

Lombini, Alessio

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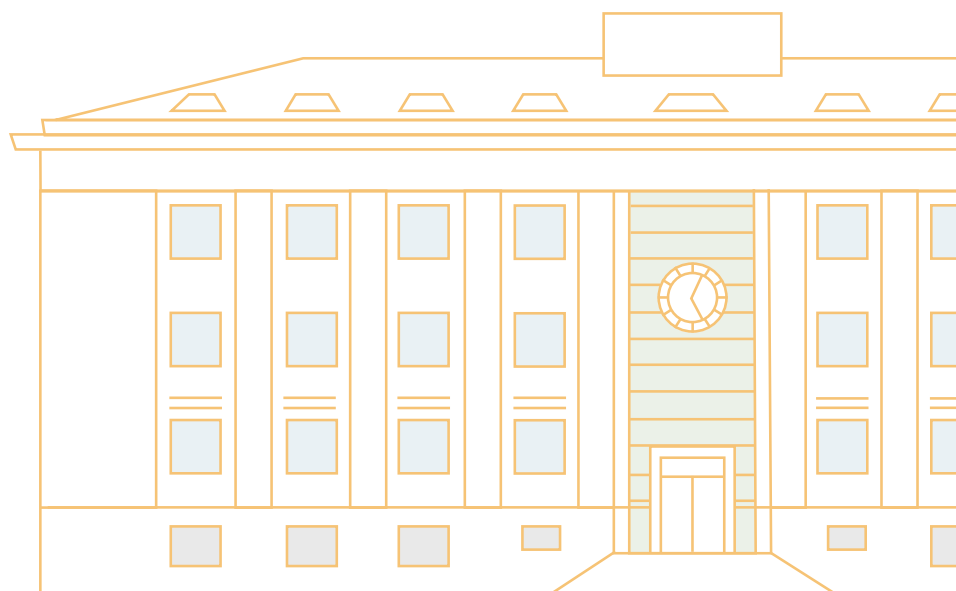
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The impact of regulatory heterogeneity on global value chain-related trade

Alessio Lombini

The impact of regulatory heterogeneity on global value chain-related trade*

Alessio Lombini[†]

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Abstract

In this paper, I estimate the impact of heterogeneity in non-tariff-measures (NTMs) policies on countries' global value chains (GVCs)-related trade and its backward and forward components. I firstly build a regulatory distance (RD) index, which measures the degree of dissimilarity in NTMs structures between two trade partners. By including the RD index in a structural gravity model, I then find a significant negative effect of regulatory distance on total, backward, and forward GVC-related trade. The negative impact results to be even stronger when I conduct the analysis only on manufacturing sectors. On the country dimension, I demonstrate that the effects of regulatory distance are associated with the exporters' and the importers' income levels.

JEL classification: E16, F13, F14, F15, F63, L51, O40

Keywords: Gravity equation, non-tariff measures, regulatory distance, trade protection, international trade, global value chains, technical regulations

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[†] University of Neuchâtel, Rue A.-L. Breguet 2, CH-2000 Neuchâtel, alessio.lombini@unine.ch

1. Introduction

The recent technological advancements and reductions in trade tariffs have made it increasingly profitable for firms to separate their production chain into individual stages. These tasks can then be allocated internationally to firms in countries with a comparative advantage in executing this specific portion of production, giving rise to global value chains (GVCs). According to the definition introduced by Hummels et al. (2001) and Baldwin and Lopez-Gonzalez (2015), a country is engaged in global value chains if it exports goods that are partly produced using foreign intermediates. Therefore, there is both an export and an import component to GVCs participation. In this context, as traditional trade barriers such as tariffs and quota restrictions decline in importance, the global rise in product standards (including sanitary regulations in food, technical rules in manufactures, and procedure for testing and certification) has become an important determinant of trade volume and patterns (Fortunato, 2002). Between 1995 and 2017, 434 new sanitary and phytosanitary (SPS) measures and 548 new technical barriers to trade (TBT) were raised at the World Trade Organization (WTO)¹, while the trade costs of NTMs were more than double those of ordinary customs tariffs in 2018 (UN, 2019).

The presence of NTMs and tariffs do not only affect trade in final products but also in intermediate goods and can strongly hamper countries' participation in international value chains. Indeed, intermediate goods can magnify the impact of trade costs on the economy, even more so if they are part of international multistage production (Antràs and De Gortari, 2020). We see this fact occurs for two main reasons. First, in international multistage production processes, goods cross borders multiple times; hence they may embody these additional costs each time they pass a new customs. Second, tariffs are commonly levied on a product's gross (total) import value instead of the value-added in the most recent production stage. As a result, the smaller the value-added in the last production process (relative to its gross value), the larger the effect of a trade barrier applied to this production stage (Yi, 2010).

This paper investigates whether the dissimilarity in bilateral NTMs regimes can affect the countries' GVC-related trade, that is, the value of goods and services exported by a country that crosses more than one border. This study uses a novel approach to measure the impact that NTMs have on countries' value chains participation and international trade. Namely, instead of using absolute proxies of NTMs such as the coverage, frequency, and prevalence ratio (e.g., Gourdon et al., 2014), I follow Cadot et al. (2015) and Inui et al. (2021)

¹ Source: WTO [SPS](#) and [TBT](#) Information Management System.

in employing a relative proxy of NTMs. More specifically, I construct a regulatory distance (RD) indicator, which measures the total bilateral dissimilarity in NTMs patterns between an exporter and its trade partner. Then, I include the RD index in a structural gravity equation, and I empirically assess how much each of the three GVC-related trade components (i.e., total, backward and forward GVC trade) is affected by a one percent increase in bilateral regulatory distance. By analyzing a sample of 59 countries across 21 sectors from 2005 to 2015, I find that regulatory distance negatively affects countries' GVC-related trade.

According to the gravity specification we look at, a unit percent increase in the RD index can lead to a fall of the GVC-related trade ranging from 3.4% to 5.8%, a decrease of the backward GVC related-trade from 5.8% to 6.3%, and a drop of the forward GVC component of export from 3.9% to 6.6%. The overall impact is even higher when I perform the analysis on manufacturing sectors only, although participation in a regional trade agreement (RTA) and cultural and linguistic ties dampen this adverse effect. Finally, by including two-way and three-way interaction terms in the gravity equation, I address the question of whether the impact of regulatory distance is associated with the exporters' and the importers' income levels. Based on the World Bank's income classification, I find that the adverse effect of bilateral regulatory distance becomes more negligible as the exporter's gross national income (GNI) rises. Furthermore, the results suggest that the marginal effect of RD is substantially more negative for developing exporters addressing a low-middle or upper-middle compared to a high income importing market.

This study relates to that body of work that pertains to international trade and GVCs participation. However, methodologically, this work provides a number of relevant contributions to the current literature. Firstly, while the vast majority of the studies that concern the impact of NTMs focus on the trade in final goods, I employ a gravity model to assess the impact of regulatory distance on the GVC-related components of countries' export, namely, total, backward, and forward GVC trade. This aspect assumes particular relevance in the context of globalization and a long-term increase in trade standards. Indeed, it provides a better understanding of the magnitude with which NTMs affect the GVC content of trade. Second, this study includes both RD indicator and tariffs rate in a gravity model, which allows quantifying the ad-valorem tariff equivalent impact of dissimilarity in NTMs, i.e., to quantify the ad-valorem tariff whose introduction would have generated the same impact as the regulatory distance in question. In particular, quantifying the tariff equivalent is relevant from both a policy and a pedagogical perspective since it allows more direct comparison and comprehension of the actual impact of dissimilarity in NTMs structures. Third, it

differentiates the regulatory distance impact per trade actor's income group, which assumes particular relevance in the context of regional trade agreements and South-South integration.

The paper proceeds as follows. Section 2 reviews the existing literature on the economic impact of NTMs and their effects on countries' GVCs participation. Section 3 introduces the data used in this study, how Borin and Mancini (2019) decompose gross export to obtain measures for GVC-related trade, and the methodology I followed to build the regulatory distance indicator. Section 4 presents the identification strategy employed, and it provides an overview of the theoretical intuitions supporting the gravity model. Section 5 begins with preliminary data observations, and it then discusses the empirical results from the baseline gravity model. Section 6 illustrates the sensitivity analysis I perform to test the robustness of the findings from the baseline model. Section 7 concludes and discusses the policy implications of this research.

2. Literature review

The recent growing debate on NTMs among researchers and policymakers has motivated advancement in the literature, particularly in terms of the impacts of NTMs on trade. Nonetheless, studies on the relationship between NTMs and GVC participation, or even between tariffs and GVCs, have remained limited. To the best of my knowledge, this study is the first that examines the impact of the bilateral regulatory distance on the countries' GVC-related trade within a structural gravity model framework. Nevertheless, this paper is related to previous studies that examine the economic repercussions of NTMs. In a broader sense, this research is also grounded on the literature concerning the effects of NTMs and the international competitiveness of sectors with consideration to GVCs.

2.1. The economic effects of non-tariff measures

Non-Tariff Measures are generally defined as “policy measures, other than ordinary customs tariffs, that can have an economic impact on international trade in goods, affecting quantities traded, or prices or both” (UNCTAD, 2017). NTMs include a broad and diverse array of policies that countries apply to exported and imported goods. Some NTMs are manifestly implemented as instruments of commercial policy (for example, subsidies and trade defense measures), while others stem from non-trade policy purposes. The latter category includes technical barriers to trade (TBT) and sanitary and phytosanitary (SPS)

measures, which have spread significantly in the last decades. These measures are mainly implemented for legitimate and essential reasons, such as food and human safety and environmental protection. Nonetheless, they may have considerable restrictive and distorting effects on international trade, and they may be implemented as disguised protection of the local industry. However, since these policies are necessary, their elimination is not an option (Cadot et al., 2015).

Based on gravity estimations and applied general equilibrium model simulations, the literature at the broader level provides mixed evidence on the repercussions of NTMs on trade. On one hand, certain studies argue that NTMs can induce more trade (Xiong and Beghin, 2011; Rindayati and Kristriana, 2018), especially on the intensive margin (Bao and Qiu, 2012; Crivelli and Groschl, 2016). Indeed, NTMs assure the introduction of specific standards that may signal a higher quality of products. As a consequence, technical measures reduce transaction costs and can raise trade values and volumes (Beghin et al., 2012; Blind, Mangelsdorf, and Wilson, 2013). Interestingly, the trade literature demonstrates that SPS and TBT requirements, which is the focus of this paper as well, tend to decrease trade on the extensive margin but increase the volume of exports per exporting firm and even the overall performance of industries (Ghodsi and Stehrer, 2016). This fact should not be surprising since NTMs can act as a barrier to entering foreign markets, but once a firm complies with the standard, the positive quality signal can increase trade values (Beghin et al., 2012).

However, while the overall presence of NTMs has a mixed effect on trade, the impact of heterogeneity in NTMs is generally negative. To that extent, Nordås and Kox (2009) provide an overview of quantifying regulatory barriers to services trade by measuring the difference in NTMs applied between trading partners rather than the mere presence of NTMs themselves. They found that regulatory heterogeneity reduces trade in services and that harmonization of country pairs' regulation could increase the total services trade by between 13% and 30% depending on the country. Similar arguments have been applied to goods in Cadot et al. (2015) and Winchester et al. (2012). In particular, in Cadot et al. (2015), the authors construct a regulatory distance indicator and show that worldwide averages of ad-valorem equivalent (hereafter AVEs) for all NTMs together range between 5 and 27 percent across sectors. Analogously, in Winchester et al. (2012), the authors build a heterogeneity index of trade regulations (HIT) and include it in a structural gravity model, finding that differences in regulations slightly reduce the agro-food trade.

2.2 Heterogeneity in non-tariff measures and global value chains

Only a few studies assess the impact of NTMs on the pattern of trade and production that are internationally connected through GVCs. Even empirical research on the general trade effects of NTMs is limited because it is challenging to study NTMs systematically due to the lack of internationally comparable, suitably coded data. Traditionally, the trade restrictiveness of NTMs has been widely computed as absolute proxies (e.g., the frequency ratio or coverage ratio) and the ad-valorem tariff equivalents (Kee, Nicita, and Olarreaga, 2009). However, this typology of measures presents two crucial drawbacks. First, as Korwatanasakul and Baek (2020) highlight, they cannot capture heterogeneity in trade policies. Second, with these NTM proxies, it is possible to establish a two-way relationship where NTMs may lead to lower trade or GVC participation, while products with low trade volumes or a low degree of GVC integration may be subject to fewer NTMs (Franssen and Solleder, 2016).

To overcome these shortcomings, a recent branch of the literature has started to address the impact of the heterogeneity in NTMs rather than their mere presence. Inui et al. (2021) examine whether and how a country's centrality in GVCs is determined by its regulatory regime dissimilarity from the global average, using country and sector-level data from the Organization for Economic Co-operation and Development (OECD) and the United Nations Conference on Trade and Development (UNCTAD). Running a regression analysis, the authors find that the more similar a country's regulatory regime is to global standards, the more likely it is positioned as a key supplier of intermediates and unfinished products for the hubs downstream in the GVCs. Similarly, Franssen and Solleder (2016) provide empirical evidence of the negative effect of heterogeneity in NTMs on GVC. More specifically, the authors examined the impact of NTMs on the country's backward participation in GVCs, focusing on technical measures. By measuring a country's regulatory distance from the rest of the world using product categories (i.e., intermediates and final consumables) at the Harmonized System (HS) two-digit sector level, they find that regulatory distance on the import of intermediates is negatively correlated with export values of goods within the same value chain, proxied by the HS section. Other studies are similar in terms of approach and results (Kox and Lejou, 2005; Winchester et al. 2012; and Peters and Cadot 2019)

While the previous researches make use of the regulatory distance indicator proposed in Cadot et al. (2015), another branch of the literature assess the economic impact of the heterogeneity in NTMs structures by using an additional compliance requirement indicator (hereafter ACRI), which was first proposed in Nabeshima, and Obashi (2019). In this study,

the authors develop the ACRI to quantify the additional regulatory requirements a country may face when exporting to the foreign country's market. The higher the value of ACRI, the greater the additional requirements in terms of technical measures in the destination country. By including the ACRI in a gravity equation, they estimate the impact on trade of regulatory burdens via product-level gravity equations, finding a significant negative impact on bilateral trade. Following their approach, Korwatanasakul and Baek (2020) conduct a cross-sectional analysis at the industry level, spanning 30 countries in 2015. Their analysis reveals that both NTMs and tariffs negatively impact backward GVC participation, and the impact of NTMs is even stronger than that of tariff measures. To summarize, previous studies have provided evidence that NTMs do affect international trade as well as the countries' participation in GVCs. Generally, this effect is mixed when we consider NTMs in absolute terms since they aim to increase the quality standards of goods and products, but overall negative when heterogeneity in NTMs is taken into account.

