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Impact of Regulatory Burdens on International Trade

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Abstract

In this paper, we develop the additional compliance requirement indicator (ACRI) to quantify the extra regulations that an exporter may face when serving the foreign country's market. The higher the value of ACRI, the greater the difference between the sets of technical regulations in the destination and origin countries. Employing the ACRI, we estimate the impact on trade of regulatory burdens via product-level bilateral gravity equations. We find a significant negative impact of regulatory burdens on bilateral trade for a full sample, but the estimated trade effects vary across sectors and depend on the development levels of the trading countries.

Keywords: non-tariff measures; technical regulations; compliance requirement; international trade; technical barriers to trade (TBT); sanitary and phytosanitary standard (SPS)

JEL Classification: F13, F14

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1. Introduction

In the last few decades, international trade has increased tremendously through reductions in import tariffs. However, the current indication is that global trade will slow down, partly because of the rise in protectionist policies around the world. Therefore, the potential trade-restrictive or discriminatory effect of non-tariff measures (NTMs) is becoming even more important. NTMs cover any policy measures other than import tariffs that are implemented at or behind the national border, potentially affecting the price of traded products, the quantity traded, or both. In particular, standards and technical regulations, such as sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT), have been subjects of interest for researchers, policymakers, and businesses.[1] To export to another country, an exporter firm, as well as the original manufacturers or producers, must comply with the technical requirements in place in the destination country, otherwise imported products can be rejected at the border if they fail to meet these requirements.[2]

Nevertheless, comprehensive empirical research on assessing the impact of technical measures on international trade has been minimal.[3] This is because it has been difficult to conduct a systematic study of technical measures due to the lack of internationally comparable data on technical measures and other NTMs at finely disaggregated product level that are suitably coded to be used in empirical analysis. Traditionally, the trade-restricting effect of NTMs has been computed as the ad valorem equivalents (AVEs) based on the partial correlation between the presence of NTMs at the destination country-product level and the

[1] The terms 'standards' and 'technical regulations' differ with respect to compliance norms: standards are market driven and are in principle voluntary, whereas technical regulations are officially enforced by governments and are mandatory. 'Technical measures' is a generic term used to refer to technical regulations, standards, and their conformity assessment procedures. Our focus is on the mandatory technical measures and thereby the terms 'technical regulations' and 'technical measures' are used interchangeably.

[2] See UNIDO (2010; 2015) for a global perspective on import rejections of agricultural and food products, and IDE-JETRO and UNIDO (2013) for a more detailed examination in the case of East Asian countries.

[3] Beghin, Maertens, and Swinnen (2015) provides a review of empirical studies on the trade effects of technical measures. More recent related studies are reviewed by UNCTAD (2018).

trade values (e.g., Kee, Nicita, and Olarreaga 2009). In this vein of approach relying on dummy variables marking the presence of NTMs in the destination country, the issue of NTMs is implied but not addressed specifically. The estimated AVEs indicate the net trade restrictiveness on the whole concerning imports of a given product but does not reveal where the restrictiveness might arise.

Looking merely at the presence of NTMs enforced in the export destination is especially problematic if a product is subject to technical requirements in both the origin and destination countries of a given trade flow. In most countries, governments adopt mandatory regulatory norms in one form or another to ensure the health and safety of its citizens and environment. To achieve the policy objective, technical regulations tend to be similar across countries because such regulations are of the most appropriate ways based on scientific findings. From the exporter's point of view, they might not substantially face 'additional' regulations when exporting in addition to domestic production and sales. Thus, what is important for exporter firms is not the mere presence of regulations in the destination country, but the existence of 'additional' regulatory requirements.

Indeed, as shown below, on average, products imported from a particular country into a particular destination market is subject to five different types of technical requirements in combination even at the finely disaggregated product level. Moreover, a set of technical regulations enforced in a destination country against imports from a particular country is often overlapped by a set of the origin country's domestic regulations. Given these observed facts in mind, we construct the additional compliance requirement indicator (ACRI) to quantify the extra regulatory burdens that an exporter firm may face when serving the foreign country's market.

The construction of the ACRI requires detailed information on technical regulations in many countries. This study uses a new database created by the United Nations Conference on

Trade and Development (UNCTAD) in collaboration with many other entities.[4] This database contains a description of each mandatory regulation, which is enforced by the national legislation, along with the measure type coded according to the UNCTAD's NTM classification, 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.[5] Utilizing these detailed information, we can construct the ACRI and estimate the impact of technical regulations on international trade more precisely, with due consideration for compliance costs.

We estimate the impact on trade of the regulatory burdens placed on exporter firms via product-level bilateral gravity equations, considering various types of technical regulations enforced against the HS six-digit products in 48 countries in the year 2015. The ACRI of our interest, taking a value between 0 and 1, captures the additional compliance requirements implied by a set of technical regulations in the destination market that constitute the market entry and trade costs faced by exporter firms. First, we show a negative correlation between ACRI and bilateral trade values at the product level. Our estimates imply that an increase in ACRI of 0.1 will on average reduce the trade value by 2.5%, taking zero trade flows into consideration. Second, by examining income groups of the destination and origin countries of bilateral trade flows, we find that exporting firms of developed countries are not affected by the extra regulatory burdens in developing countries. In contrast, the trade-diminishing effect of regulatory burdens appears to be more worrisome for developing countries. Third, the trade effects of regulatory burdens vary in magnitude and signs among industry groups. The adverse effect is most noticeable for foodstuffs and machinery sectors.

Outside the aforementioned literature estimating AVEs, most of the recent empirical

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[4] See our companion paper, Nabeshima and Obashi (2019), for details of the database.

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

research on the trade consequences of NTMs attempt to assess the forgone (or enhanced) trade linked to technical measures in a gravity equation. Among those concerning the costs of complying with foreign technical requirements faced by exporter firms, however, the past studies tend to either have a narrow focus or rely on the simple counting at the aggregate level to quantify technical requirements. First, some studies narrowly focus on product-specific regulations such as stringency of maximum residue levels (MRLs) (e.g., Disdier and Marette 2010; Xiong and Beghin 2014) while others conduct single-sector or single-country analyses of product standards and regulations (Bao 2014; Portugal-Perez, Reyes, and Wilson 2010). Even an exceptional study by Crivelli and Groeschl (2016) that examines bilateral trade flows at the HS four-digit level among a large number of countries, focuses only on the impact of SPS-related concerns on agricultural and food sectors, using the WTO database for specific trade concerns (STCs) reported by exporters. These studies generally find that product-specific regulations diminish trade while international harmonization of standards enhances trade but may not be representative.[6]

Second, Bao and Qiu (2012) and Bao and Chen (2013) examine bilateral trade flows aggregated over sectors, using the total number of TBT notifications by respective countries to the WTO in order to quantify the technical requirements and their trade effect. Since governments impose diverse regulations in combination even at the finely disaggregated level, simply adding up the counted numbers of notifications over various sectors appears to be less informative in quantifying the overall degree of technical requirements. Furthermore, since the implementation pattern of combining diverse regulations varies across countries with different legislative systems, the expected impact of the simple count variable on trade is

[6] Recent studies examining firms' export performance in relation to regulatory burdens also tend to have a limited focus, relying on a specific episode of the international harmonization of product standards or on firm survey. Exceptions include Fontagné et al. (2015) and Fontagné and Orefice (2018), both of which utilize the WTO TBT STCs database matched with a firm-level panel data of French exporters.

ambiguous. A similar concern arises about the use of a frequency ratio, which measures the number of product items subject to regulations within a given sector (Bao 2014; Crivelli and Groeschl 2016).

