulatory burden. The impact of ACRI on all margins showed larger magnitude from developing countries to developed countries, compared to all other south-north trade. For the

total trade flow (value), intensive margin, and quantity margin, effect of ACRI in agriculture showed larger magnitude compared to the manufacturing sectors in terms of the size of coefficients; the cost of complying with additional regulations were severe in agriculture sector relative to manufacturing sector. The overall trade-diminishing effect of the ACRI is twice larger in agriculture sectors compared to the manufacturing sectors.

Second, ACRI discourage the participation in GVCs through both backward and forward participation. Regardless of the domestic value-added or foreign value-added, regulatory burden discourage countries to participating in global production networks. Surprisingly, technical regulations showed higher adverse effect on GVCs participation compared to non-technical regulations, where non-technical regulations often explicitly hamper international trade. This may imply that exporters face more difficulty complying with technical regulations than explicit trade costs before entering the foreign market.

Lastly, ACRI overall increased the quality of traded goods, both the conventional unit value and price-controlled Quality Estimate (QE). In manufacturing sector, additional regulatory burden increased the price of goods (unit value) and also sophisticated the quality of goods (both unit value and QE). On the other hand, in agriculture sector, additional regulatory burden showed statistically insignificant result on the price of good (unit value) but sophisticated the quality of goods (QE). The result indicates that regulations in the agriculture sector are relatively harmonized than the manufacturing sector.

Since NTMs are in place (in most cases) to deal with legitimate concerns about citizens' health, safety, and environmental protection, mere elimination of NTMs is not desirable or possible. While international trade nature suffered from complying with additional regulations via overall trade flow, product diversification, volume of incumbent goods, and participation in the current fragmented production network, they sophisticated the quality of goods traded, fulfilling the original purpose of sorting out low-quality or inadequate goods in the local market. The policy focus should be on dealing with the international differences in NTMs. This could be achieved either through bilateral dialogues on harmonization or mutual recognition of regulations in each country or the strengthening of the regulatory compliance capabilities of the country and individual domestic firms.

To effectively utilize technical regulations, NTMs need to be comparable. As regulations are created based on available scientific knowledge and local conditions, sometimes harmonization

of regulations may be difficult or impossible (or, in some cases, inappropriate). However, countries can discuss and collaborate to facilitate the mutual recognition of regulations. This kind of discussion can take place in conjunction with the various regional forums and regional integration efforts, such as ASEAN, the RCEP, or the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP). This is especially important to developing countries because they tend to face much more difficulties in exporting when there are differences between domestic and foreign regulations.

The improvements of regulatory compliance capabilities of firms and society is another task for effective usage of technical regulations. To meet the regulatory requirements in importing countries, firms need to understand the requirements and take specific actions to ensure compliance (e.g., modifications to products, production process). This means that aspiring exporting firms need to develop and possess sufficient managerial and technological capabilities to comply with the regulations in importing countries. In addition to the capabilities required at the firms, the society also needs to be equipped with testing and other quality assurance facilities to assist firms in complying with regulations. In developing countries, these entities are in short supply or sometimes non-existent. Investment in these facilities should be a part of industrial development policies. Again, in this area, regional collaboration may be a way to economize on the investment and share the facilities among a group of countries.

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