3. Data collection and regulatory distance index construction

In this section, firstly, I present the source of the data for GVC-related trade measures and the approach with which they are constructed. Then, I describe the data for technical regulations and the methodology implemented to construct the bilateral RD indicator. Finally, I explain the sources of the rest of the data included in this work.

3.1 Data on global value chains–related trade

Beyond the mere expansion of trade, an additional dimension of globalization has been the growth of global value chains over the past two decades. In an increasingly integrated world economy fuelled by policy reforms in support of trade, a downward trend in transportation and communication costs, and exponential technological progress, the production processes have been more fragmented across the globe. All these factors have given rise to networks of supply chains in which value is added at each phase before crossing the border to be passed on to the next production stage, in other words, GVCs. More importantly, the growth of GVCs has enabled countries to better exploit their comparative advantages by allowing them to join a production chain without supplying all the other upstream capabilities (IMF, 2016). In this study, I employ measures of total, backward and forward GVC-related trade as dependent variables. These three indicators are derived from

the data available in the Trade in Value Added database (TiVA release 2018, OECD), and they cover 21 unique sectors across 59 countries during the years from 2005 to 2015. All three trade indicators are measured in millions of US Dollars, and they are retrieved from the World Integrated Trade Solution (WITS) portal. Table A1 and Table A2 list, respectively, the samples of countries and sectors covered by this study.

More recently, the literature started to decompose exports into distinct value-added components used to measure GVCs participation. In this paper, I make use of GVCs trade-related measures constructed following the Borin and Mancini (2019) approach, which can be considered as an extension of the Hummels et al. (2001) and Koopman et al. (2014) methodologies. In particular, in Borin and Mancini (2019), the authors provide a new set of tools for value-added accounting of trade flows at the sectoral, aggregate, and bilateral levels that can be employed to explore a broad array of empirical questions concerning GVC-related trade and countries' participation in GVCs. They also overcome the main drawbacks that make imprecise and partially incorrect the value-added decompositions of bilateral exports previously proposed in the literature.

Figure 1 shows the Borin and Mancini (2019) extension of the Koopman et al. (2014) methodology and how they decompose the value-added components of gross exports². In line with the mentioned disaggregation, we can broadly define GVC-related trade as the difference between gross and traditional trade³, i.e., the value of goods and services that crosses more than one border. Equations (1) and (2) present a more formal definition of GVC-related trade and its sub-components:

$$GVC - related\ trade_{ijk} = Backward\ GVC_{ijk} + Forward\ GVC_{ijk} \quad (1)$$

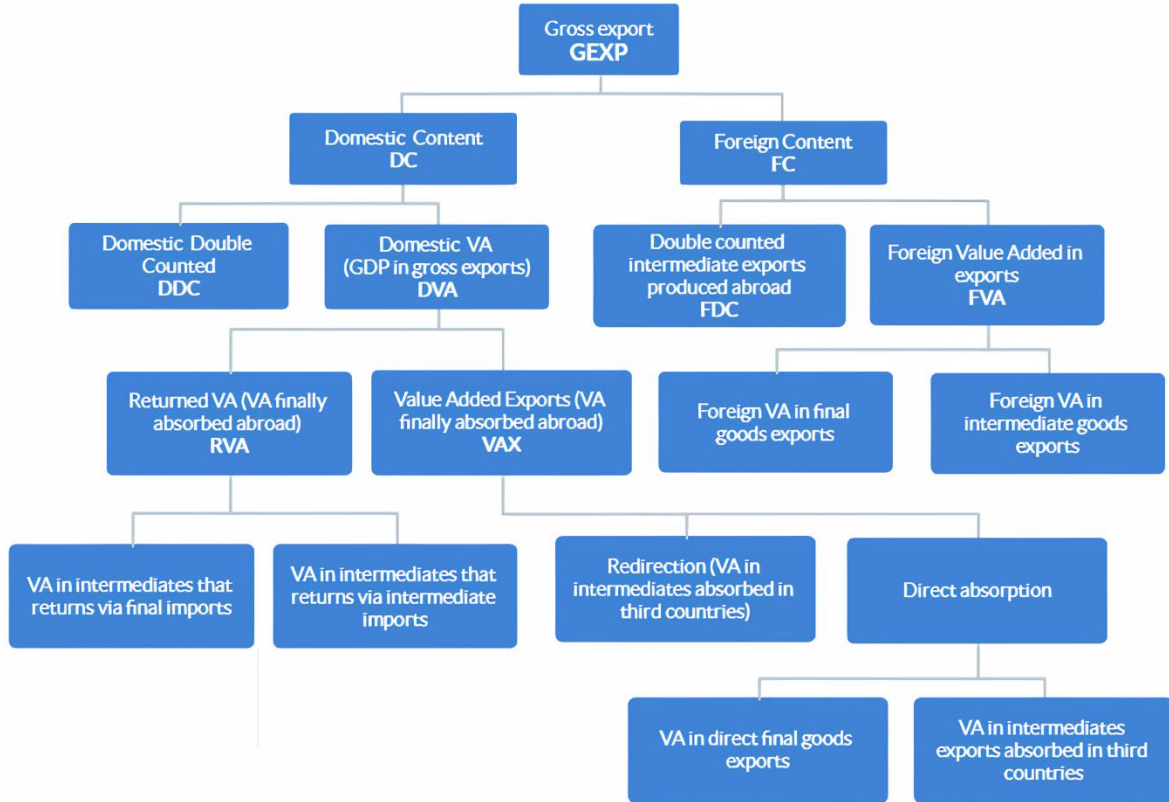
$$Backward\ GVC_{ijk} = Pure\ Backward\ GVC_{ijk} + Two_sided\ GVC_{ijk} \quad (2)$$

Where the *GVC – related trade*_{ijk} between exporter *i* and importer *j* in sector *k* can be decomposed into “backward” and “forward” components. The *Backward GVC*_{ijk} participation corresponds to the sum of “*Pure Backward GVC*_{ijk}” and “*Two_sided GVC*_{ijk}”. *Pure Backward GVC*_{ijk} is the value of goods and services produced with imported inputs and exported by sector *k* of country *i* to the final destination market, where the exporting sector is engaged in GVC activities at the end of the chain.

² For more technical details on the decomposition, see Borin and Mancini (2019).

³ Note that Borin and Mancini (2019) defines traditional trade as the value of goods and services that crosses just one border, that is, the exports whose value is entirely originated at the domestic level.

Figure 1: Borin and Mancini refinement of the Koopman, Wang, and Wei breakdown of aggregate exports



Source: Author representation based on Borin and Mancini (2016).

Two_sided GVC $_{ijk}$ is the value of goods produced with imported inputs, exported by the sector k of country i to partners, which, in turn, re-exports it to other markets; here, the exporting sector k is situated in a position of the chain that is more central. More generally, *Backward GVC* $_{ijk}$ corresponds to the value of import content in country i 's exports towards importer j (in sector k), and it is analogous to the Vertical Specialization Index (VS) proposed in Hummels et al. (2001)⁴.

On the other hand, *Forward GVC* $_{ijk}$ (or “pure forward GVC related-trade”) is the value-added in goods entirely generated within the domestic chains of country i – that is, without any border crossing – exported by the sector k to partner j , which, in turn, re-exports it to other markets. In this case, the exporting sector is engaged in GVC activities at the origin of the chain. In other words, measures of forward GVC trade are calculated by aggregating the content of a country’s domestic production assimilated in other countries’ exports and, it

⁴ For the equivalence between the backward GVCs participation and the ‘import content of exports’ in Hummels et al. (2001), see Borin and Mancini (2019), Appendix C. For more information on the GVC-related measures, see the data user guide available in the [WITS portal](#).

can be considered the first correct implementation of the VS1 index suggested by Hummels et al. (2001)⁵.

As highlighted in Borin and Mancini (2019), *Forward GVC_{ijk}* differs from the version of the VS1 Indicator proposed by Koopman et al. (2014). Indeed, while the VS1 Index is constructed by aggregating the content of a country's production embedded in other countries' exports, the *Forward GVC_{ijk}* index is a portion of country *i*'s exports (like the VS index). However, this is not necessarily true for the measure proposed by Koopman et al. (2014). To provide an instance, suppose that a particular intermediate component exported by a country *i* later undergoes other processing stages in different countries; the original component will be double-counted several times in the summation of country *i*'s content in other countries' exports. The difference between the original value of goods exported by *i* and the corresponding amount that enters in the Koopman et al. (2014) indicator rise with the relative upstreamness of country *i*'s production. Finally, *GVC – related trade_{ijk}* presents three desirable features. First, once expressed as a share of gross trade, it is bounded between 0 and 1. Second, it is additive at any degree of aggregation and disaggregation of trade flows; hence data can be summed at any level to obtain the proper GVC participation measures at the desired level of aggregation⁶. Third, GVC-related trade and its backward and forward components can be considered proxies for a country's positioning in GVCs (Borin et al., 2020).

3.2 Non-tariff measures data collection

While the scarcity of comparable data has long hampered empirical work on the effect of NTMs, since 2011, the UNCTAD, in collaboration with several other agencies, has assembled an extensive database of NTMs, namely the TRAINS-NTMs. This global database contains detailed and comprehensive data on NTMs obtained from researchers working systematically through all laws and regulations that may affect merchandise trade in a particular country. To include NTMs measures in this study, I use the latest researcher file (v12) of the UNCTAD database, which presents collected NTMs for 92 reporters against 234

⁵ To sum up, the forward linkage represents the seller-related measure or supply-side in the GVC participation index, while the backward linkage shows the buyer's perspective or the sourcing side in GVCs.

⁶ For example, GVC-related trade measures can be aggregated at total country exports level, at world (sector) exports level, at country groups level, et cetera.

Figure 2: UNCTAD–MAST Classification of Non-Tariff Measures

Import-related measures	Technical measures	A	Sanitary and Phytosanitary (SPS) measures
		B	Technical barriers to trade (TBT)
		C	Pre-shipment inspections and other formalities
	Non-technical measures	D	Contingent trade-protective measures
		E	Non-automatic licensing, quotas, prohibitions, and quantity-control measures
		F	Price-control measures, including additional taxes and charges
		G	Finance measures
		H	Measures affecting competition
		I	Trade-related investment measures
		J	Distribution restrictions
		K	Restrictions on post-sales services
		L	Subsidies (excl. export subsidies)
		M	Government procurement restrictions
		N	Intellectual property
		O	Rules of origin
Export-related measures	P	Export-related measures	

Source: UNCTAD (2017)

trade partners, covering 5771 products over more than a century timespan. These measures are set within a common classification framework, and they are assigned to tariff lines within the World Customs Organization's Harmonized System (HS). The policies covered by NTMs and their nomenclature are illustrated at their broadest in Figure 2. The data cover more than

90 percent of world trade and more than 100 countries (UNCTAD, 2017). All data is published online and is available through several web-portals⁷.

Overall, UNCTAD–MAST Classification consists of 16 chapters (A to P). Chapters A to O concern import-related NTMs, whereas chapter P covers measures that countries impose on their exports. Another fundamental distinction is between technical measures (chapters A, B, and C) and non-technical measures (chapters D to O). Technical measures to trade have objectives that are not primarily trade-related, such as protecting human and animal health, but have trade impacts nonetheless. On the contrary, non-technical measures have purposes and mechanisms that discriminate against foreign producers. These can be considered non-tariff barriers as distinct from non-tariff measures. Following the main approach presented by the literature (Inui et al. 2021; Peters and Cadot 2019; Dolabella, 2020; and Franssen and Solleder 2016), this article focus on SPS and TBT measures, for which there are 72 distinct types in the NTM classification. The distribution of SPS and TBT measures is highly concentrated in all countries, and, among all the NTMs types, they are the only ones for which a harmonization would lead to higher levels of trade and GVCs participation.

3.3 Regulatory distance indicator

Following Cadot et al. (2015), I measure the distance in regulatory patterns as the difference between the structures in which two countries impose NTMs, classified according to the UNCTAD-MAST nomenclature, across products. More specifically, I look at whether two countries apply the same NTM types to the same products in a given year. Borrowing an instance provided in Cadot et al. (2015), suppose that the country i imposes NTM B840 (TBT inspection requirements) on the product HS 840731 (spark ignition reciprocating piston engines of a type used for the propulsion of vehicles of a cylinder capacity not >50cc). If the country j also applies B840 on HS840731, countries i and j have a “similar” regulatory structure for the given measure-product pair, and the regulatory distance is zero. By contrast, if country j does not impose B840 on that product and implements either no NTM or instead, say, B810 (i.e., product registration requirements), countries i and j are considered as “different” for that particular measure-product pair and the regulatory distance variable takes the value of one. Formally, the distance in regulatory structure or, more simply, “regulatory distance” can be expressed and aggregate as follows. The specific NTM type (l) imposed by

⁷ UNCTAD–ERIA asean.i-tip.org, UNCTAD’s TRAINS portal trains.unctad.org; and World Bank WITS platform at wits.worldbank.org;

an importing country (j) to a specific product (k) coming from an exporting country (i) in a given year (t) is defined as a “dummy” variable⁸:

$$n_{jikt}^l = \left\{ \begin{array}{l} 1, \text{ if country } j \text{ applies NTM type } l \text{ to product } k \text{ from origin } i \text{ in year } t \\ 0, \text{ if no such NTM is applied} \end{array} \right\} \quad (3)$$

The regulatory distance measure (RD) at the measure-product level in year t is then:

$$RD_{lkt} = |n_{jikt}^l - n_{ijkt}^l| \quad (4)$$

If both countries implement the same measure to a particular product, the regulatory distance is 0; if they do not, the equation yields 1. To inspect regulatory patterns, I then aggregate the regulatory distance variable over all measures and all products to get an overall measure of dissimilarity. Formalizing the definition again, I estimate the distance in regulatory structures between countries i and j in year t , RD_{jit} , using the following equation:

$$RD_{jit} = \frac{1}{N} \sum_k^K \sum_l^L |n_{jikt}^l - n_{ijkt}^l| \quad (5)$$

Where N is the total number of product-NTM combinations, L is the number of all different NTM types that I aggregate, and K the number of different products over which the average is built.⁹ In its entirety, RD_{jit} corresponds to the sum of the absolute values of the differences in NTMs application. Instead, as an individual term, RD_{lkt} is either zero (when both i and j apply a given NTM to the same product) or one (when one of the two trade partners imposes a measure that the other does not to a given product). Because the total amount of product-NTM combinations normalizes the regulatory distance, the RD index lies between zero and one, and it is typically a small number. It is essential to point out that this index does not tell how much two countries are regulated; instead, it only measures relative positions of similarity. Remarkably, the approach is highly flexible, and the regulatory distance can be disaggregated to a product or sector level. Indeed, comparisons can be made between two or more countries, or entire RTAs or regional groups can be benchmarked against each other.