This study overcomes these two limitations in the literature by proposing the ACRI to approximate the overall regulatory burdens due to diverse technical measures enforced in combination. Using the UNCTAD NTM database, we are able to construct the ACRI at the destination-origin-product level and assess the impact of regulatory burdens on trade flows in a wide range of products, sectors and countries. The related studies often use either notification-based data, which covers only new measures upon legislative amendments, or STCs data, which covers only the restrictive regulations that are perceived as sizable trade barriers by exporters. Unlike most of the existing studies, we employ the UNCTAD NTM database, which theoretically covers the universe of technical regulations in many countries. As far as we know, there are only a few studies using the newly constructed UNCTAD data according to the new NTM classification: the only published article is Niu et al. (2018), which estimates AVEs; the related ongoing works include Cadot et al. (2015) and Nabeshima and Obashi (2019), which proposes, respectively, a measure of the regulatory distance and dissimilarity of NTM regimes between countries, and Disdier, Gaigné, and Herghelegiu (2018) on the quality effects of standards on exporter firms.

Our proposed ACRI complements the earlier studies that propose summary indicators to evaluate regulatory differences between countries at the product level as an alternative to the conventional count variable and frequency ratio. Drogué and DeMaria (2012), for example, use Pearson's distance to measure the dissimilarity between vectors representing a series of MRLs set on apples and pears. Although the Drogué and DeMaria (2012)'s indicator is calculated to be symmetric between a given pair of countries, Winchester et al. (2012) propose a directional indicator to capture the relative stringency of a series of MRLs affecting animal and plant products in the destination compared to the origin country of each trade flow. Departing from these indicators building on the quantitative information of MRLs, our proposed 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.

The rest of the article is organized as follows. Section 2 explains the underlying data on NTMs and details the general state of technical measures implemented around the world. Section 3 explains the motivations and methodologies used to construct the ACRI. Section 4 uses the ACRI to estimate the impact of regulatory burdens on bilateral trade flows, and section 5 concludes.

2. Overview of Technical Measures

Before examining whether the extra regulatory burdens in the destination country relative to the domestic regulations in the origin country adversely affect bilateral trade flows, this section briefly describes the data for technical measures and highlights some facts on existing technical measures. These facts motivate us to quantify the additional compliance requirements faced by exporters.

2.1. Data for Technical Measures and Other Non-Tariff Measures

We make use of UNCTAD's NTM database, which was created by reflecting all the NTM information that had been gathered as of March 2017 on 57 countries (see Table 2 below) implementing NTMs in 2015. The database systematically records the mandatory measures that are implemented against merchandise products imported from abroad in a non-tariff form, by scrutinizing national legal documents. For each NTM, we have information on the implementing (importing or destination) country, the type of measure, the affected product, and the affected (exporting or origin) country/region.

NTMs are categorized based on their purpose into chapter 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), following the M3 version of UNCTAD NTM classification (UNCTAD 2015a).[7] 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 H2, H3, or H4 version of the HS classification. We convert all the product information to the six-digit 5,224 codes of the H2 version for consistency.[8] Ultimately, expanding the data set into a bilateral basis – by looking at the affected country information for each of the implementing countries – yields NTM information on 5,224 products traded between 57 x 56 = 3,192 destination-origin country pairs.

2.2. Existing Technical Measures

Using the data set processed as described above, we begin by counting the number of existing technical measures for each of destination-origin-product combinations. According to the measure definitions in the M3 classification, we consider NTMs classified under

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[7] Although the M3 classification includes 16 chapters, the scope of the worldwide data collection under the UNCTAD initiative was limited to chapters A to I and P as of March 2017. Among them, chapter P is reserved for export-related measures, and is outside the scope of the current paper. We also exclude chapter D (contingent trade protective measures) from our data analysis due to data incompleteness.

[8] The number of product codes is counted after omitting miscellaneous codes for which no specific NTM information is available. The conversion tables from the newer to the older HS version are obtained from the Trade Statistics Branch of the United Nations Statistics Division (UNSD 2014).

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 to us.

Table 1 summarizes the distribution of the different codes/types of technical measures in force as of 2015 across destination-origin-product combinations. The first row of Table 1 reports the total number of codes for technical measures (irrespective of the actual incidence); the mean, standard deviation, minimum, and maximum number of technical measures in force at the destination-origin-product level, calculated for the combinations subject to some measure; and the proportion of the affected combinations in the overall number of combinations. The corresponding figures for the subcategories of technical measures are reported in the second to fourth rows.

Measure category	Total no. of measure codes	No. of measures in force at the destination-origin-product level				Proportion of destination-origin-product combos with some measure in force
		Mean	Std. dev.	Min.	Max.	
Technical Measures	77	4.89 (2.82)	4.72	1	39	57.7%
SPS	41	4.83 (1.08)	3.91	1	24	22.5%
TBT	30	3.22 (1.43)	2.71	1	23	44.4%
Pre-shipment	6	1.29 (0.30)	0.48	1	4	23.6%

Table 1. Number of Technical Measures at the Destination-Origin-Product Level

Notes: The overall sample includes non-tariff measures implemented by 57 countries against imports from 56 countries at the HS six-digit level, i.e. 57 x 56 x 5,224 = 16,675,008 destination-origin-product combinations. Technical measures are defined as those classified under chapters A–C, except for explicit prohibitions coded under A11, A12, and B11. The mean values are calculated over the destination-origin-product combinations that are subject to technical measures of concern; as a reference, the mean values calculated by including observations of zeros are shown in parentheses.
Source: Authors' calculation.

Considering all the possible codes at any aggregation level – mostly two-digit numerical codes – the total number of possible codes for technical measures is 77. About 60% of the destination-origin-product combinations in our sample are subject to some technical measure. For those affected combinations, 4.89 (out of 77) types of technical measures are implemented simultaneously on average. As a reference, the mean is also calculated by including destination-origin-product combinations with no technical measure, as shown in parentheses.[9] Even at the finely disaggregated product level, most countries tend to implement multiple technical measures in combination to achieve their policy purpose against the respective origin countries. Furthermore, countries often combine different types of technical measures even within the same subcategory.

Tables 2 and 3 complement Table 1. Table 2 reports the average numbers of technical measures in force that are calculated over origin-product pairs for the respective destination countries, by considering origin-product pairs subject to some technical measure and by including origin-product pairs with no technical measure (in parentheses). Destination countries are ranked in descending order of the average number of measures. The world averages are shown at the bottom of the table.[10] The income group of the destination countries is indicated, based on the World Bank's classification as of 2015: high income (10), upper-middle income (16), lower-middle income (19), and low income (12 countries).[11]

[9] By construction, it holds that 4.89 x 57.7% = 2.82.

[10] The world average for non-zero observations is calculated over destination-origin-product combinations subject to some measure and is not necessarily equal to the cross-country average of by-destination figures.

[11] The World Bank's historical income-group classification as well as how countries are classified into income groups is obtained from the World Bank Data Help Desk webpage (World Bank 2019).