⁸ In some instances, an importer applies several different regulations classified under the same NTM code (for example, two different certificates – a health certificate and a veterinary certificate). In such cases, only a “1” is still counted for this importer–product–NTM combination.

⁹ L refers to the total of all 72 possible SPS and TBT measure types; K refers to all unweighted products in the respective sectors (all products, agriculture, mining, and manufacturing).

The index can also address specific groups of NTMs only (Cadot et al., 2015). For this study, I compute the yearly bilateral regulatory distance for each trade-partners pair separately, focusing on SPS and TBT measures.

Data for this variable present a considerable number of missing values. More precisely, we see missing observations for all European Union countries for 2005, 2006, 2007, 2008, and 2011 and South Korea from 2005 to 2009. Given the pattern they present, I opt for a linear interpolation to impute missing values. This algorithm finds the value y at x by detecting the closest points (x_0, y_0) and (x_1, y_1) , such that $x_1 > x$ and $x_0 < x$ where y_0 and y_1 are observed and calculating:

$$y = \frac{y_1 - y_0}{x_1 - x_0} (x - x_0) + y_0 \quad (6)$$

When (x_1, y_1) and (x_0, y_0) cannot be found on both sides of x , the same formula applies to the two closest points on the same side of x . As shown in Table A 4 in the Appendix, the missing values for the RD index drop drastically from 23.92% to 0.11% after performing linear interpolation.

3.4 Other data and variables for gravity analysis

In addition to the RD indicator, which is a trade flow direction-specific variable, I also gather data that account for international trade costs. These data mainly come from the Centre d'Études Prospectives et d'Informations Internationales (CEPII) Gravity database, the TRAINS database through the WITS portal, and the World Bank database. The CEPII Gravity database provides a large set of data typically used in structural gravity analysis for any country pair existing between 1948 and 2019. These variables include information on geographical distance, including distances that reflect the within-country spatial distribution of activity; dummy variables on trade facilitation measures, such as GATT/WTO membership, the existence of regional trade agreements and nature of these agreements; as well as dummy variables on cultural proximity such as language, religion, origins of the legal system, colonial ties, et cetera. To account for bilateral, sectoral-specific trade costs, I also gather data on the bilateral Effectively Applied Tariffs from the UNCTAD TRAINS database. The applied tariffs rate is based on Revision 3 of the International Standard Industrial Classification (ISIC 3), and they are aggregated at the two-digit level for a total of 35 sectors. This study also relies on measures of national income per person, or GNI per capita,

calculated using the World Bank Atlas method. GNI per capita is measured in current US dollars, and data for this variable are retrieved from the World Bank Database.

In order to properly merge applied tariff rates with the rest of the data, some adjustment is needed. Firstly, the former suffers from a relevant share of missing values (approximately 53 percent). Instead of carrying an imputation based on an econometric approach, I treat them as follows. For all importer-exporter pairs belonging to the European Union, I replace bilateral tariffs equal to 0. Then, for all EU importers, I replace their applied tariffs equal to that of the European Union as a whole towards the specific extra-EU exporter. This approach is justified by the fact that there are no tariffs or non-tariff barriers between members of the customs union and, differently from a free-trade area, members of the customs union impose a common external tariff scheme on all products entering the union (Erskine, 2006). Finally, I replace the remaining missing values with the weighted average most-favored-nation (MFN) tariffs rate¹⁰.

Secondly, data on GVCs participation and tariffs are based on two different sector-classifications, TiVA and ISIC revision 3, respectively. Therefore, a harmonization to a common classification is needed to merge them. Based on the “concordance” package provided by Liao et al. (2020), I harmonize applied tariffs from ISIC Revision 3 to ISIC Revision 4. Then, following the guidelines provided in the TiVA indicators guide, I match the sectors from ISIC Revision 4 to TiVA Classification. Table A3 and Table A4 in the Appendix provide descriptive statistics and display the number and proportion of missing values for each of the variables used in this research.

4. Gravity model and identification strategy

In this section, I first introduce the intuition and the theoretical foundations behind the structural gravity model. Then, I present the identification strategy implemented to assess the effect of heterogeneity in NTMs patterns on countries’ GVC-related trade measures. Based on Yotov et al. (2016), I estimate a structural gravity equation and extend it to the sector level as proposed by Kinzius et al. (2019).

¹⁰ Data on weighted mean most favored nations tariff rate are gathered from the World Bank database.

4.1 Structural gravity model: intuitions and theoretical foundations

Based upon an analogy with Newton's law of gravitation, the gravity equation applied to international trade is one of the most known empirical relationships in economics. In its most basic version, the gravity equation implies that, just as bodies are reciprocally attracted in proportion to their sizes and distance, countries trade in proportion to their respective market size (i.e., GDP) and the distance between them. Put more formally, we can write the intuitive gravity equation as follows:

$$\log X_{ij} = \alpha + \beta_1 \log GDP_i + \beta_2 \log GDP_j + \beta_3 \log \tau_{ij} + \varepsilon_{ij} \quad (7)$$

where X_{ij} indicates exports from exporter i to importer j , and GDP represents each country's gross domestic product. τ_{ij} identifies trade costs between the two countries and, in the intuitive gravity model, it is proxied by the geographical distance between them as an observable proxy for trade costs. ε_{ij} is a random error term. The α term is a regression constant, and the β terms are coefficients to be estimated. Intuitively, we expect larger countries to trade more but also countries that are further apart to trade less because transport costs between them are higher (Shepherd et al., 2019). However, the intuitive gravity model is not free of shortcomings once more advanced concepts from the trade literature are introduced. For instance, it does not take into account the concepts of trade creation and trade diversion, as well as it does not consider equal decreases in trade costs across all routes, including domestic trade, but only changes in relative prices (Bacchetta et al., 2012).

To overcome these limitations, the applied literature has proposed several alterations to the basic gravity model. Significant in this sense is the seminal contribution of Anderson and van Wincoop (2003), where the authors show that controlling for relative trade costs is crucial for a well-specified gravity model. In its essence, the Anderson and Van Wincoop (2003) gravity model is a demand function in which consumers have “love of variety” preferences. Following Krugman (1979) on the production side, the model assumes that each firm produces a unique product variety under increasing returns to scale, and a producer in one country can sell goods in any country. Once we appropriately perform the aggregation, it is possible to derive the “gravity with gravitas” model as follows (Shepherd et al., 2019):

$$\log X_{ij}^k = \log Y_i^k + \log E_j^k - \log Y^k + (1 - \sigma_k)[\log \tau_{ij}^k - \log \Pi_i^k - \log P_j^k] \quad (8a)$$

$$\Pi_i^k = \sum_{j=1}^c \left\{ \frac{\tau_{ij}^k}{P_j^k} \right\}^{1-\sigma_k} \frac{E_j^k}{Y^k} \quad (8b)$$

$$P_j^k = \sum_{i=1}^c \left\{ \frac{\tau_{ij}^k}{\Pi_i^k} \right\}^{1-\sigma_k} \frac{Y_i^k}{Y^k} \quad (8c)$$

where X_{ij}^k is exports indexed over trade partners (i and j) and sectors (k), Y is GDP, E_j^k is expenditure in importer j (which is not necessarily the same as GDP at the sector level), $Y^k = \sum_{i=1}^c Y_i^k$ corresponds to the world GDP, τ_{ij}^k is trade costs and σ_k is the intra-sectoral elasticity of substitution (between varieties).

The first notable characteristic of the Anderson and Van Wincoop (2003) gravity model is the inclusion of two additional parameters, Π_i^k , and P_j^k , called multilateral resistance terms (MRT). The authors refer to the first term as “outward multilateral resistance”, and it essentially encompasses the fact that exports from exporter i to importer j depend upon trade costs across all potential export markets. The second term is called “inward multilateral resistance”, and it similarly captures the dependence of imports into country j from country i on trade costs across all possible suppliers. Together, these variables are the key to the model, and they resolve the issues previously identified as problems with the intuitive gravity. In other words, this model takes into consideration the fact that changes in trade cost on one bilateral route can affect trade flows on all other routes because of relative price effects. Since the intuitive model does not include these two multilateral resistance terms, but they are, by construction, correlated with trade costs, there is an acknowledged case of omitted variables bias in the intuitive model. This issue is particularly relevant when we move from cross-sectional to panel data and, therefore, account for time factors.

In this context, a milestone contribution in deriving a theoretically founded gravity equation has been provided by Baldwin and Taglioni (2006). In their seminal work, the authors identify three major errors in the traditional approach of estimating gravity equations: the gold, silver, and bronze medal mistakes, respectively. The gold mistake refers to the incorrect control for the multilateral resistance terms. Indeed, P_j^k and Π_i^k are theoretical constructs, and, as a result, they are not directly observable. Several authors tried to account for the MRT by including a large set of dummy variables or proxies for the “remoteness index”; however, this approach has been proved to lead to consistent bias (Head and Mayer 2014). By contrast, Olivero and Yotov (2012) demonstrate that the multilateral resistance

terms should be accounted for by including importer-time and exporter-time fixed effects in a dynamic gravity estimation framework with panel data. It should be noted that in addition to accounting for the unobservable multilateral resistance terms, the importer-time and exporter-time fixed effects will also absorb the size variables (E_{jt} and Y_{it}) from the structural gravity model. Similarly, they will also account for all other observable and unobservable country-specific characteristics, which vary across these dimensions, including institutions, various national policies, and exchange rates (Yotov et al., 2016).

The silver medal mistake refers to averaging the reciprocal trade flows. From a theoretical point of view, the structural gravity model suggests that trade should preferably be treated separately each way (exports from i to j at time t being one observation, and exports from j to i at time t another). Finally, the bronze medal mistake refers to the inappropriate deflation of trade flows, typically by the US aggregate price index. Since the gravity equation is an expenditure function allocating nominal GDP into nominal imports, inappropriate deflation would probably create biases via spurious correlations. However, as Bacchetta et al. (2012) highlight, the time dummies or country fixed effects take this into account.

4.2 Estimation strategy

In this sub-section, I present the econometric strategy I execute to assess the impact of bilateral regulatory distance in non-tariff measures on total, backward and forward GVC-related trade. This study uses a structural gravity equation and extends it to the sector level, as suggested by Kinzius et al. (2019) and Yotov et al. (2016). Then, following the seminal work of Santos Silva and Tenreyro (2006), I opt for the fixed effects Poisson Pseudo Maximum Likelihood (PPML) estimator¹¹. Indeed, there are several reasons to prefer this estimator over the others proposed in the literature. Firstly, in the presence of heteroscedasticity, the parameters of log-linearized models estimated by OLS lead to biased estimates of the actual elasticities, distorting the interpretation of the model. These biases might be critical for the comparative assessment of economic theories and the evaluation of the effects of different policies (which is the aim of this study as well). By contrast, the PPML estimator is robust to the different patterns of heteroscedasticity.

The second source of concern rises from the high quantity of zeros typically present in trade data. Over the years, the trade literature has proposed several techniques to deal with this problem. Among others, the exclusion of $Trade_{ij} = 0$ from the dataset or the arbitrary

¹¹ The model is estimated in the statistical software Stata using the command “ppmlhdf” (Correia et al. 2020).

substitutions of small numbers with zeros such as \$1,000 or the minimum unit. However, these procedures will generally lead to inconsistent estimators of the parameters of interest¹². By contrast, the employment of the PPML estimator represents an effective and convenient solution to the presence of zero trade flows since it allows to estimate the gravity model in its multiplicative form instead of the logarithmic form (Santos Silva and Tenreyro, 2006).

Equation (9) presents the baseline specification, which is an adaption of the traditional gravity model in its multiplicative version to match with the framework of this study:

$$GVC_{ijt}^k = \exp[\beta_0 + \beta_1 \ln(1 + RD_{ijt-1}) + \beta_2 \ln(1 + Tariff_{ijt-1}^k) + \beta_3 RTA_{ijt-1} + \beta_4 \ln(Dist_{ij}) + \theta_{ij} + \delta_{it}^k + \gamma_{jt}^k] \varepsilon_{ijt}^k \quad (9)$$

Where GVC_{ijt}^k refers to either total, backward, or forward GVC-related trade (measured in millions of USD) between exporter i in industry k and importer j in year t . RD_{ijt-1} identifies the regulatory distance between countries i and j in year $t - 1$. $Tariff_{ijt-1}^k$ consists of the average effectively applied tariffs rate imposed from country j to country i in sector k in year $t - 1$. RTA_{ijt-1} is a dummy variable equal to 1 if trade partners i and j are part of a regional trade agreement in year $t - 1$, 0 otherwise; $\ln(Dist_{ij})$ is the log of the population-weighted distance between the two most populated cities (in km) of countries i and j . θ_{ij} corresponds to a set of time-invariant variables (mostly dummy variables) typically employed in gravity models indicating contiguity, common language (official and second languages), colonial ties (direct and indirect links), common legal origins (post-1991), whether common legal origin changed in 1991, and the religious proximity. δ_{it}^k and γ_{jt}^k are exporter-sector-time and importer-sector-time fixed effects, respectively. ε_{ijt}^k is the stochastic error term.

Some aspects of the underlying model specification deserve a more in-depth explanation. Following Yotov et al. (2016), Kinzius et al. (2019), and Dolabella (2020), all trade policy variables¹³ are lagged by one year for three reasons: firstly, by using annual trade data, the analysis cannot control the exact date of implementation of each policy. Therefore, if we consider, for instance, tariffs and NTMs without lagging, the estimates might be biased

¹² Excluding observations in which trade equals zero leads to a sample-selection problem since very small countries would be inevitably left out from the dataset. Similarly, the arbitrary substitution of zeros with small amounts leads to results that depend on the units of measurement, and as a consequence, the interpretation of the gravity coefficients as elasticities are lost. Frankel (1997) and Yotov et al. (2016) provide a more comprehensive description of the major approaches to dealing with trade zeros and the corresponding drawbacks.