Destination country	Income group	Mean no. of measures at the origin-product level		Destination country	Income group	Mean no. of measures at the origin-product level	
Gambia	L	14.18	(1.79)	Paraguay	UM	4.50	(1.22)
US	H	12.45	(11.64)	Brunei Darussalam	H	4.38	(1.78)
Australia	H	9.45	(8.83)	Liberia	L	4.34	(1.45)
Guatemala	LM	9.15	(1.75)	Honduras	LM	4.26	(1.35)
Brazil	UM	8.58	(6.46)	Viet Nam	LM	3.96	(3.70)
Canada	H	8.50	(7.94)	Ghana	LM	3.84	(3.62)
Nicaragua	LM	7.95	(1.57)	Costa Rica	UM	3.74	(1.11)
Russian Federation	UM	7.36	(5.56)	Togo	L	3.73	(0.62)
Thailand	UM	7.16	(2.21)	Afghanistan	L	3.73	(0.45)
Venezuela	UM	6.92	(6.45)	Uruguay	H	3.72	(1.96)
New Zealand	H	6.89	(4.03)	Guinea	L	3.50	(3.22)
European Union	H	6.71	(5.85)	Chile	H	3.34	(2.05)
Peru	UM	6.54	(2.35)	India	LM	3.31	(3.10)
Philippines	LM	6.21	(5.81)	Ethiopia	L	3.06	(2.55)
China	UM	5.92	(3.61)	Sri Lanka	LM	3.05	(2.88)
Myanmar	LM	5.84	(1.52)	Singapore	H	2.96	(2.77)
Japan	H	5.68	(5.30)	Nigeria	LM	2.96	(2.37)
Cape Verde	LM	5.52	(1.64)	El Salvador	LM	2.91	(0.93)
Panama	UM	5.48	(1.27)	Kazakhstan	UM	2.89	(1.15)
Colombia	UM	5.35	(2.98)	Mali	L	2.88	(2.72)
Mexico	UM	5.30	(1.95)	Burkina Faso	L	2.69	(2.54)
Indonesia	LM	5.28	(2.84)	Niger	L	2.59	(2.44)
Cambodia	LM	5.28	(3.43)	Nepal	L	2.42	(2.29)
Ecuador	UM	5.22	(1.59)	Senegal	L	2.07	(0.68)
Benin	L	5.18	(1.92)	Tajikistan	LM	1.86	(1.10)
Malaysia	UM	5.12	(1.86)	Cuba	UM	1.32	(1.20)
Bolivia	LM	4.94	(1.58)	Côte d'Ivoire	LM	1.22	(0.22)
Lao PDR	LM	4.77	(1.49)	Pakistan	LM	1.13	(0.39)
Argentina	UM	4.51	(3.58)				
				World average		**4.89**	**(2.82)**

Table 2. Average Number of Technical Measures over Origin-Product Pairs, by Destination Country

Notes: See notes on Table 1. Countries are divided into high (H), upper-middle (UM), lower-middle (LM), and low (L) income groups, following the World Bank's classification.
Source: Authors' calculation.

The simultaneous implementation of multiple technical measures is prevalent among high-income countries such as the United States (US), followed by Australia and Canada. The US on average implements 12.5 different types of technical measures simultaneously against the imports of a certain product from a certain country. Developed countries not only adopt more stringent regulations such as MRLs (e.g., Xiong and Beghin 2014) but also combine a wider range of different regulations together, compared to less-developed countries. Some lower-income countries such as Gambia and Guatemala also implement multiple technical measures simultaneously but against targeted imports. In Gambia, for example, the average calculated over origin-product pairs subject to some technical measure is 14.2, whereas the average calculated by including origin-product pairs with no technical measure is only 1.8. Such noticeable disparity between the average figures is also observed for Guatemala and other lower-income countries – indicating that they concentrate technical measures against a limited scope of products or countries.

Table 3 examines the distribution of technical measures in force across destination-origin-product combinations (as reported in the first row of Table 1), calculating summary statistics by destination and origin country income groups. It shows a clear tendency for higher-income countries to implement a larger number of different types of technical measures simultaneously against imports from trading partner countries of any income group. No income group of destination countries shows a noticeable variation in the average number of technical measures across the income groups of origin countries. Focusing on the destination-origin-product combinations subject to some technical measure, a destination country implements different numbers of technical measures against different origin countries within the same product code for only 4.2% of the combinations. That is, preferential operation of technical measures – discriminating between trading partner countries – is rare, except for the US and other high-income countries and for Senegal (low-income group).

Country income group		No. of measures in force at the destination-origin-product level				Proportion of destination-origin-product combos with some measure in force
Destination	Origin	Mean	Std. dev.	Min.	Max.	
High	High	6.77 (5.20)	5.93	1	39	76.8%
	Upper-middle	6.80 (5.22)	5.95	1	39	76.8%
	Lower-middle	6.80 (5.22)	5.95	1	39	76.8%
	Low	6.80 (5.22)	5.95	1	39	76.8%
Upper-middle	High	5.43 (2.78)	4.36	1	26	51.3%
	Upper-middle	5.43 (2.79)	4.36	1	26	51.3%
	Lower-middle	5.42 (2.78)	4.36	1	26	51.3%
	Low	5.42 (2.78)	4.36	1	26	51.3%
Lower-middle	High	4.12 (2.17)	4.24	1	34	52.7%
	Upper-middle	4.12 (2.17)	4.25	1	34	52.7%
	Lower-middle	4.12 (2.17)	4.25	1	34	52.7%
	Low	4.12 (2.17)	4.25	1	32	52.7%
Low	High	3.24 (1.89)	3.16	1	36	58.5%
	Upper-middle	3.26 (1.89)	3.17	1	36	58.0%
	Lower-middle	3.26 (1.89)	3.17	1	36	58.0%
	Low	3.25 (1.89)	3.17	1	36	58.0%

Table 3. Technical Measures at the Destination-Origin-Product Level, by Country Income Group

Note: See notes on Table 2.
Source: Authors' calculation.

Moreover, as is implied by the observed, simultaneous implementation of multiple technical measures, a set of technical measures enforced against imports by a country is often overlapped by a set of domestic regulations in its trade counterpart. Here, since preferential operation of technical measures is rare, we approximate a set of domestic regulations by a set of technical measures enforced in the origin country against imports from all countries in the world, which are also expected to affect domestic production and sales.[12] Among the destination-origin-product combinations with some technical measure in the destination country, which accounts for 57.7% of the sample (Table 1), the origin country implements some regulation domestically for two-thirds of those affected cases. Looking into cases in which both the destination and origin countries implement some regulation, a set of foreign regulations is not overlapped by a set of domestic regulations for 29.3% of the cases, whereas a set of foreign regulations is identical to a set of domestic regulations for merely 3.5% of the cases. More importantly, for the rest – 67.2% of the cases – a set of foreign regulations and a set of domestic regulations overlap with each other.

3. Additional Compliance Requirements in Export Destinations

Given the pervasiveness of the simultaneous implementation of multiple regulations and the prevalence of overlaps of foreign and domestic regulations, this section discusses how to identify the trade-diminishing effect of technical measures. We first argue that what is trade-restrictive is additional regulations enforced in the destination country relative to the regulatory regime in the origin country. We then propose a measure of the additional compliance requirements.

3.1. Trade-Diminishing Effect of Technical Measures

The presence of technical measures is not necessarily trade-restrictive, unlike other non-technical NTMs.[13] Technical measures would be barriers to trade if countries enforced

[12] Although the UNCTAD NTM database contains information on whether each regulation applies to domestic entities (or domestically produced goods) as well as foreign exporter firms (or imported foreign products), we cannot utilize that information due to the data incompleteness for some countries.

[13] NTMs coded under chapters E, F, G, H, or I are different from technical measures in terms of

different standards and technical regulations, but they would enhance trade if countries imposed technical requirements in an internationally harmonized manner or streamlined conformity assessment procedures through mutual recognition agreements. What is trade-restrictive is not the mere presence of technical measures in the export destination but substantially effective regulations in place in the destination relative to the origin country. As a thought experiment, suppose that regulation A is enforced in the home country while regulations A and B are enforced in the foreign country. Because firms operating domestically in the home country already comply with regulation A, only regulation B requires additional compliance by firms to start exporting to the foreign country in addition to serving the domestic market.

Thus, to identify the trade-diminishing effect of technical measures, we need to approximate the additional compliance requirements of effectual regulations in the export destination. One may immediately think of simply counting the number of additional regulations by comparing import regulations in the destination country with domestic regulations in the origin country. Such an approach, however, is subject to non-negligible shortcomings.

By simply counting the number of (additional) regulations, we treat all types of technical measures equally at the disaggregation level of interest although NTMs are coded in a hierarchical tree structure.[14] NTMs coded within the same grouping at the aggregate level are more closely related with each other than those classified under different groupings. Among TBT of chapter B, for example, measures classified under B3 are labelling, marking and packaging requirements while those in B8 are conformity assessment related to TBT. B31

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 by definition 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 competition, and investments, which might adversely affect trade.

[14] For more details on the structure of the UNCTAD database, see Nabeshima and Obashi (2019).

(labelling requirement) and B32 (marking requirement) are similar as are B82 (testing requirement) and B83 (certification requirement). It would be better to take into consideration the tree-like structure of the NTM coding system when comparing regulations between countries.

Furthermore, the tree-like structure of the NTM coding system is not uniform across measure types: although most of technical measures are coded at the two-digit level, three-digit numerical codes are available under A85 and B85 while those in chapter C are coded only with one-digit numerical codes. The different disaggregation levels across measure types imply that the count of additional regulations might be biased if equally considering all the possible codes at any aggregation level. For instance, the overlapped regulations between a certain pair of countries tend to be observed more frequently at the more aggregate level, which would underestimate the degree of effectual regulations. To overcome these shortcomings, we propose the ACRI, based on the proximity measure called cosine similarity, as described in detail in the following subsection.[15]

3.2. Additional Compliance Requirement Indicator

We first construct a vector representing a regulatory pattern of technical measures regarding product h implemented domestically in the origin country j as

$$F_{jh}^{D} = \left(F_{jh1}^{D}, \cdots, F_{jhk}^{D}, \cdots, F_{jhK}^{D}\right),$$

where F_{jhk}^{D} is the number of technical measures in force within a measure type grouping k. This domestic regulatory pattern vector (F_{jh}^{D}) is approximated by a set of technical measures implemented in the origin country j against imports from all countries (with no discrimination among trading partners), which are also expected to be applicable to domestic production and

[15] 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., Jaffe 1986; Branstetter 2006) uses cosine similarity to measure the proximity of one firm to another in terms of patenting patterns.

sales. For technical measures classified under chapters A and B, we ignore three-digit numerical codes, which are available under A85 and B85 only, and check the incidence at the two-digit level; meanwhile, those classified under chapter C are coded only with one-digit numerical codes. Given such unbalanced tree-like structure, we consider 17 groupings (i.e. K=17) as listed in the appendix, and count the number of technical measures in force at the two-digit level for groupings of chapters A and B and at the one-digit level for chapter C.[16] Each element of the vector (F_{jhk}^{D}) therefore takes an integer value between 0 and the maximum possible number shown in the appendix.[17]

The count of technical measures may be affected by the potential number of regulations enforced in combination, depending on different legislative systems across countries. Nevertheless, the cumulative burden of multiple forms and types of similar regulations, even if being imposed to achieve equivalent policy objectives, can be burdensome for exporter firms. Thus, we count the number of technical measures by measure type groupings rather than using binary variables so as to represent the regulatory pattern. In addition, when calculating cosine similarity to gauge the proximity between a pair of regulatory pattern vectors, not a nominal frequency but a relative frequency of technical measures of each grouping (i.e. a proportion in the overall number of observations for the country) will matter.

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

[16] A technical measure is coded at a higher level even though more disaggregated codes exist, if a relevant legal document does not provide enough information to assign the measure to a disaggregated level. Such cases are rare exceptions and account for 3% of the technical measures recorded in our data set. Another case is where the 'not elsewhere specified (n.e.s.)' code is used if a requirement is precisely defined in a legal document but does not match any of the existing codes. 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 can be used in constructing the original database.

[17] To consider the relatedness among measure codes, we could alternatively use the Mahalanobis distance with the 'revealed' relatedness matrix among the vector elements, as in Bloom, Schankerman, and Van Reenen (2013).

$$F_{ijh}^{F} = \left(F_{ijh1}^{F}, \cdots, F_{ijhk}^{F}, \cdots, F_{ijhK}^{F}\right),$$

where F_{ijhk}^{F} is the number of technical measures in force within a type grouping k.

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

$$F_{ijh} = \left(F_{jh1}^{D} + F_{ijh1}^{F}, \cdots, F_{jhk}^{D} + F_{ijhk}^{F}, \cdots, F_{jhK}^{D} + F_{ijhK}^{F}\right),$$

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_{jh}^{D} to F_{ijh} is calculated as

$$\mathrm{Cos}(\theta)_{ijh} = \frac{F_{jh}^{D} \cdot F_{ijh}{}'}{\left\|F_{jh}^{D}\right\| \left\|F_{ijh}\right\|} = \frac{\sum_{k=1}^{K} F_{jhk}^{D} F_{ijhk}}{\sqrt{\sum_{k=1}^{K} \left(F_{jhk}^{D}\right)^{2}} \sqrt{\sum_{k=1}^{K} F_{ijhk}{}^{2}}},$$

where $\mathrm{Cos}(\theta)_{ijh}$ is represented using an inner product of the two regulatory pattern vectors and their magnitudes. θ is the measure of an angle between the vectors and takes a value between 0 degree (identical) and 90 degree (orthogonal) because both vectors are composed only of elements with positive integer values. The lower the cosine similarity, the more the combined vector (F_{ijh}) is de-correlated with the domestic regulation vector (F_{jh}^{D}), i.e. the greater the degree of effectual regulations in the destination country i.

Finally, using the cosine similarity, we define the ACRI for the destination country i with respect to the origin country j for product h as

$$ACRI_{ijh} = 1 - \text{Cos}(\theta)_{ijh},$$

which takes a higher value between 0 and 1 when the degree of effectual regulations in the destination country i, or their additional compliance requirements, is calculated to be greater. The ACRI is bilateral direction-specific: ACRI of from country A to country B can be different from ACRI of from country B to country A.