¹³ i.e., the RD index, the tariff rate variable, and the variable RTA.

towards zero, resulting in an underestimation of the potentially adverse effect¹⁴. Secondly, as argued in Ghodsi et al.(2017), it is reasonable to assume that intermediate goods do react with a delay to changes in trade costs. For this reason, using lags ensures that we account for adjustments in trade flows, which do follow only after some time of adaptation. Thirdly, a widely-known challenge in the gravity model is to properly account for the endogeneity in trade policies variables because they may correlate with unobservable cross-sectional trade costs (Yotov et al., 2016). For instance, the RTA_{ij} variable may suffer from “reverse causality” because, ceteris paribus, a given country is more likely to liberalize its trade towards a trade partner with which has a solid economic integration. Although the regulatory distance indicator is less likely to suffer from endogeneity and reverse causality (Franssen and Solleder 2016), this issue persists for the variables $Tariff_{ij}^k$ and RTA_{ij} . Therefore, following Allard et al. (2016), Tinta (2017), Ghodsi et al.(2017), and Dolabella (2019), I take the lagged values of trade policies variables in order to lessen this problem. Moreover, as suggested in Kinzius et al. (2019), since the practice of including lagged trade policies variables is not standard in the trade literature, contemporaneous values are used instead as a robustness check, yielding similar results.

Modeling the gravity equation explicitly with tariffs avoids omitted variable bias since, as shown by Cheng et al. (2015), tariffs negatively impact GVC trade. Moreover, I include tariffs and the RD indicator in logarithm forms, $\ln(1 + RD_{ijt-1})$ and $\ln(1 + Tariff_{ijt-1}^k)$, so that β_1 and β_2 provide a direct estimate of the trade elasticities for these two variables, and their trade effect can be directly compared. Then, based on Yotov et al. (2016), for each of the specifications presented in this study, I translate the effect of the RD measures into ad-valorem tariff equivalent effects (AVEs), i.e., the ad-valorem tariff rate whose introduction would have generated the same impact as the regulatory distance in question. Equation (10) formalizes the AVE estimation for the bilateral RD variable:

$$AVE_{RD} = \left[e^{\hat{\beta}_{RD}/\hat{\beta}_{Tariff}} - 1 \right] \times 100 \quad (10)$$

Where $\hat{\beta}_{RD}$ and $\hat{\beta}_{Tariff}$ are the estimated coefficients associated with variables RD and Tariffs specified in equation Eq. (9), respectively.

¹⁴ The same reasoning also applies to the regional trade agreements variable, although in this case, we would see an underestimation of the positive treatment effects instead.

As introduced in Section 4.1, one primary concern when estimating the gravity equation is to properly account for multilateral resistance terms. I do so by including importer-sector-year and exporter-sector-year fixed effects (Head and Mayer 2014; Yotov et al. 2016). These directional fixed effects absorb not only multilateral resistances but also all economic size terms, like production and expenditures. For instance, these sets of fixed effects control for differences across countries in the expenditure of domestic consumers and differences in economic size, which is an important determinant of importers' market access. They also absorb changes in productivity that are sector-specific and vary over time, such as a new production technology adopted in a specific country. Finally, these sets of fixed effects control also for time-invariant country-product characteristics.

Given this identification, we can interpret the estimated coefficient of the RD index as the average percent change in bilateral-sectoral-yearly GVC-related trade from exporter i in sector k to importer j caused by the increase of one point percent in the bilateral regulatory distance (in year $t - 1$). This interpretation remains valid for the coefficients of all logged regressors, which are elasticities and do not need a transformation to be interpreted. For regressors not in logs (i.e., dummy variables and the Religion Proximity Index), the following formula yields the semi-elasticity: $\% \text{ change} = (e^{\hat{\beta}_x} - 1) \times 100$; where $\hat{\beta}_x$ is the coefficient of the not logged variable X . This is negative for negative betas and positive for positive betas. Moreover, it approximately equals $100 \times (\hat{\beta}_x) \%$ for betas close to zero.

5. Empirical results

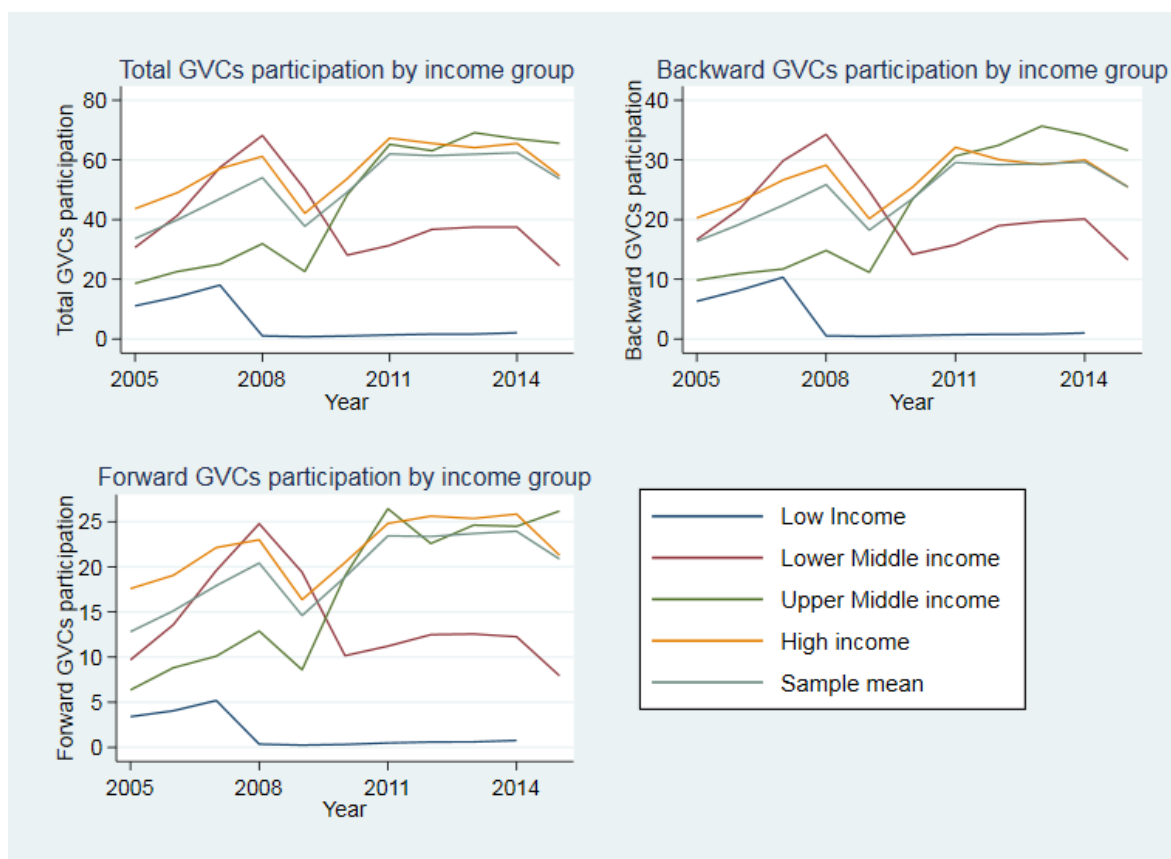
This section begins with a preliminary data observation of GVC-related trade measures and regulatory distance by exporter-income groups. Then, I will present the results from the structural gravity model baseline.

5.1 Development of regulatory distance and GVC-trade measures

Based on the World Bank income classification, I rank exporters into four income groups: low-income (L), lower-middle income (LM), upper-middle (UM), and high-income (H) countries¹⁵. Figure 3 plots the development of total, backward and forward GVC participation by exporter income-group from 2005 to 2015. For all three measures of GVCs

¹⁵ The income classification is based on the national income per person, or GNI per capita, calculated using the World bank [Atlas method](#). To provide a benchmark, for the year 2010, low-income countries are defined as

Figure 3: Evolution of total, backward, and forward GVCs participation per income-group



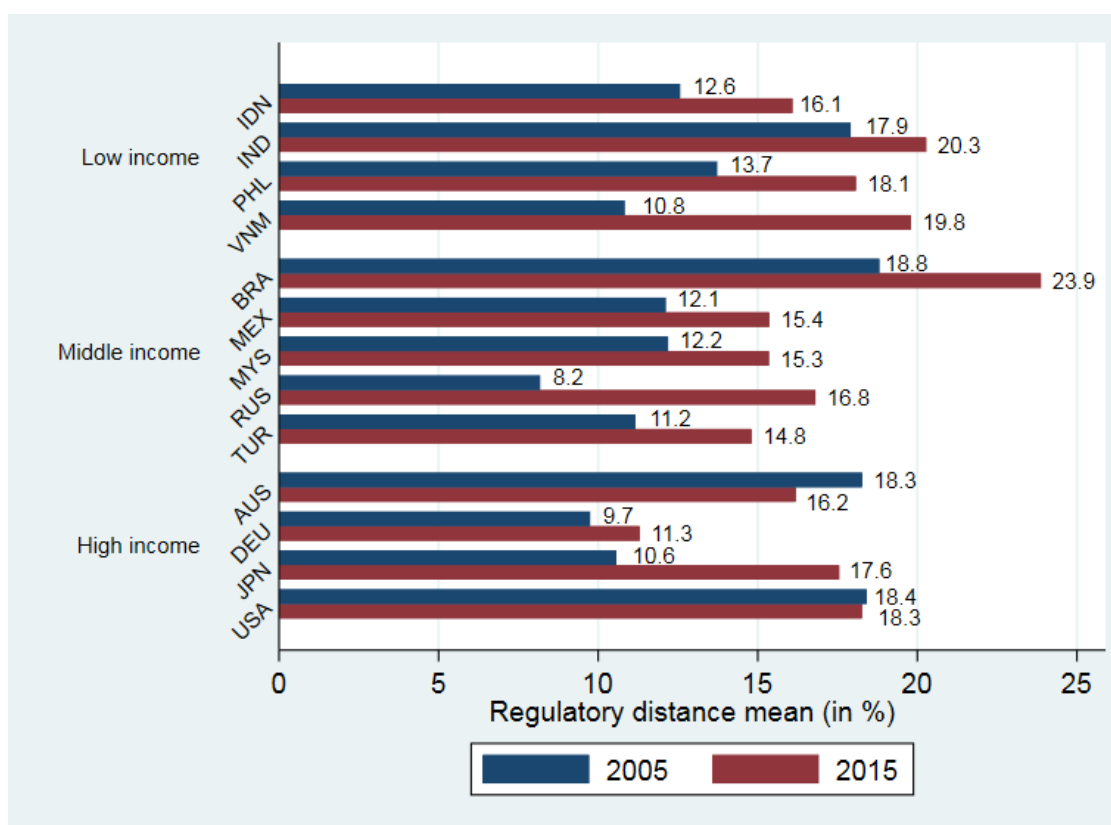
Notes: bilateral GVCs measures are averaged by exporter income groups with respect to all the trade partners. GVC-related trade indicators are measured in millions of USD. The timespan takes into account the years from 2005 to 2015. Source: Author's calculation.

participation, high-income exporters enjoyed a higher integration in value chains in 2005. In 2008, the global financial crisis worldwide hit the participation in international value chains, although we see remarkable differences in the magnitude across exporter-income groups. Indeed, for all three GVC-related trade measures, the lower-middle-income countries were those who more heavily suffered in terms of GVC trade, contrary to upper-middle-income exporters, for which GVC-trade measures sharply rose after 2008. Finally, considering the most recent years, upper-middle-income countries gained a larger share of GVCs participation, not only with respect to the lower-income but also developed economies.

Considering the regulatory distance in NTMs, Figure 4 shows the degree of heterogeneity in technical measures for some selected economies by income groups in 2005

those with a GNI per capita of \$1,005 or less in 2010; lower-middle-income countries are those with a GNI per capita between \$1,005 and \$3,975; upper-middle-income economies are those between \$3,975 and \$12,275; high-income economies are those with a GNI per capita of \$12,275 or more.

Figure 4: Evolution of regulatory distance for selected exporters



Notes: the bilateral regulatory distance is averaged among all the trade partners for the above-presented countries. Following the [World Bank's Income Classification](#), the low-income group includes the low- and low-middle income groups; middle-income corresponds to the upper-middle income group, and high-income corresponds to the high-income group. Exporters are classified by GNI per capita, computed following the World Bank Atlas method. Source: Author's calculation.

and 2015. Overall, the figure shows how regulatory distance has increased more for developing economies than for high-income countries. This fact should not be surprising for at least two reasons. Firstly, in parallel with the increase in living standards, developing economies also raise the quality standards of both intermediate and final goods, and, in the absence of trade agreement, the heterogeneity with respect to their trade partners as well. In other words, there exists a positive correlation between the level of development and regulatory heterogeneity in trade policies (Franssen and Solleder, 2016). Secondly, harmonization of new standards in trade is more likely to occur in high-income countries where firms may have more substantial financial bases to comply with the foreign NTMs policies. Figure A1, which shows the development in RD per income group, seems to confirm this intuition. Indeed, we see that low-income exporters experience, on average, the highest values of regulatory distance, while high-income exporters have the lowest. Annex B provides

additional gravity analysis on the association between the effect of regulatory distance and the exporters' and the importers' income levels.

5.2 Gravity estimation results

Baseline estimation results from Eq. (9) are reported in Table 1. Columns (1) to (3) present the gravity model results on total, backward, and forward GVC-related trade, for all sectors. According to the specification in column (1), the bilateral total GVC-related trade from exporter i to importer j decreases on average by 5.2% following the rise of 1% in the bilateral regulatory distance in year $t - 1$. This effect is significant at the 1% level. The average ad-valorem tariffs equivalent effect (AVE) of the RD index amounts to 36.92%, meaning that the average regulatory distance in question would generate the same impact as a tariff rate of 36.92%. The effect of the Tariff variable is remarkably higher than that of the RD index. Indeed, an increase of 1% in tariffs in importer j in year $t - 1$ would cause an average drop of 16.5% of total GVC participation in bilateral exports of country i to the importing economy j . Also, for this variable, the effect is significant at the 1% level. Particularly relevant in this context is the establishment of a regional trade agreement. With a coefficient statistically significant at a 1% level, membership in an RTA in year $t - 1$ would augment the total GVC trade of roughly 11.40%.