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

Summary statistics for ACRI are shown in Table 4, which looks into the distribution of calculated ACRI by destination and origin country income groups. We divide destination-origin-product combinations into four different cases in terms of the presence of technical measures in the destination and origin countries, as shown in the first four column headings of the table. For example, (Yes; Yes) indicates a case in which both the destination and origin countries implement some technical measure against a certain product category. The possible values of ACRI are also shown in the column headings. The last four columns report the mean, standard deviation, maximum, and minimum values of ACRI calculated for the (Yes; Yes) case. We do not report the figures for the other three cases because the ACRI is calculated as or set equal to an extreme value, 0 or 1, and there are no variations among the observations of concern.

Country income group		(Yes/No whether some regulation implemented in destination; Yes/No whether some domestic regulation implemented in origin)				ACRI for (Yes; Yes) obs.			
		(Yes; Yes)	(Yes; No)	(No; Yes)	(No; No)				
Destination	Origin	ACRI=[0,1)	ACRI=1	ACRI=0	ACRI=0	Mean	Std. dev.	Min.	Max.
Overall	**Overall**	**37.7%**	**20.0%**	**19.7%**	**22.6%**	**0.186**	**0.182**	**0**	**0.904**
H	H	63.6%	13.1%	12.8%	10.4%	0.176	0.183	0	0.894
H	UM	44.5%	32.3%	6.7%	16.5%	0.191	0.183	0	0.904
H	LM	44.9%	31.9%	7.6%	15.6%	0.258	0.212	0	0.902
H	L	48.2%	28.6%	9.6%	13.6%	0.260	0.179	0	0.878
UM	H	44.5%	6.8%	31.9%	16.8%	0.158	0.172	0	0.860
UM	UM	32.1%	19.2%	19.0%	29.7%	0.163	0.175	0	0.870
UM	LM	32.4%	18.9%	20.1%	28.6%	0.219	0.213	0	0.882
UM	L	33.7%	17.6%	24.1%	24.5%	0.228	0.188	0	0.882
LM	H	44.8%	7.9%	31.6%	15.7%	0.134	0.141	0	0.875
LM	UM	32.4%	20.3%	18.7%	28.6%	0.137	0.148	0	0.879
LM	LM	31.9%	20.8%	20.6%	26.7%	0.183	0.180	0	0.891
LM	L	34.6%	18.1%	23.2%	24.1%	0.165	0.152	0	0.885
L	H	48.6%	9.9%	27.9%	13.6%	0.185	0.177	0	0.857
L	UM	33.7%	24.3%	17.5%	24.6%	0.178	0.177	0	0.885
L	LM	34.6%	23.4%	17.9%	24.1%	0.191	0.187	0	0.899
L	L	35.7%	22.2%	22.1%	19.9%	0.160	0.158	0	0.863

Table 4. Additional Compliance Requirement Indicator, by Destination and Origin Country Income Group

Note: See notes on Table 2.
Source: Authors' calculation.

As indicated in the first row of the table, the origin country as well as the destination country implements some technical measure for 37.7% of the destination-origin-product combinations. For those (Yes; Yes) observations, the calculated ACRI ranges from 0 to 0.904 with a mean of 0.186, following the right-skewed distribution. Note that in the case of (Yes; Yes), ACRI is calculated as zero only when domestic and foreign regulations are identical to each other; such a case accounts for only a few percentages of the (Yes; Yes) observations.

The proportion of (Yes; Yes) cases in the total destination-origin-product combinations is the highest for country pairs of high-income groups (63.6%) and lowest for those of lower-middle-income groups (31.9%). Focusing on the (Yes; Yes) case, the calculated average value of ACRI ranges from 0.134 for the trade flows from high-income to lower-middle-income countries, to 0.260 for the trade flows from low-income to high-income countries. If there are some overlaps between domestic and foreign regulations, lower-income countries tend to face additional compliance requirements to a greater extent when their products are exported to higher-income countries, compared with the opposite direction of trade flows. Furthermore, higher-income countries are more active in implementing a series of different types of technical measures (as shown in Tables 2 and 3). Reflecting this, the proportion of (Yes; No) cases, in which the destination country implements some regulation despite no domestic regulation in the origin, tends to be larger for trade flows with high-income countries as the destination.

Table 5 resembles Table 4, but examines the distribution of calculated ACRI by industry group. For the first three groups of agricultural sectors – animal products, vegetable products, and foodstuffs – the proportion of (Yes; Yes) cases exceeds 85%, suggesting that both destination and origin countries frequently use a variety of technical measures. In contrast, the proportion of (Yes; Yes) cases is less than 20% for the stone/glass and metals sectors. Additionally, for agricultural sectors, ACRI is on average calculated as lower than other sectors. A set of domestic regulations tends to be similar in composition to a set of foreign regulations in the case of agricultural sectors, though the calculated ACRI is close to one in some cases.

Industry group	No. of HS 6-digit codes	(Yes/No whether some regulation implemented in destination; Yes/No whether some domestic regulation implemented in origin) (Yes; Yes) ACRI=[0,1)	(Yes; No) ACRI=1	(No; Yes) ACRI=0	(No; No) ACRI=0	ACRI for (Yes; Yes) obs. Mean	Std. dev.	Min.	Max.
Total	**5,224**	**37.7%**	**20.0%**	**19.7%**	**22.6%**	**0.186**	**0.182**	**0**	**0.904**
Animal products	220	89.1%	4.4%	4.4%	2.2%	0.120	0.129	0	0.897
Vegetable products	315	85.7%	4.3%	4.3%	5.8%	0.136	0.156	0	0.904
Foodstuffs	194	86.0%	6.0%	5.9%	2.1%	0.156	0.161	0	0.902
Mineral products	152	28.0%	23.6%	23.3%	25.1%	0.213	0.186	0	0.872
Chemicals	813	40.7%	19.9%	19.6%	19.8%	0.191	0.184	0	0.895
Plastics/rubbers	212	24.1%	24.7%	24.6%	26.6%	0.227	0.198	0	0.865
Hides and skins	74	35.3%	22.4%	21.4%	20.9%	0.212	0.180	0	0.842
Wood products	234	27.5%	22.2%	21.7%	28.5%	0.220	0.193	0	0.856
Textiles	848	33.4%	22.5%	22.5%	21.6%	0.220	0.192	0	0.846
Footwear	55	28.3%	20.9%	20.4%	30.4%	0.220	0.186	0	0.842
Stone/glass	193	18.8%	24.7%	24.2%	32.4%	0.226	0.186	0	0.831
Metals	584	18.3%	23.9%	23.6%	34.2%	0.224	0.191	0	0.848
Machinery	799	30.3%	22.9%	22.6%	24.1%	0.210	0.199	0	0.857
Transportation	134	34.4%	22.4%	22.2%	21.0%	0.205	0.189	0	0.854
Miscellaneous	397	23.2%	21.7%	21.5%	33.5%	0.196	0.186	0	0.860

Table 5. Additional Compliance Requirement Indicator, by Industry Group

Notes: See notes on Table 1. Definitions of industry groups are defined at the two-digit level as follows: animal products include HS01-05, vegetable products include HS06-15, foodstuffs include HS16-24, mineral products include HS25-27, chemicals include HS28-38, hides and skins include HS39-40, wood products include HS44-49, textiles include HS50-63, footwear includes HS64-67, stone/glass includes HS68-71, metals include HS72-83, machinery includes HS84-85, transportation includes HS86-89, and miscellaneous includes HS90-99.
Source: Authors' calculation.