Despite a long-term dropping in transportation costs, distance and contiguity still remain influential factors in value chain integration. While a 1% increase in (population-weighted) distance between the two most populated cities is associated with an 81% decrease in the dependent variable, contiguity between two countries increases on average the integration in the value chain of country i by approximately 35%. Finally, cultural factors also play a role in this context. Indeed, both common language and common legal origins have a positive and statistically significant effect on the total GVC-related trade.

In columns (2), I conduct the analysis on the backward GVC indicator, namely, on the import content of exports of country i to country j (in sector k). Interestingly, regulatory distance has a more substantial impact on the backward linkages of exports than on the total GVC-related trade. Indeed, one point percent increase in bilateral regulatory distance in year $t - 1$ is associated with a 6.3% fall in the backward participation of exports of country i , while the ad-valorem tariff equivalent is 96.31%. The effect is statistically significant at the 1% level. On the contrary, the estimated elasticity for the variable Tariff is lower than the previous specification ($- 0.093$) but still highly significant (s.e. = 0.02). Again, RTA,

Table 1: baseline: the effect of regulatory distance on countries GVC-related trade

Sectors considered	All sectors			Manufacturing		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Overall GVCp	Backward GVCp	Forward GVCp	Overall GVCp	Backward GVCp	Forward GVCp
ln(1 + RD)	-.052*** (.016)	-.063*** (.017)	-.043** (.021)	-.083*** (.015)	-.071*** (.017)	-.103*** (.018)
ln(1 + tariff)	-.165*** (.02)	-.093*** (.02)	-.266*** (.027)	-.095*** (.019)	-.07*** (.021)	-.141*** (.021)
RTA	.108*** (.036)	.191*** (.036)	.045 (.05)	.149*** (.036)	.209*** (.037)	.117** (.048)
Log Distance	-.809*** (.022)	-.814*** (.023)	-.805*** (.027)	-.774*** (.021)	-.802*** (.024)	-.729*** (.024)
Contiguity	.3*** (.029)	.27*** (.033)	.337*** (.035)	.288*** (.029)	.256*** (.034)	.33*** (.029)
Common-language	.144*** (.037)	.149*** (.037)	.138*** (.049)	.143*** (.038)	.152*** (.038)	.126*** (.047)
Common colonizer	-.234** (.116)	.15 (.093)	-.466*** (.163)	-.185 (.116)	.135 (.096)	-.4** (.164)
Religion proximity index	-.033 (.055)	-.108* (.057)	.059 (.077)	-.06 (.053)	-.098* (.058)	-.009 (.057)
Colonial-tie	.073 (.087)	.071 (.09)	.013 (.108)	.07 (.089)	.056 (.092)	.029 (.106)
Common legal origin	.263*** (.024)	.258*** (.026)	.286*** (.031)	.252*** (.024)	.256*** (.027)	.26*** (.026)
Legal origin changed	-.102** (.04)	-.136*** (.042)	-.108** (.053)	-.12*** (.038)	-.144*** (.043)	-.144*** (.043)
Same colonizer	-.106 (.08)	-.117 (.076)	-.153 (.108)	-.029 (.079)	-.094 (.078)	.031 (.095)
_cons	12.942*** (.178)	12.429*** (.194)	12.229*** (.234)	12.647*** (.177)	12.387*** (.199)	11.397*** (.205)
Pseudo R ²	.914	.92	.912	.92	.92	.922
RESET Test	0.348	0.644	0.152	0.045	0.539	0.745
AVE _{RD}	36.92	96.31	17.72	139.70	176.36	108.38

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer–sector level. Variables for RD, tariffs, and RTA are lagged by one year. All regressions include exporter–sector–year and importer–sector–year fixed effects. Standard errors are in parentheses. *Significance levels:* *** $p < .01$, ** $p < .05$, * $p < .1$

and common language present positive and statistically significant coefficients at the 1% level.

Column (3) presents the results on pure forward GVC related-trade, that is, the domestic value-added re-exported by the trade partner(s). Among the three dimensions of bilateral-sectoral trade, the forward linkages are those less affected by the bilateral dissimilarity in NTMs structures. Indeed, the elasticity of the RD index in year $t - 1$ is just -0.043 (s.e. = 0.021), with an associated AVE of 17.72%. On the other hand, tariffs seem to

matter most on the forward GVC participation in exports, where an increase of one unit percent in duties is related to a drop of 26.6% of the forward participation in exports. This fact should not be surprising. Indeed, the trade of intermediate goods can magnify the impact of tariffs on the economy, even more if they are at the origin of international multistage production (Antràs and De Gortari, 2020). Interestingly, the variable RTA shows a positive but not statistically significant coefficient, while the coefficients of other cultural, political, and distance-related variables are in line with those in columns (1) and (2).

In columns (4) to (6), I repeat the analysis considering only the manufacturing sectors¹⁶. Restricting the sample to specific sectors enables the comparison of the RD impact on GVC-related measures among different industries. For all specifications, the estimated elasticities for RD index are higher than those in columns (1) to (3), with the highest impact on the forward GVC trade (the elasticity is -0.103 , s.e. = 0.018). Similarly, ad-valorem tariff equivalents are higher than those estimated over all sectors, with the highest AVE (176.36%) when the analysis is carried out on the backward GVC trade. Interestingly, compared to the analysis conducted over all sectors, we see lower elasticities for the variable Tariff, with coefficients ranging from -0.07 (column 5) to -0.141 (column 6). Concerning the rest of the coefficients, they are overall similar to those of specification (1) to (3) in terms of magnitude and statistical significance. Finally, to check the adequacy of the estimated models, I performed a heteroskedasticity-robust Regression Equation Specification Error Test (RESET) (Ramsey, 1969). Essentially, the RESET tests for the correct specification of the conditional expectation, which is performed by checking the significance of an additional regressor constructed as $\hat{\beta}_y^2$, where $\hat{\beta}_y$ denotes the model's fitted values. Since it tests the null hypothesis of correct model specification, the model is considered misspecified whenever this coefficient is statistically significant. The corresponding p-values are reported at the bottom of Table 1, and, overall, they confirm the proper specification of the models.

6. Robustness and sensitivity analysis

This section presents the tests that I run to measure the robustness of the baseline results and their sensitivity to different model specifications. Firstly, I run the analysis with data for the dependent variables gathered from a different data source (World Input-Output Database). Secondly, I use panel data with intervals in order to allow for adjustment in trade

¹⁶ Manufacturing sectors belong to industries from 10 to 33 according to the ISIC Revision 4 Classification. See Table A2 for more information on the specific sectors.

flows. Then, I use contemporaneous values for the trade policy variables and test the model with different lag lengths. Finally, I employ the variable RD index without imputing the missing values.

As a first robustness check, I use data for total, backward, and forward GVC-related trade gathered from the World Input-Output Database (WIOD) for 40 countries across 21 sectors from 2000 to 2014¹⁷. As Jones et al. (2016) highlight, relevant differences exist between the official statistics provided by the ICIO tables. A first source of the differences among ICIO tables arises from the specific compilation methods and assumptions used to reconcile data from different sources and cope with data availability or reliability issues. Another reason lies in the way goods and services are broken down by end-use category in the ICIO table, which affects the results obtained for Input-Output indicators and explains some discrepancies between the data sources. Differences in data coverage between ICIO tables may also be at the origin of discrepancies observed with official statistics. For example, the inclusion, or not, of re-exports or processing trade in the data may result in the differences observed, especially for economies involved in such activities like Mexico, China, or Belgium. Therefore, this first robustness check tests whether the baseline results are robust to a different methodology used to aggregate GVC-related trade measures and a different country sample.

Table 2 presents the results from the gravity model estimation. Columns (1) to (3) present the gravity model results on total, backward, and forward GVC-related trade, respectively. Column (1) shows a negative impact of bilateral regulatory distance (the elasticity equals -0.034) on total GVC-related trade. With a p-value of 0.053, this coefficient is barely above the statistical significance threshold of 5% level. For the remaining specifications (columns 2 and 3), the estimated RD index elasticities are in line in terms of sign and statistical significance with those of Table 1 but different in terms of magnitude and ad-valorem tariffs equivalents. However, this outcome should not be surprising since I estimate the model on a remarkably smaller sample. Concerning the models' specification, the RESET Ramsey Test rejects the null hypothesis of non-misspecification for the models with total and forward GVC-related trade as dependent variables. This outcome suggests that the inclusion of nonlinear functions, which can either be power terms or interaction terms, would be more advisable for these data. Despite this, the results in Table 2 demonstrate that baseline

¹⁷ Table A 5 and Table A 6 list, respectively, the sample of countries and the sample of sectors covered by this study using data from WIOD Release 2016.

Table 2: gravity model estimation with data from WIOD (2016)

Dependent variable	(1) Overall GVCp	(2) Backward GVCp	(3) Forward GVCp
ln(1 + RD)	-.034* (.018)	-.061*** (.019)	-.054** (.023)
ln(1 + tariff)	-.079*** (.021)	-.039* (.022)	-.126*** (.026)
RTA	.14*** (.048)	.216*** (.046)	.086 (.066)
Log Distance	-.906*** (.027)	-.876*** (.029)	-.927*** (.037)
Contiguity	.299*** (.032)	.324*** (.036)	.27*** (.041)
Common-language	.201*** (.043)	.176*** (.048)	.281*** (.058)
Common colonizer	1.424*** (.211)	1.411*** (.244)	1.369*** (.195)
Religion proximity index	-.012 (.064)	-.024 (.065)	-.066 (.098)
Colonial-tie	-.03 (.119)	-.144 (.13)	-.082 (.141)
Common legal origin	.307*** (.025)	.31*** (.027)	.333*** (.03)
Legal origin changed	-.068 (.043)	-.151*** (.049)	-.078 (.054)
Same colonizer	-.276** (.116)	-.225** (.099)	-.423** (.167)
_cons	13.509***	12.817***	12.966***
Observations	270128	270128	270052
Pseudo R ²	.925	.93	.92
RESET Test	0.000	0.451	0.000
AVE _{RD}	54.35	385.68	53.43

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the WIOD database, 2016 version. Variables for RD, tariffs and RTA are lagged by one year. Standard errors are clustered at the exporter–importer–sector level. All regressions include exporter–sector–year and importer–sector–year fixed effects. Standard errors are in parentheses. *Significance levels:* *** $p < .01$, ** $p < .05$, * $p < .1$

results are overall robust to different methodologies of construction of the dependent variables as well as to a different country sample.

As a second robustness check, I allow for adjustment in trade flows by using panel data with intervals instead of data pooled over consecutive years (Yotov et al., 2016). As introduced in Section 4.2, trade flows do not respond immediately to changes in trade policy. The challenge of adapting trade flows is even more pronounced in econometric specifications with fixed effects. As noted in Cheng and Wall (2005), fixed-effects estimation applied to

data pooled over consecutive years has been criticized on the grounds that dependent and independent variables cannot fully adjust in a single year. For this reason, in the baseline model (Table 1), I include trade policy variables lagged by one year. However, the literature also offers different approaches to deal with this issue. For instance, Treffer (2004) conducts gravity analysis on panel data with 3-year intervals while Anderson and Yotov (2016) opt for 4-year intervals. Moreover, Olivero and Yotov (2012) demonstrate that gravity estimates obtained with 3-year and 5-year interval trade data are overall similar, while estimations performed with panel samples pooled over consecutive years produce suspicious estimates of the trade cost elasticity parameters.

For this study, I opt for 3-year intervals (2005, 2008, 2011, and 2014) to both account for adjustment in trade flows and preserve the estimation efficiency. Since I do not use lagged variables for these three models, I deal with the issue of reverse causality by including importer-exporter-sector fixed effects. Yotov et al. (2016) and Kinzius et al. (2019) show that two major benefits are associated with using exporter–importer-sector fixed effects in gravity estimations. First, they absorb all time-invariant bilateral trade costs at the sector level, such as distance, a shared border, or specific industry linkages. Second, pair fixed effects account for the endogeneity of trade policy variables (Baier and Bergstrand, 2007). For this reason, this model specification can also be considered a further control for the endogeneity in the baseline estimation.

In Table 3, I present the results from the gravity model estimation using 3-year intervals. Columns (1) to (3) present the gravity model results on total, backward, and forward GVC-related trade, respectively. Concerning the RD index, the estimation shows positive and statistically significant coefficients at the 5% level (column 1) and 1% level (column 2), in line with the baseline results. However, the analysis on the forward linkages of exports (column 3) reveals a non-statistically significant effect of bilateral regulatory distance. Similarly, the dummy variable RTA shows non-statistically significant coefficients for all three specifications. Interestingly, the overall impact of regulatory distance is smaller on GVC-trade measures compared to the baseline. More precisely, RD index coefficients for columns (1) and (2) are, respectively, 1.8% and 0.5% smaller than those reported in Table 1. Overall the results seem to be robust for the analysis on total and backward GVC-related trade, while the outcome of column (3) casts some doubts on the endogeneity of the RD effect on the forward GVC trade.

Table 3: gravity model estimation with 3-year time intervals

Dependent variable	(1) Overall GVCp	(2) Backward GVCp	(3) Forward GVCp
ln(1 + RD)	-.034** (.016)	-.058*** (.016)	-.014 (.021)
ln(1 + tariff)	-.069*** (.01)	-.045*** (.01)	-.09*** (.014)
RTA	.006 (.025)	.027 (.025)	-.012 (.037)
_cons	6.884*** (.039)	6.3*** (.039)	6.147*** (.057)
Observations	271807	271801	269243
Pseudo R ²	.984	.98	.979
RESET Test	0.035	0.369	0.004
AVE _{RD}	64.28	259.72	16.91

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer-sector level. All variables are in contemporaneous values. All regressions include exporter-sector-year, importer-sector-year, and exporter-importer-sector fixed effects. Standard errors are in parentheses. *Significance levels:* *** $p < .01$, ** $p < .05$, * $p < .1$

In Table 4, I present my third robustness check in which I test whether the choice of lags for the trade policies variables is driving the results. Using lags ensures that I account for changes in trade flows, which do not follow immediately but only after some time of adaptation. Since this practice is not standard in the literature, following Kinzius et al. (2019), I use contemporaneous trade policy variables as a robustness check (columns 1 to 3). As for the specification in Table 3, exporter-importer-sector fixed effects are included to control for endogeneity. Furthermore, as recommended in Yotov et al. (2016), I also perform the gravity analysis with alternative lag intervals (2-year lags) to test whether the lag length chosen in the baseline is driving the results (columns 4 to 6).