4. Trade Effects of Additional Compliance Requirements

Using the proposed ACRI, this section examines whether and to what extent substantially effective regulations in the destination country relative to the origin country discourage bilateral trade in the gravity framework. After describing the data and variables to be used in our gravity analysis, we show and interpret the estimation results.

4.1. Data and Variables for Gravity Analysis

We work with bilateral trade data for the single year 2015, for which the NTM information is available, at the HS six-digit product level of the H2 version, obtained from the UN

Comtrade database (United Nations 2017).[18] Although 57 countries (as listed in Table 2) are included in our NTM data set, we limit our gravity analysis to 48 countries for which trade statistics for 2015 are available at the UN Comtrade database.[19] We focus on 5,219 (out of 5,224) product codes because no country in our sample exported or imported the other five product codes. Among 48 x 47 x 5,219 (= 11,774,064) destination-origin-product combinations, we exclude those subject to explicit import prohibitions for SPS, TBT, or other reasons – coded under A11, A12, B11, E311, E312, E313, or E32 – for which trade values should be zero at the national tariff lines (under HS six-digit codes of our interest). The excluded ones together account for 9% of the total number of combinations. Ultimately, we carry out gravity analysis based on the trade and regulation data for 10,612,932 destination-origin-product combinations (at the maximum).

We examine the effects of the ACRI on bilateral trade at the product level in the gravity equation of a cross-sectional form by including origin and destination country fixed effects to control for so-called multilateral resistance (Anderson and van Wincoop 2003), as well as product fixed effects. We are interested in identifying the effects of bilateral variables on bilateral trade at the product level. As a proxy for country pair-wise trade costs – including cross-border transportation costs, telecommunication costs, and other costs related to geographical distance – we include conventional gravity variables, as in Santos Silva and Tenreyro (2006). These variables are population-weighted bilateral distance between countries in kilometres and country pair-specific dummy variables indicating contiguity, common official or primary language, post-1945 colonial relationship, and regional trade agreement. All these variables regarding country pair-wise trade costs are obtained from the

[18] The UNCTAD NTM database contains the information on starting dates for the respective recorded measures; however, the starting date data is subject to inconsistencies across the reporting countries (Disdier, Gaigné, and Herghelegiu 2018), which might depend on different national legislative systems, and we are not confident in constructing a panel data of NTMs to be examined.

[19] Nine countries did not report trade statistics for 2015 – Cuba, Ghana, Gambia, Honduras, Liberia, Mali, Nigeria, Tajikistan, and Venezuela.

Centre d'Études Prospectives et d'Informations Internationales (CEPII) Gravity database (CEPII 2017).

As a proxy for bilateral, direction-specific trade costs, we include variables capturing the trade policies of the destination country against the origin country at the product level, as well as the ACRI variable of our interest. Using tariff data obtained from the UNCTAD TRAINS database (UNCTAD 2015b), we construct a simple average ad valorem tariff (calculated over national tariff lines) and a dummy variable indicating the presence of a non-ad valorem tariff at the HS six-digit level. In addition, making use of the UNCTAD NTM database, we construct dummy variables indicating the presence of the hard measures classified under chapters E or F and the presence of (potential) non-tariff barriers to trade classified under chapters G, H, or I.

One thing to note is that we treat the European Union (EU) as a single unit for trading purposes because the NTM information is recorded for EU as a whole in the UNCTAD database. However, data on distance and associated indicator variables available from the CEPII are at a country level. So we need to (re)construct variables for the overall EU: First, following the methodology proposed by Mayer and Zignago (2005) , we calculate the distance between the EU and country j (outside the EU). Our formula is $d_{EUj} = \sum_{i \in EU} (pop_i / pop_{EU})\, d_{ij}$, where pop_i is the population of the EU member country i and pop_{EU} is the overall EU's population. d_{ij} is the distance between countries i and j, which is calculated as an average of intercity distances weighted by the share of the city in the overall country's population. Second, for the dummy variables, we simply take the maximum among the EU members with respect to a certain trading partner.

4.2. Estimation Results

Our baseline estimation results are reported in Table 6. We primarily estimate the log-linearized gravity equation by ordinary least square (OLS), focusing only on non-zero trade values, but verify whether the estimation results obtained using OLS are robust to the adoption of Poisson pseudo-maximum likelihood (PPML) estimation. It is a common perception in the empirical trade literature that estimating the multiplicative form of gravity equation by PPML is a natural way to deal with prevalent zero-value observations in trade data. Furthermore, as shown in Santos Silva and Tenreyro (2006), the presence of heteroskedasticity in the gravity model can generate strikingly different, biased estimates when the gravity equation is log-linearized, rather than estimated in levels. An alternative approach to treat zero trade values would be a two-stage estimation procedure proposed by Helpman, Melitz, and Rubinstein (2008); however, its dependence on the homoskedasticity assumption poses non-negligible drawback as pointed out in Santos Silva and Tenreyro (2015).

	[1]	[2]	[3]	[4]
Estimator:	OLS	OLS	OLS	PPML
Dependent variable:	$\ln T_{ij}$	$\ln T_{ij}$	$\ln T_{ij}$	T_{ij}
Explanatory variables				
Log distance	-0.767***	-0.766***	-0.767***	-0.634***
	(0.005)	(0.005)	(0.005)	(0.038)
Contiguity dummy	0.470***	0.471***	0.460***	0.382***
	(0.011)	(0.011)	(0.011)	(0.057)
Common-language dummy	0.196***	0.195***	0.180***	-0.166*
	(0.008)	(0.008)	(0.008)	(0.070)
Colonial-tie dummy	0.190***	0.188***	0.191***	0.170*
	(0.013)	(0.013)	(0.013)	(0.078)
RTA dummy	0.131***	0.131***	0.139***	0.312***
	(0.008)	(0.008)	(0.008)	(0.069)
Log (1 + AV tariff)	-0.040***	-0.041***	-0.040***	-0.022
	(0.003)	(0.003)	(0.003)	(0.031)
Non AV dummy	-0.233***	-0.229***	-0.236***	-0.193
	(0.020)	(0.020)	(0.020)	(0.201)
Dummy for hard measures	0.047***	0.038***	0.053***	-0.095
	(0.011)	(0.011)	(0.011)	(0.070)
Dummy for other NTBs	0.030	0.025	0.033	0.175
	(0.033)	(0.033)	(0.033)	(0.143)
Dummy for technical measures		0.085***		
		(0.008)		
ACRI			-0.229***	-0.155*
			(0.010)	(0.074)
Destination, origin, product fixed effects	YES	YES	YES	YES
Number of observations	1,118,021	1,118,021	1,118,021	10,600,120
R^2	0.384	0.384	0.384	
Deviance				17,882,559
Deviance test: prob > chi2				0.000

Table 6. Baseline Estimation Results

Notes: A dependent variable in the OLS regressions is trade value in US dollars at the destination-origin-product level. To conduct PPML, we rescale and express the dependent variable as trade value in millions of US dollars to avoid numerical problems, though the PPML estimator is scale-invariant. Estimated coefficients are accompanied by robust standard errors in parentheses. Asterisks denote statistical significance: *** significant at the 0.1% level; ** significant at the 1% level; * significant at the 5% level.
Source: Authors' calculation.