Column (1) shows that the impact of bilateral contemporaneous regulatory distance is 0.9% smaller in magnitude than lagged RD, providing further evidence that trade flows take time to adjust to changes in NTMs patterns. When we consider the backward linkages of bilateral-sectoral exports instead, contemporaneous and lagged regulatory distance have a similar impact (column 2). However, column (3) reveals a non-statistically significant effect of the RD index, suggesting that contemporaneous regulatory distance does not affect the forward GVC component of exports. In columns (4) to (6), I run the gravity model with trade policy variables lagged by two years. The negative effect of regulatory distance is smaller

Table 4: gravity model estimation with contemporaneous and 2-year lags trade policy variables

Lag length in trade policy variables	No lags			2-year lags		
	(1) Overall GVCp	(2) Backward GVCp	(3) Forward GVCp	(4) Overall GVCp	(5) Backward GVCp	(6) Forward GVCp
ln(1 + RD)	-.041*** (.015)	-.063*** (.014)	-.011 (.022)	-.047*** (.016)	-.059*** (.016)	-.039* (.021)
ln(1 + tariff)	-.06*** (.007)	-.038*** (.008)	-.081*** (.01)	-.166*** (.02)	-.1*** (.02)	-.263*** (.027)
RTA	.039* (.021)	.043** (.019)	.033 (.034)	.097*** (.036)	.177*** (.037)	.032 (.05)
Log Distance				-.815*** (.022)	-.818*** (.024)	-.814*** (.028)
Contiguity				.296*** (.03)	.268*** (.033)	.333*** (.035)
Common-language				.153*** (.037)	.162*** (.037)	.14*** (.049)
Common colonizer				-.212* (.113)	.16* (.094)	-.457*** (.161)
Religion proximity index				-.027 (.055)	-.106* (.057)	.068 (.078)
Colonial-tie				.066 (.086)	.07 (.089)	.01 (.108)
Common legal origin				.256*** (.024)	.249*** (.026)	.279*** (.031)
Legal origin changed				-.097** (.04)	-.132*** (.043)	-.101* (.053)
Same colonizer				-.11 (.079)	-.117 (.076)	-.156 (.107)
_cons	6.794*** (.037)	6.243*** (.033)	6.019*** (.058)	13.009*** (.181)	12.479*** (.199)	12.337*** (.239)
Observations	741837	741798	737757	596245	596206	596005
Pseudo R ²	.983	.979	.977	.914	.92	.911
RESET Test	0.036	0.414	0.056	0.294	0.551	0.170
AVE _{RD}	96.30	441.36	14.25	32.67	80.30	15.90

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer-sector level. All regressions include exporter-sector-year, importer-sector-year fixed effects. Regressions in columns (1) to (3) also include exporter-importer-sector fixed effects. Standard errors are in parentheses. *Significance levels:* *** $p < .01$, ** $p < .05$, * $p < .1$

with a 2-year lag for all three components of bilateral sectoral exports than with a single-year lag, suggesting that the repercussions of dissimilarity in NTMs structures on GVC-related trade measures strongly decreases over time. Interestingly, tariffs show similar behavior to that of regulatory distance. Indeed, when we consider the analysis conducted with

contemporaneous tariff values, the impact is substantially smaller than that of 1-year lag tariffs. On the contrary, elasticities for the 2-years lagged tariffs are overall close to those of the 1-year lagged ones, supporting the idea that trade flows take time to adjust to changes in bilateral trade costs. Except for the specification reported in column (1), the models estimated with contemporaneous and 2-year lagged trade policies variables pass the RESET test, that is, the RESET test confirms the correct specification of the gravity equations. To sum up, the results are overall robust to the number of lags chosen for the analysis conducted on total and backward GVC-related trade. On the other hand, the regulatory distance effect on the forward GVC component of exports was not statistically significant in none of the two models.

As the fourth and last robustness check, I test whether the results are driven by the imputation method I choose to fulfill the missing values of the RD index. As explained in Section 3.3, the linear interpolation algorithm assumes that a variable y (the variable having missing observations) varies linearly with a variable x within gaps. Admittedly, this condition might not be fully met in this context. For this reason, I repeat the analysis for the gravity model baseline while keeping the missing observations of the variable RD index instead of fulfilling them.

Table 5 presents the results of the sensitivity analysis. The RD index shows negative and statistically significant coefficients at the 1% level for all three specifications. Interestingly, for specifications (1) and (3), the regulatory distance elasticities are even higher when missing values are not imputed. This is especially true when I measure the effect on total and forward GVC-related trade, where the impact associated with a 1% increase in bilateral RD index is, respectively, 0.6% and 2.3% higher than in the baseline. Similarly, ad-valorem tariff equivalents are also larger in magnitude for the not imputed version of the RD index when I test its impact on total and forward GVC trade, while it is slightly lower on backward GVC-related trade compared to the baseline results. To complete the analysis, I performed the same set of specification RESET tests performed before. The p-values of the heteroskedasticity-robust RESET tests at the bottom of Table 5 suggest that the null hypothesis of the proper model specification is not rejected and that the models are correctly specified for all three dependent variables. Altogether, the results demonstrate that neither the imputation of missing values nor the imputation technique chosen have driven the baseline results.

Table 5: gravity model estimation, RD index with missing values

Dependent variable	(1) Overall GVCp	(2) Backward GVCp	(3) Forward GVCp
ln(1 + RD)	-.058*** (.016)	-.058*** (.017)	-.066*** (.02)
ln(1 + tariff)	-.171*** (.02)	-.099*** (.02)	-.268*** (.026)
RTA	.102*** (.038)	.181*** (.037)	.039 (.054)
Log Distance	-.811*** (.021)	-.835*** (.022)	-.795*** (.027)
Contiguity	.296*** (.027)	.262*** (.03)	.341*** (.03)
Common-language	.145*** (.037)	.151*** (.035)	.136*** (.051)
Common colonizer	-.187* (.11)	.185** (.089)	-.374** (.156)
Religion proximity index	.061 (.052)	-.006 (.053)	.109 (.07)
Colonial-tie	-.011 (.095)	-.044 (.095)	-.036 (.121)
Common legal origin	.25*** (.024)	.236*** (.024)	.276*** (.031)
Legal origin changed	-.116*** (.037)	-.15*** (.038)	-.128*** (.049)
Same colonizer	-.098 (.076)	-.105 (.068)	-.147 (.113)
_cons	12.989*** (.175)	12.626*** (.186)	12.202*** (.234)
Observations	481226	481203	480977
Pseudo R ²	.923	.929	.92
RESET Test	0.756	0.183	0.058
AVE _{RD}	40.08	80.12	27.79

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer–sector level. Variables for RD, tariffs and RTA are lagged by one year. All regressions include exporter–sector–year and importer–sector–year fixed effects. Standard errors are in parentheses. *Significance levels:* *** $p < .01$, ** $p < .05$, * $p < .1$

7. Policy implications and conclusion

This research aims to contribute to the trade literature by adopting a structural gravity model approach to assess the impact of bilateral regulatory distance in NTMs on the GVC components of countries' exports. Following Cadot et al. (2015), I built a regulatory distance index, which measures the heterogeneity in NTMs adopted between different country-pairs. Then, I included estimates for the RD indicator, as well as a large array of control variables

and trade directional fixed effects, in a set of gravity equations to estimate the effect that these variables have on the GVC-related components of countries' trade. Moreover, for each model specification, I calculated the ad-valorem tariff equivalent for the RD index, that is, the ad-valorem tariff whose introduction would have generated the same impact as the regulatory distance in question. Measures of total, backward and forward GVC-related trade, which are the dependent variables of the gravity models, were constructed following the Borin and Mancini (2019) methodology of value-added decomposition of gross exports.

The empirical analysis indicates a negative and statistically significant relationship between bilateral regulatory distance and the GVC-related components of countries' exports. In particular, when the analysis is conducted on all sectors, the RD index registers the highest impact on backward GVC-related trade with an average elasticity of -0.063 and an ad-valorem tariff equivalent of 96.31%. Instead, when the gravity analysis considers only the exports of manufacturing goods, the regulatory distance has the highest impact on the forward GVC-related trade with an average elasticity of -0.103 and an AVE of 108.38%.

In order to assess the overall robustness of my findings, I conducted a broad set of sensitivity analyses. More precisely, I first tested the methodology with which the GVC-related trade measures are built and the country sample. Then, I adopted a different approach to take into account the adjustment in trade flows. I next tested the choice of lagged trade policies variables, the lags-length, as well as the potential endogeneity of the regressors. Finally, I checked whether the imputation technique to fulfill missing values drove the results for the variable of interest. Overall, the robustness tests I implemented confirm the solidity of the findings for the analysis performed on the total and backward GVC components of trade. However, the specifications having forward GVC trade as a dependent variable did not pass part of the tests, casting doubts of the overall robustness of the regulatory distance effect on the forward GVC linkages of countries' exports.

Complementary to these analyses, this study also includes two additional models to assess whether an interaction exists between the impact of regulatory distance and the exporter's and the importer's development levels (see [Annex B](#)). In the first gravity model, the baseline equation (Eq. 9) is extended with a two-way interaction term between the RD index and the exporter's GNI per capita, while the second model includes a three-way interaction between the RD index and the importers' and exporters' levels of development. Overall, the results suggest that the negative effect of regulatory distance is lower for exporters with higher levels of gross national income (GNI). Also, the marginal effect of RD

is more adverse for developing exporters addressing a low-middle or upper-middle compared to a high-income importing market.

It is worth highlighting that the empirical findings reported herein should be considered in light of some limitations. The first most obvious caveat of this research lies in its country coverage. Due to the complexity of generating and retrieving reliable data on GVC trade, this study covers only 59 economies, cutting off a large amount of small and less developed countries. For this reason, it might be complex to generalize these findings to all the low-income economies, for which regulatory distance might be even more costly in terms of GVCs participation (as partially shown in [Annex B](#)). Second, based on Cadot et al. (2015), this work employs a measure of total-bilateral dissimilarity in NTMs, i.e., the RD index. However, this indicator does not assess the bilateral regulatory distance at the sector level. By allowing the sectoral dimension of regulatory distance might benefit the analysis in terms of precision. Third, the robustness analysis presented in [Table 5](#) shows that results are neither driven by the imputation of missing values nor by the algorithm employed. Nevertheless, assuming that data are missing at random (MAR) or completely at random (MCAR), a multiple imputation or a full information maximum likelihood (FIML) estimation would be more robust approaches to deal with incomplete data (Rubin, 1996; Enders and Bandalos, 2001). Finally, although this work investigates heterogeneity in the regulatory distance at countries' income levels, it does not take into account other relevant dimensions such as countries' market size and their geographical position. Therefore, future studies should also consider these aspects in order to provide a more comprehensive understanding of the linkages by which dissimilarity in NTMs affects countries' GVC participation.

Although this research should be seen as a relevant starting point rather than conclusive, it contains important policy implications. Indeed, it demonstrates the substantial influence of heterogeneity in NTMs on GVC components of countries' exports, particularly on the total and backward GVC trade. It is worth pointing out that integration in GVCs itself is not a guarantee of higher income and growth. Indeed, low levels of exports diversification and sophistication, summed to a participation in the low value-added portions of GVCs, lead to the risk of being permanently confined to these segments (Fortunato and Razo, 2014). Nevertheless, as Allard et al. (2016) highlight, scaling up in the GVC – increasing the share of foreign value-added in one country's exports – is associated with better chances to enhance structural transformation and economic growth. Also, the insertion into GVCs can boost positive spillovers into the domestic economy through backward linkages if the domestic sectors are competitive enough to contribute to the value chain. In this sense, this study

provides shreds of evidence that high levels of regulatory distance might hamper the countries' attempt to climb up the GVCs and that harmonization and mutual recognition might be essential tools to reconcile the countries' needs of trade regulation and the aim of scaling international value chains.

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Appendix A: Additional tables and figures

Table A 1: List of sample countries

ISO alpha-3	Country	ISO alpha-3	Country
ARG	Argentina	JPN	Japan
AUS	Australia	KAZ	Kazakhstan
AUT	Austria	KHM	Cambodia
BEL	Belgium	KOR	Korea Republic
BGR	Bulgaria	LTU	Lithuania
BRA	Brazil	LUX	Luxembourg
BRN	Brunei Darussalam	LVA	Latvia
CAN	Canada	MAR	Morocco
CHE	Switzerland	MEX	Mexico
CHL	Chile	MLT	Malta
CHN	China	MYS	Malaysia
COL	Colombia	NLD	Netherlands
CRI	Costa Rica	NZL	New Zealand
CYP	Cyprus	PER	Peru
CZE	Czech Republic	PHL	Philippines
DEU	Germany	POL	Poland
DNK	Denmark	PRT	Portugal
ESP	Spain	ROU	Romania
EST	Estonia	RUS	Russia
FIN	Finland	SAU	Saudi Arabia
FRA	France	SGP	Singapore
GBR	United Kingdom	SVK	Slovak Republic
GRC	Greece	SVN	Slovenia
HKG	Hong Kong	SWE	Sweden
HUN	Hungary	THA	Thailand
IDN	Indonesia	TUN	Tunisia
IND	India	TUR	Turkey
IRL	Ireland	USA	United States
ISR	Israel	VNM	Vietnam
ITA	Italy		

Source: OECD ICIO Tables.

Table A 2: List of sample sectors

TiVA industry code	Sector	ISIC Rev. 4
D01T03	Agriculture, forestry and fishing	From 01 to 03
D05T06	Mining and extraction of energy-producing products	05, 06
D07T08	Mining and quarrying of non-energy producing products	07, 08
D09	Mining support service activities	09
D10T12	Food products, beverages, and tobacco	10, 11, 12
D13T15	Textiles, wearing apparel, leather and related products	13, 14, 15
D16	Wood and products of wood and cork	16
D17T18	Paper products and printing	17, 18
D19	Coke and refined petroleum products	19
D20T21	Chemicals and pharmaceutical products	20, 21
D22	Rubber and plastic products	22
D23	Other non-metallic mineral products	23
D24	Basic metals	24
D25	Fabricated metal products	25
D26	Computer, electronic and optical products	26
D27	Electrical equipment	27
D28	Machinery and equipment, nec	28
D29	Motor vehicles, trailers and semi-trailers	29
D30	Other transport equipment	30
D31T33	Other manufacturing; repair, and installation of machinery and equipment	31, 32, 33
D35T39	Electricity, gas, water supply, sewerage, waste and remediation services	35,36, 37, 38, 39

Source: OECD ICIO Tables.

Table A 3: Summary statistics**A3.a: Summary statistics, full dataset**

	N	Mean	Std. Dev.	Min	Max	Skewness
Total GVCp	790454	51.203	431.563	0.000	62320.387	47.483
Backward GVCp	790415	24.444	254.913	0.000	39311.383	68.278
Forward GVCp	790482	19.556	182.127	0.000	25558.621	42.842
RD index	601398	12.053	8.508	0.000	29.872	-0.336
RD index (imputed values)	789600	13.421	8.095	0.000	29.872	-0.613
Log RD index	601398	2.050	1.284	0.000	3.430	-0.872
Log RD index (imputed values)	789600	2.252	1.187	0.000	3.430	-1.247
Effectively applied tariff	753942	5.219	12.226	0.000	1425.050	17.705
Log Tariff	753942	1.070	1.145	0.000	7.263	0.671
Log Distance	790482	8.502	0.998	5.081	9.886	-0.778
Contiguity	790482	0.038	0.191	0.000	1.000	4.833
Common-language	790482	0.089	0.285	0.000	1.000	2.878
Common colonizer	790482	0.023	0.151	0.000	1.000	6.309
Religion proximity index	763686	0.169	0.263	0.000	0.988	1.633
Colonial-tie	790482	0.012	0.110	0.000	1.000	8.859
Common legal origin	790482	0.321	0.467	0.000	1.000	0.765
Legal origin changed	790482	0.133	0.339	0.000	1.000	2.166
Same colonizer	790020	0.043	0.202	0.000	1.000	4.524
RTA	790482	0.418	0.493	0.000	1.000	0.333
GNI per capita (exporter)	790482	24588	19910	460	88740	0.771

Notes: Summary statistics are computed over the whole timespan (2005 – 2015). Total GVCp refers to total GVC-related trade, Backward GVCp refers to Backward GVC-related trade, and Forward GVCp refers to Forward GVC-related trade. Source: Authors' calculation.

A3.b: Summary statistics, 3-year time intervals

	N	Mean	Std. Dev.	Min	Max	Skewness
Total GVCp	287440	53.051	437.840	0.000	61343.984	44.073
Backward GVCp	287434	25.365	255.398	0.000	37814.605	63.571
Forward GVCp	287448	20.158	187.975	0.000	24345.078	41.010
RD index	175980	10.337	8.582	0.000	29.026	0.010
RD index (imputed values)	287028	13.338	8.111	0.000	29.026	-0.590
Log RD index	175980	1.820	1.333	0.000	3.402	-0.535
Log RD index (imputed values)	287028	2.244	1.187	0.000	3.402	-1.230
Effectively applied tariff	277704	5.385	11.369	0.000	408.090	6.995
Log Tariff	277704	1.090	1.156	0.000	6.014	0.658
RTA	287448	0.415	0.493	0.000	1.000	0.344

Notes: The summary statistics are computed over the same years of the robustness check presented in Table 3, namely, 2005, 2008, 2011, and 2014. Total GVCp refers to total GVC-related trade, Backward GVCp refers to Backward GVC-related trade, and Forward GVCp refers to Forward GVC-related trade. Source: Authors' calculation.

Table A 4: Summary of missing values

	Missing	Total	Percent missing
Total GVCp	28	790,482	0.000
Backward GVCp	67	790,482	0.010
Forward GVCp	0	790,482	0.000
RD index	189,084	790,482	23.920
RD index (imputed values)	882	790,482	0.110
Log RD index	189,084	790,482	23.920
Log RD index (imputed values)	882	790,482	0.110
Effectively applied tariff	36,540	790,482	4.620
Log Tariff	36,540	790,482	4.620
Log Distance	0	790,482	0.000
Contiguity	0	790,482	0.000
Common-language	0	790,482	0.000
Common colonizer	0	790,482	0.000
Religion proximity index	26,796	790,482	3.390
Colonial-tie	0	790,482	0.000
Common legal origin	0	790,482	0.000
Legal origin changed	0	790,482	0.000
Same colonizer	462	790,482	0.060
RTA	0	790,482	0.000
GNI per capita (exporter)	0	790,482	0.000

Notes: The summary of missing values is computed over the whole timespan (2005 – 2015). Source: Authors' calculation.

Table A 5: WIOD data, country coverage

ISO alpha-3	Country	ISO alpha-3	Country
AUS	Australia	IND	India
AUT	Austria	IRL	Ireland
BEL	Belgium	ITA	Italy
BGR	Bulgaria	JPN	Japan
BRA	Brazil	KOR	Korea Republic
CAN	Canada	LTU	Lithuania
CHE	Switzerland	LUX	Luxembourg
CHN	China	LVA	Latvia
CYP	Cyprus	MEX	Mexico
CZE	Czech Republic	MLT	Malta
DEU	Germany	NLD	Netherlands
DNK	Denmark	POL	Poland
ESP	Spain	PRT	Portugal
EST	Estonia	ROU	Romania
FIN	Finland	RUS	Russia
FRA	France	SVK	Slovak Republic
GBR	United Kingdom	SVN	Slovenia
GRC	Greece	SWE	Sweden
HUN	Hungary	TUR	Turkey
IDN	Indonesia	USA	United States

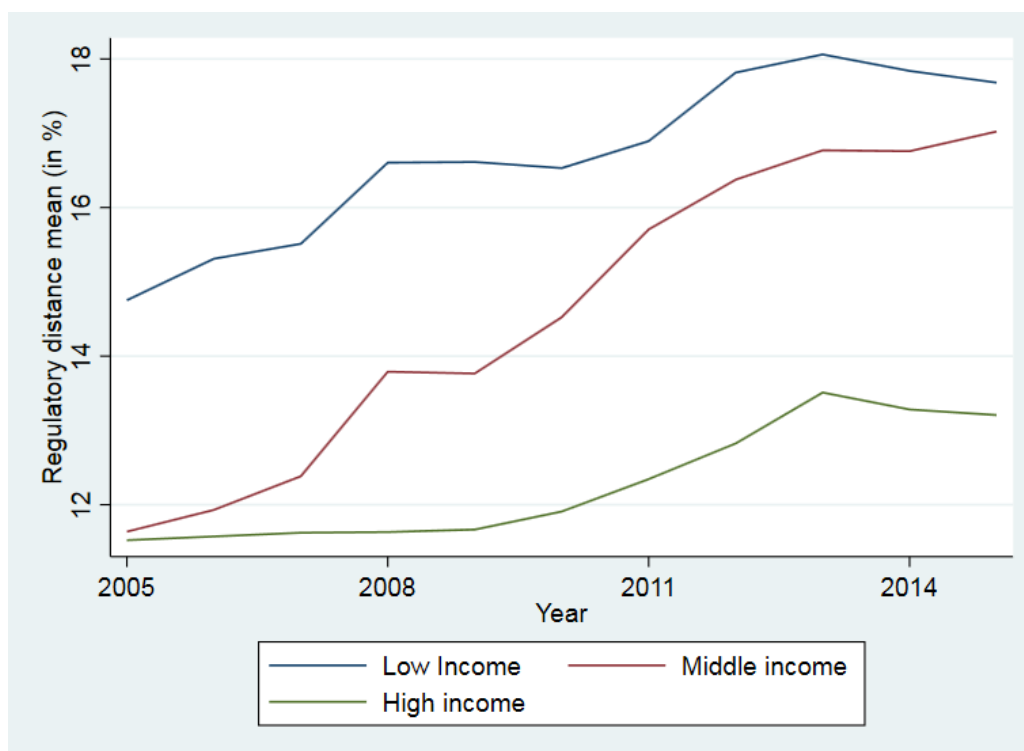
Source: World Input-Output Database; WIOD Data, 2016 Release.

Table A 6: WIOD data, sector coverage

WIOD sector	Industry	ISIC Rev. 4
Crop and animal production, hunting and related service activities	Agriculture, forestry and fishing	01
Fishing and aquaculture	Agriculture, forestry and fishing	03
Mining and quarrying	Mining and quarrying	From 05 to 09
Manufacture of food products, beverages and tobacco products	Manufacturing	From 10 to 12
Manufacture of textiles, wearing apparel and leather products	Manufacturing	From 13 to 15
Manufacture of wood and of products of wood and cork	Manufacturing	16
Manufacture of paper and paper products	Manufacturing	17
Manufacture of coke and refined petroleum products	Manufacturing	19
Manufacture of chemicals and chemical products	Manufacturing	20
Manufacture of basic pharmaceutical products	Manufacturing	21
Manufacture of rubber and plastic products	Manufacturing	22
Manufacture of other non-metallic mineral products	Manufacturing	23
Manufacture of basic metals	Manufacturing	24
Manufacture of fabricated metal products, except machinery and equipment	Manufacturing	25
Manufacture of computer, electronic and optical products	Manufacturing	26
Manufacture of electrical equipment	Manufacturing	27
Manufacture of machinery and equipment n.e.c.	Manufacturing	28
Manufacture of motor vehicles, trailers and semi-trailers	Manufacturing	29
Manufacture of other transport equipment	Manufacturing	30
Manufacture of furniture, other manufacturing	Manufacturing	31 and 32
Repair and installation of machinery and equipment	Manufacturing	33
Electricity, gas, steam and air conditioning supply	Electricity, gas, steam and air conditioning supply	35

Source: World Input-Output Database; WIOD Data, 2016 Release.

Figure A 1: Development of regulatory distance per exporter income-group



Notes: for each income group, the bilateral regulatory distance is averaged among all the trade partners. Exporters are classified by GNI per capita, following the World Bank Atlas method. Source: Author's calculation.

Appendix B: Gravity analysis by income group

This extra section addresses the question of whether the regulatory distance impact might be associated with the exporters' and the importers' income levels.

The trade literature provides some evidence of the existence of differences in the pattern of NTMs, as well as their impact on trade, according to the countries' level of development. Particularly insightful in this sense is the contribution provided by Dolabella (2020). In his work, the author selects a gravity framework to decompose the impact of technical measures (i.e., TBT and SPS) across income country-groups, finding both that exporters from least developed nations (low and lower-middle income countries) are the most affected by a new TBT and that high-income countries impose the most restrictive technical measures. Similarly, Ghodsi et al. (2017) estimate the trade effects of NTMs for more than 100 countries with a gravity approach. The authors find an intense concentration of NTMs among upper-middle and high-income countries, while simultaneously, these countries are also the most frequently targeted by NTMs. Moreover, they discover that the trade-impeding effects of SPS measures decrease with higher income levels. In contrast to the two previous studies, which consider NTMs in cumulative terms, Nabeshima and Obashi. (2019) analyzes how the impact of additional regulatory compliance requirements changes by destination and origin country income groups. Their findings suggest that additional regulatory burdens faced by exporters when serving the less-developed countries' market reduce the exports from other less-developed countries but not affect those from developed countries. Instead, the regulatory burdens in serving the developed country's market restrict the trade flow originating from any country regardless of the income level.

To the best of my knowledge, no study has disentangled the impact of regulatory dissimilarities on the GVC-related trade by country income group. Therefore, I contribute to the current literature by estimating how the effect of regulatory distance on GVC trade is related to the countries' development levels. More specifically, I build two additional models by including two-way and three-way interaction terms to the baseline gravity equation, i.e., Eq. (9).

In the first model, I estimate the simple relationship between the RD index and the exporter's development level, proxied by the GNI per capita. Equation (11) formalizes the first specification:

$$\begin{aligned}
GVC_{ijt}^k = & \exp[\beta_0 + \beta_1 \ln(1 + RD_{ijt-1}) + \beta_2 (\ln(1 + RD_{ijt-1}) \times GNI_{it}) \\
& + \beta_3 \ln(1 + Tariff_{ijt-1}^k) + \beta_4 RTA_{ijt-1} + \beta_5 \ln(Dist_{ij}) \\
& + \theta_{ij} + \delta_{it}^k + \gamma_{jt}^k] \varepsilon_{ijt}^k
\end{aligned} \tag{11}$$

Where $\ln(1 + RD_{ijt-1}) \times GNI_{it}$ is a two-way interaction term between the log of RD index in time $t - 1$ and GNI_{it} , which corresponds to the Gross National Income per capita of exporter i in year t . The rest of the equation is identical in terms of variables and interpretation to the baseline Eq. (9). According to this specification, a positive value for the interaction term coefficient would imply that the higher the exporter's GNI per capita, the less negative (or more positive) the effect of bilateral regulatory distance.

In the second model, I extend the analysis by interacting the relationship between the RD index with the destination and the origin countries' levels of development. Based on Eq. (9), I propose a three-way gravity model:

$$\begin{aligned}
GVC_{ijt}^k = & \exp[\beta_0 + \beta_1 \ln(1 + RD_{ijt-1}) \\
& + \beta_2 (\ln(1 + RD_{ijt-1}) \times Developing_{it} \times Income Class_{jt}) \\
& + \beta_3 \ln(1 + Tariff_{ijt-1}^k) + \beta_4 RTA_{ijt-1} + \beta_5 \ln(Dist_{ij}) \\
& + \theta_{ij} + \delta_{it}^k + \gamma_{jt}^k] \varepsilon_{ijt}^k
\end{aligned} \tag{12}$$

Where the term $\ln(1 + RD_{ijt-1}) \times Developing_{it} \times Income Class_{jt}$ is a three-way interaction between the log of RD index in time $t - 1$, the dummy variable $Developing_{it}$, which equals one if the exporter is classified as developing country in year t and 0 otherwise¹⁸, and the categorical variable $Income Class_{jt}$ that classifies the importing country as either low (L), lower-middle (LM), upper-middle (UM), or high (H) income economy, following the World Bank's income classification. Moreover, the model also includes the main effects of the RD index and the variables used as moderators, as well as the two-way interaction among them. However, for the sake of simplicity, they are not presented in this work. The rest of the equation is identical in terms of variables and interpretation to the baseline Eq. (9). As base categories for the interaction term, I opted for "non-developing exporter" for the dummy variable $Developing_{it}$ and low-income importer group for the

¹⁸ More specifically, the variable $Developing_{it}$ equals one if the exporting market is either a low-income, lower-middle and upper-middle country, while it equals zero if the exporting market is an high-income economy, according to the World Bank's income classification.

categorical variable $Income\ Class_{jt}$. Given this particular specification, a negative coefficient would imply that a GVC-trade measure from a developing exporter, oriented toward an importing market belonging to either LM, UM, or H income groups, is on average more negatively affected than that of a low-income importing market.