The first three columns of the table show the estimated coefficients, accompanied by the corresponding robust standard errors in parentheses, that are obtained using OLS with different sets of explanatory variables. All three columns/specifications include a set of variables usually employed in the gravity analysis as a proxy for country pair-wise trade costs, the log of the simple average ad valorem tariff, and the non-ad valorem tariff dummy. The coefficients for the conventional gravity variables and the tariff variables are all estimated in an expected direction with statistical significance. In addition, the dummy variable marking the presence of hard measures is estimated to be significantly positive while the dummy for the presence of other (potential) non-tariff barriers is estimated to be insignificant and positive in each column. The former result can be interpreted as suggesting that hard (quantity or price control) measures are more likely to be implemented when trade volume is more substantial after controlling for other covariates.

In addition to the set of explanatory variables employed in the first column, the second column includes a dummy variable indicating the presence of technical measures at the destination-origin-product level. This is the dummy variable that has been traditionally employed to quantify the trade restrictiveness of technical measures by calculating AVEs in the related literature (e.g., Kee, Nicita, and Olarreaga 2009). The coefficient for the technical measures dummy is estimated to be significantly positive, which can be interpreted in a similar way to our interpretation of the estimates for the hard measures dummy – it would be likely to have no technical measure, as well as no hard measure, implemented against lower volume of trade flows.

The third column includes the ACRI variable of our interest, instead of the technical measures dummy. The coefficient of ACRI is estimated, as expected, to be significantly negative under the significance level of 0.001. The estimates suggest that the product-level bilateral trade value decreases by 22.9% when ACRI is changed from 0 to 1, with other things unaltered, when focusing on trade flows of non-zero values. It appears that the additional compliance requirements of substantially effective regulations in the destination country relative to the domestic regulatory regime in the origin country discourage bilateral trade at the product level to some extent. Notice that when we employ the ACRI variable, the above-mentioned relationship between technical measures and trade volumes is no longer likely, because low trade volumes are unlikely to lead to greater regulatory burdens faced by exporters (not necessarily less burdens either). The estimated negative correlation therefore can be explained exclusively by the additional compliance requirements of effectual regulations in the destination markets.

The fourth column includes the same set of explanatory variables as in the third column, but estimated using PPML for robustness check. The difference in the number of observations between the third and fourth columns corresponds to the incidence of zero trade flows. The differences in the estimated coefficients would partly reflect the impact of possible sample selection bias on the OLS estimates. The estimated coefficient for ACRI is still estimated to be significantly negative at the significance level of 0.05, although the magnitude becomes smaller by considering zero trade flows. The additional compliance requirements of effectual regulations in the destination country discourage bilateral trade of even small values. It follows from $\mathrm{e}^{-0.155} = 0.856$ that the product-level bilateral trade value decreases by 14.4% when ACRI is changed from 0 to 1, with other things unaltered. If ACRI increases by 0.1, the trade value decreases by 2.5% since $\mathrm{e}^{-0.155\times 0.1} = 0.985$.

We look into the coefficient for ACRI by obtaining the OLS and PPML estimates of the same specification as columns 3 and 4 of Table 6 for four subsamples divided by destination and origin country income groups and for 15 subsamples by industry group. The estimated coefficients for ACRI by destination and origin country income groups are reported in Table 7. Here, we follow the World Bank's classification as for Tables 2 and 3, but aggregate upper-middle, lower-middle, and low-income groups into a single non-high-income group for simplicity. The first two columns of Table 7 show the estimated coefficient for ACRI obtained using OLS and the number of observations included in the estimated sample for each destination and origin income group pair, and the latter two columns estimated using PPML.

Country income group		OLS		PPML	
Destination	Origin	ACRI	No. of observations	ACRI	No. of observations
High	High	-0.396*** (0.035)	144,430	-0.312 (0.171)	430,601
High	Non-high	-0.234*** (0.018)	229,678	-0.161 (0.120)	1,814,764
Non-high	High	0.038 (0.035)	318,764	-0.815* (0.369)	1,776,609
Non-high	Non-high	-0.096*** (0.015)	425,149	-0.060 (0.138)	6,578,146

Table 7. Estimated Coefficients for ACRI, by Destination and Origin Country Income Group

Notes: See notes on Table 6. Countries are divided into high-income and non-high-income groups, the latter of which includes upper-middle, lower-middle, and low-income groups, following the World Bank's classification.
Source: Authors' calculation.

First, looking at the trade flows among high-income countries, the coefficient for ACRI is estimated to be significantly negative: a higher ACRI decreases the product-level bilateral trade among high-income countries, as in the full sample. The PPML estimate is negative and statistically significant at the significance level of 0.1.

Similarly, the OLS estimate obtained for the trade flows among non-high-income countries suggests that trade among less-developed countries is adversely affected by the burden of effectual regulations in the destination country. This result fits with the general concern that trade among developing countries is much smaller than theory predicts, which seems to be partly attributable to regulatory burdens on exporter firms. In addition, looking at the exports from non-high-income to high-income countries, the OLS estimate indicates a statistically significant negative result, which fits with the general perception that exporters in developing countries face difficulties meeting the regulatory requirements imposed in developed countries.

For these two trade flows including non-high-income countries as the origin country, the PPML estimates are still negative but lose statistical significance. A difference in significance between the OLS and PPML estimates can be related to the earlier studies that detect a significantly negative impact of MRLs not on the probability of trade (the extensive margin), but on the amount of trade (the intensive margin) (Disdier and Marette 2010; Xiong and Beghin 2014).[20] It appears through the lens of these previous findings that regulatory burdens do not hinder the exporter's entry to the destination market while decreasing developing countries' exports to their existing trading partners.

Second, in contrast, looking at the exports from high-income to non-high-income countries, the OLS estimate is not statistically significant while the PPML estimate is significantly negative. It appears that developed countries' exports to their existing trading partners in developing countries are not affected by regulatory burdens. Developed countries' exports of smaller values as well as their access to the developing countries' markets, on the other hand, might be sensitive to and adversely affected by regulatory burdens.

Based on these estimated results, we highlight the differential impacts of regulatory burdens on trade, depending on the development levels of destination and origin countries. In particular, focusing on non-zero trade flows, the regulatory burdens placed on foreign firms exporting to a developing country decrease the exports from the other developing countries but not affect those from developed countries; meanwhile, the regulatory burdens placed on foreign firms exporting to a developed country diminish the exports from the both types of countries. Differences in the trade impact of TBT (measured by the number of notifications to the WTO) between developed and developing countries are well documented in the literature (e.g., Bao and Chen 2013; Bao and Qiu 2012). Our findings complement these previous findings by focusing exclusively on the additional compliance requirements implied by a series of technical regulations enforced in the destination markets rather than looking at their

[20] Disdier and Marette (2010) find that the MRL that caps antibiotic residues in crustaceans enforced in the US, EU, Canada, and Japan's markets has a significantly negative impact not on the extensive margin but on the intensive margin of trade. Xiong and Beghin (2014) show similar results for the high-income OECD country's MRLs on pesticides for plant products.

mere presence.

The estimated coefficients for the ACRI by industry group are reported in Table 8. For foodstuffs and machinery sectors, both the OLS and PPML estimates are significantly negative with a relatively large magnitude, which suggests that the extra regulatory burdens in the destination country discourage bilateral trade considerably. If the ACRI increases by 0.1, the trade value decreases by 9.8% (i.e., $e^{-1.032\times0.1} = 0.902$) and 6.4% (i.e., $e^{-0.659\times0.1} = 0.936$), respectively, in the foodstuffs and machinery sectors. Our findings on foodstuffs sector are in line with the general implications suggested by Disdier and Marette (2010) and Crivelli and Groeschl (2016) and those on machinery sector are consistent with Portugal-Perez, Reyes, and Wilson (2010).

Industry group	OLS		PPML	
	ACRI	No. of observations	ACRI	No. of observations
Animal products	-0.651*	12,884	-0.676	358,483
	(0.258)		(0.507)	
Vegetable products	-0.161	40,900	0.826	599,676
	(0.131)		(0.435)	
Foodstuffs	-0.736***	40,577	-1.032***	373,445
	(0.129)		(0.262)	
Mineral products	-0.136	17,812	0.176	320,817
	(0.102)		(0.333)	
Chemicals	-0.083**	123,879	0.072	1,581,067
	(0.032)		(0.130)	
Plastics/rubbers	-0.214***	71,312	-0.033	452,520
	(0.039)		(0.104)	
Hides and skins	-0.303***	14,186	0.401	146,520
	(0.089)		(0.237)	
Wood products	-0.025	53,117	-0.069	497,750
	(0.045)		(0.136)	
Textiles	0.101**	177,194	0.133	1,819,233
	(0.031)		(0.104)	
Footwear	-0.054	16,376	-0.235	116,488
	(0.073)		(0.144)	
Stone/glass	-0.210***	46,432	-0.295	419,458
	(0.047)		(0.225)	
Metals	0.043	141,828	0.219*	1,273,002
	(0.029)		(0.105)	
Machinery	-0.612***	224,372	-0.659**	1,550,140
	(0.025)		(0.195)	
Transportation	-0.232**	27,652	-0.173	260,564
	(0.074)		(0.246)	
Miscellaneous	-0.133***	109,500	0.208	830,957
	(0.028)		(0.174)	

Table 8. Estimated Coefficients for ACRI, by Industry Groups

Note: See notes on Tables 5 and 6.
Source: Authors' calculation.

For some sectors such as animal products, plastics/rubbers, stone/glass, and transportation, the OLS estimates are significantly negative while the PPML estimates are still negative but lose statistical significance. It appears that for these sectors, regulatory burdens diminish countries' exports to their existing trading partners but not hinder the exporter's access to the potential destination market. The estimates for the textiles and metals sectors show unexpected results: the estimated coefficients are positive and even significant in some cases, suggesting the opposing effects of regulatory burdens on trade. Although to disentangle the opposing effects is beyond the scope of the current paper, the positive effects of regulatory burdens on trade could be explained by the information cost-saving effect (Portugal-Perez, Reyes, and Wilson 2010), as opposed to the compliance cost-raising effect.

5. Conclusion

In this paper, we developed the ACRI indicator to quantify the extra regulatory burdens that an exporter may face when serving the destination country's market in addition to the domestic operation. This is a novel approach to assess the potential impact of regulatory burdens on bilateral trade flows. Unlike the traditional approach, our proposed ACRI captures the direction-specific additional compliance requirements implied by a set of technical regulations that constitute the market entry and trade costs faced by exporters. The higher the value of ACRI, the greater the difference between the sets of regulations in the destination and origin countries. The idea is that exporters will need to incur additional costs to cover the additional requirements in complying with foreign regulations when they are exporting to or serving the foreign country's market. Employing the ACRI variable, we estimated the trade effects of regulatory burdens in product-level bilateral gravity equations.

For a full sample, including all the countries and sectors in our data set, we detected a negative correlation between ACRI and bilateral trade values using both OLS and PPML. Looking into income groups of the destination and origin countries, our estimates suggest that regulatory burdens faced by exporters when serving the less-developed country's market decrease the trade flows originating from other less-developed countries but not affect those from developed countries. The regulatory burdens in serving the developed country's market, on the other hand, diminish the trade flows originating from any country irrespective of the development level. In addition, the trade effects of regulatory burdens vary in magnitude and signs among industry groups, with noticeable adverse effects detected for foodstuffs and machinery sectors.

For subsamples by country income group and by industry group, there are differences in significance and magnitude and even in signs between the OLS and PPML estimates. We tried to interpret the differential impacts of regulatory burdens on trade, depending on the development levels of destination and origin countries as well as across sectors, from the lens of previous studies' findings. Nevertheless, although our focus was kept on the compliance cost-raising effect of primary importance, there might be other possible channels through which regulatory burdens affect trade. One channel is the information cost-saving effect mentioned above: Portugal-Perez, Reyes, and Wilson (2010) argue that product standards can potentially reduce exporters' costs of collecting market information by conveying information on technical requirements, compatibility or interoperability of products, consumer tastes and so on. Similar arguments can be extended to the regulatory burdens implied by standard-like technical measures. The informational content that technical measures convey for more complex products is thought to be relatively more valuable though it is not easy to capture the information costs across products.

The other channel is competition effect among existing and potential exporter firms. The greater regulatory burdens in serving a foreign market may discourage potential exporters entering the market, but also may force less productive firms out of the market and provide protection to the remaining exporters (Bao and Chen 2013). As a result, the protected, remaining firms might be able to increase their exports despite the regulatory burdens. To deal with such firm heterogeneity in productivity while assessing the trade effects of regulatory burdens, country-level analysis as in this study is insufficient and in-depth analysis using firm-level data is called for future studies.

In a more complicated manner, the trade effects of regulatory burdens may not be limited to a bilateral trade relationship subject to the technical regulations of concern. The greater regulatory burdens faced by exporters originating from a given country may affect related exports from the third country. Also, the greater regulatory burdens may deflect the destination of the affected exports: firms may be self-selected into the markets with less regulatory burdens. Such third country effects have been examined in the context of regulatory harmonization through trade agreements (Chen and Mattoo 2008; Disdier, Fontagné, and Cadot 2015), but could be extended to the more general context of cross-country regulatory differences.

Last but not the least, our findings about the trade effects of ACRI can be interpreted as suggesting that international efforts toward regulatory harmonization – to decrease the ACRI – would enhance bilateral trade. Note, however, that our current research interest is focused exclusively on the trade effects of regulatory burdens faced by exporter firms and that we are not arguing that reducing or eliminating cross-country regulatory differences improves economic welfare. Especially in the presence of concerns for health, safety and the environment and associated external effects, regulatory harmonization is not necessarily socially optimal even if enhancing trade (Beghin, Disdier, and Marette 2015; Disdier and Marette 2010; Xiong and Beghin 2014). With the recent and ongoing advancement in the coverage and quality of NTM data, future research could measure the social benefits and costs of technical measures and investigate the welfare implications as well as the trade effects of cross-country regulatory differences.

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Appendix

Technical measure group	Maximum possible no. of measures within group
A1	4
A2	3
A3	4
A4	3
A5	4
A6	5
A8	7
A9	1
B1	3
B2	3
B3	4
B4	3
B6	1
B7	1
B8	6
B9	1
C	5

Table A1. Groupings of Technical Measures Considered in Constructing the Regulatory Pattern Vector

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