Table A 7 reports the results from the gravity models estimation. Columns (1) to (3) present the gravity model results from Eq (11). By looking at the specification in columns (1) and (2), we see that the interaction terms between the RD index and the exporters' GNI per capita are statistically significant at the 1% significance level, which justifies the inclusion of the terms in the model. Also, in both model specifications, the coefficients are positive, meaning that exporters with higher levels of GNI per capita suffer less the negative effect of regulatory distance. On the contrary, once the analysis is conducted on the forward GVC-related trade, the interaction term shows a positive but no longer statistically significant coefficient, suggesting that this data cannot tell a meaningful relationship between forward GVC-trade and the exporter's income level. Finally, the p-values of the RESET tests at the bottom of Table A 7 suggest the adequate specifications of the models in columns (1) to (3).

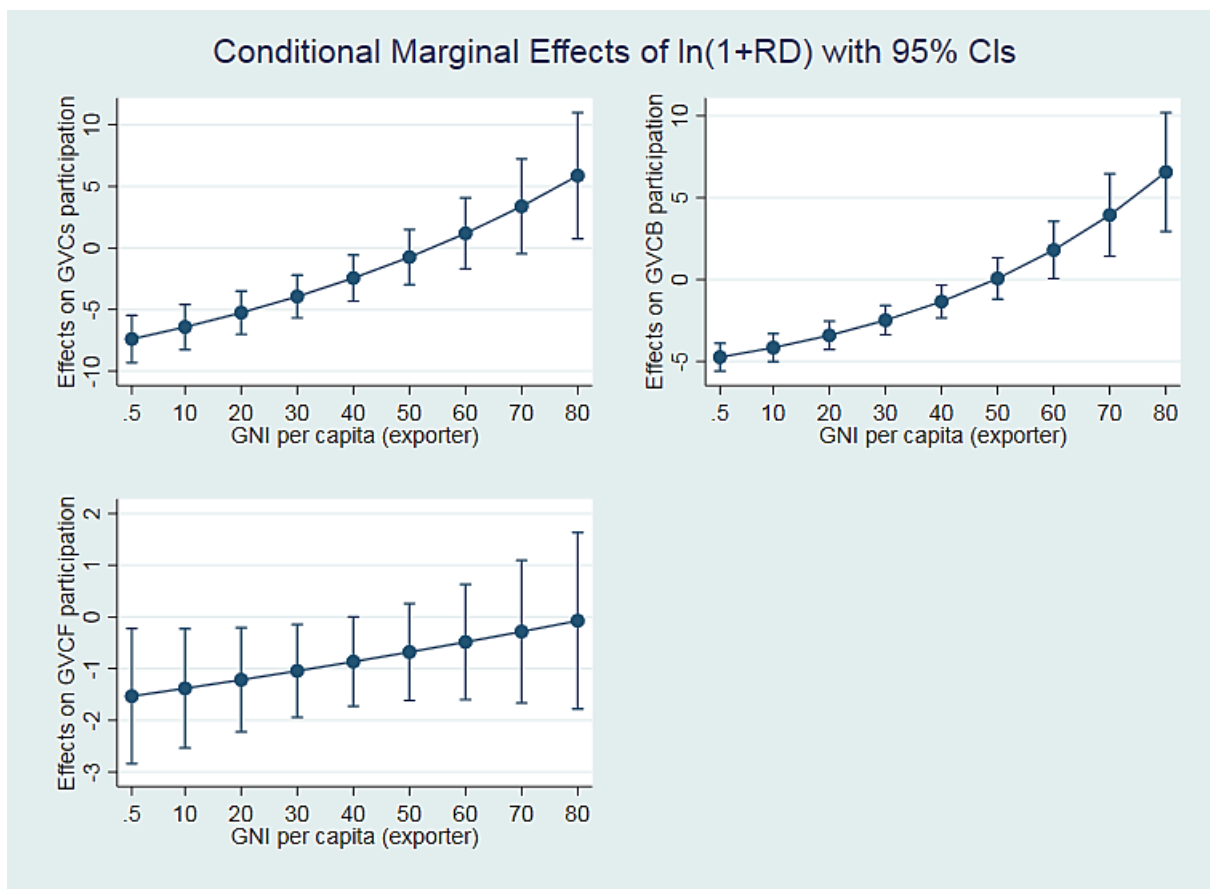
Figure A 2 uses the results of columns (1) to (3) in Table A 7 to plot the average marginal effect of regulatory distance on the three outcome variables, conditional to the exporters' GNI per capita. The horizontal axes measure the different levels of GNI per capita taken into account. The first quadrant shows that RD has the most negative impact on GVC-related trade for the least developed exporters, while its effect becomes more positive as the exporter's GNI per capita increases. Indeed, the marginal effect of RD is -7.4% for exporters with a GNI per capita of 500 USD, and it becomes increasingly positive until reaching $+5.8\%$, for destination economies with a GNI per capita of 80 thousand USD. However, the marginal effect is statistically significant only for those exporters with a GNI per capita below 40 thousand USD and above 70 thousand USD. Similarly, the second quadrant reveals that the marginal effects of RD range from -4.7% for exporters with a GNI per capita of 500 USD to a $+6.5\%$ for the most developed exporters. In this case, the marginal effect is significant at all exporter's income levels except for the 50 thousand USD level. The third quadrant shows that the marginal effect is negative and statistically significant at the 5% level for those exporters with a lower level of GNI per capita (up to 40 thousand USD), while it loses significance as the GNI per capita rises at higher income levels.

Table A 7: Gravity model analysis with two-way and three-way interaction terms

Model considered	Equation (11)			Equation (12)		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Overall GVCp	Backward GVCp	Forward GVCp	Overall GVCp	Backward GVCp	Forward GVCp
ln(1 + RD)	-.159*** (.024)	-.229*** (.025)	-.078** (.037)	-.331*** (.096)	-.26*** (.09)	-.324*** (.115)
ln(1 + RD) × GNI	.003*** (.001)	.005*** (.001)	.001 (.001)			
ln(1 + tariff)	-.167*** (.02)	-.096*** (.02)	-.267*** (.027)	-.165*** (.019)	-.095*** (.019)	-.262*** (.027)
RTA	.111*** (.036)	.195*** (.036)	.046 (.05)	.143*** (.037)	.235*** (.037)	.074 (.054)
Log Distance	-.811*** (.022)	-.818*** (.023)	-.805*** (.027)	-.799*** (.022)	-.806*** (.024)	-.797*** (.027)
Contiguity	.304*** (.029)	.28*** (.032)	.338*** (.034)	.322*** (.029)	.299*** (.033)	.352*** (.034)
Common-language	.146*** (.037)	.152*** (.037)	.138*** (.049)	.149*** (.036)	.145*** (.038)	.143*** (.049)
Common colonizer	-.229** (.116)	.157* (.093)	-.467*** (.163)	-.266** (.118)	.114 (.094)	-.478*** (.166)
Religion proximity index	-.053 (.055)	-.147*** (.056)	.053 (.078)	.002 (.056)	-.072 (.057)	.08 (.079)
Colonial-tie	.075 (.087)	.054 (.091)	.019 (.107)	.125 (.083)	.132 (.085)	.048 (.105)
Common legal origin	.258*** (.024)	.251*** (.026)	.285*** (.031)	.249*** (.025)	.243*** (.027)	.275*** (.032)
Legal origin changed	-.104*** (.04)	-.147*** (.042)	-.107** (.053)	-.11*** (.039)	-.152*** (.042)	-.113** (.052)
Same colonizer	-.106 (.079)	-.12 (.075)	-.152 (.108)	-.104 (.079)	-.105 (.076)	-.152 (.107)
ln(1 + RD) × Developing × Income Class						
1 LM				-.461*** (.164)	-.456*** (.177)	-.445** (.179)
1 UM				-.567*** (.163)	-.349** (.168)	-.736*** (.188)
1 H				-.541*** (.154)	-.336** (.161)	-.613*** (.177)
_cons	13.01*** (.179)	12.555*** (.194)	12.251*** (.235)	12.374*** (.215)	12.012*** (.233)	11.617*** (.269)
Observations	657981	657943	657687	657981	657943	657687
Pseudo R ²	.914	.921	.912	.915	.921	.912
RESET Test	0.374	0.279	0.125	0.125	0.962	0.960

Note: All dependent variables are in millions of current US dollars. Data for the dependent variables come from the OECD TiVA database, 2018 version. Standard errors are clustered at the exporter–importer–sector level. Variables for RD, tariffs, and RTA are lagged by one year. All regressions include exporter-sector-year and importer-sector-year fixed effects. Standard errors are in parentheses. *Significance levels: *** $p < .01$, ** $p < .05$, * $p < .1$*

Figure A 2: Average marginal effects of regulatory distance by exporter' GNI per capita



Notes: The average marginal effects are plotted with 95 percent confidence intervals. GVCs refers to total GVC-related trade (or GVCs participation), GVCB refers to Backward GVC-related trade (or backward GVCs participation), and GVCF refers to Forward GVC-related trade (or forward GVCs participation). GNI per capita is measured in thousands of US current dollars. Source: Author's calculation.

From an economic point of view, these findings suggest that dissimilarity in NTMs constitutes a relatively higher barrier to GVC participation in low-income countries than in middle and high-income countries. There might be several underlying reasons to explain this fact. Firstly, regulatory distance can be viewed as additional costs of compliance that firms in the exporter countries face to sell their products in a particular importing market. In this sense, conformity verification costs are relatively higher for developing countries and small producers, as they are often fixed costs and not proportionate to the value of the exports (contrary to tariff). However, the reasons behind the more considerable impact of regulatory distance for lower-income countries do not only lie in compliance costs. Indeed, a higher prevalence of NTMs addresses the sectors of export mainly interested by developing countries, such as agriculture and apparel. Therefore, regulatory distance costs also have a relative higher weight for the low-income countries' exports basket (UNCTAD, 2018).

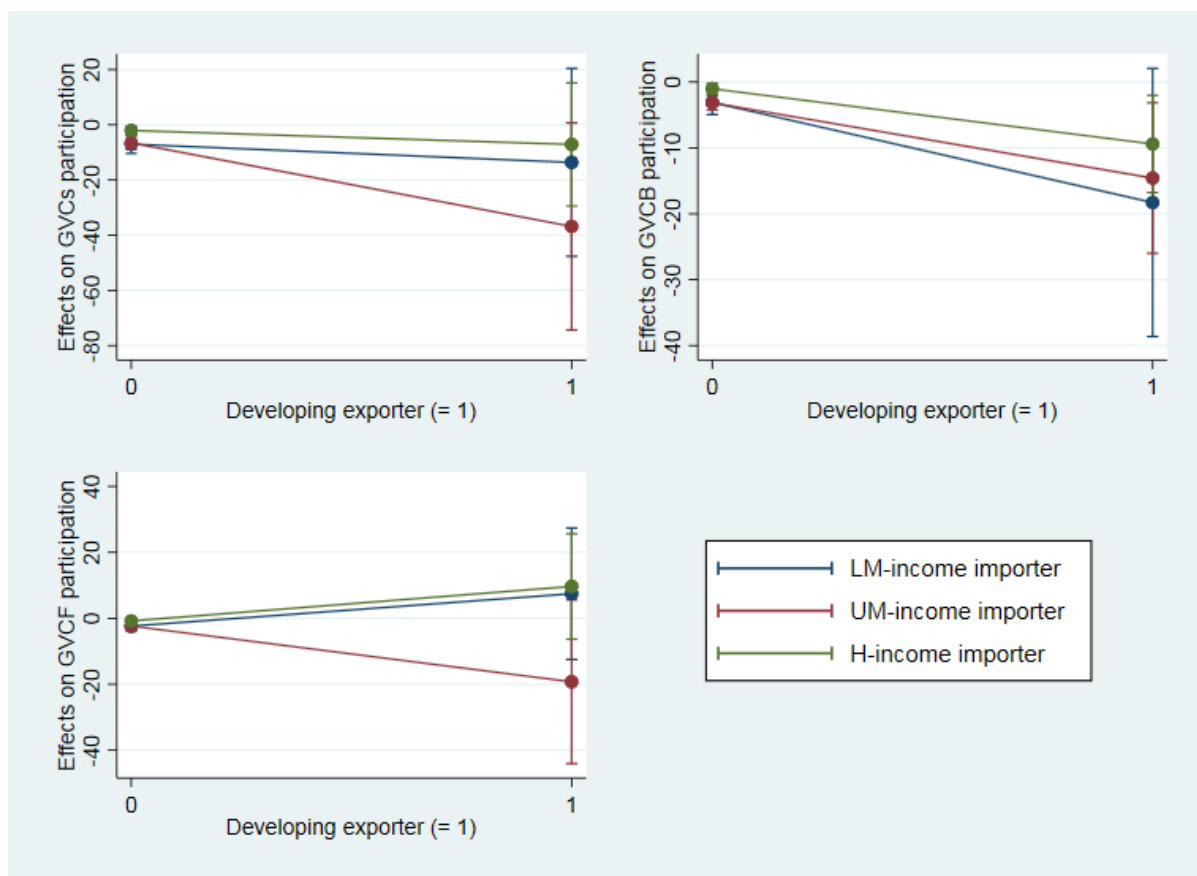
Columns (4) to (6) of Table A 7 present the gravity model results from Eq (12), which includes the interaction between RD and exporters' and importers' income levels. Interestingly, for all three specifications, we find that when the bilateral regulatory distance rises, the value of GVC-related trade measures from developing countries toward low-middle, upper-middle, and high income importers are lower relative to low-income importers (the baseline). These findings support the idea that the impact of regulatory distance depends not only on the exporters' traits but also on the importing market's level of development. Finally, the models estimated with the three-way interaction passed the RESET test, that is, the RESET test confirms the correct specification of the gravity equations.

Figure A 3 uses the results of columns (4) to (6) in Table A 7 to plot the marginal effects of regulatory distance on developing exporters' GVC trade measures at the different levels of importers' income. The horizontal axes distinguish whether the exporting economy is classified as developing (= 1) or developed (= 0). The first quadrant shows that the marginal effect of regulatory distance on GVC-related trade is significantly negative for high-income countries regardless of the importing market's level of income, and strongly negative (– 36.8%), and statistically significant (p -value = 0.055) for developing countries addressing an upper-middle income market. By contrast, the marginal effect loses significance when developing countries serve low-middle and high-income importing markets. The second quadrant reveals that the marginal effect of RD on backward GVC trade is overall negative and statistically significant for both developing and developed exporters, regardless of the importing market's income level¹⁹. In this case, we see regulatory distance having the most substantial effect (– 18.2%) on developing exporters when they trade with low-middle income importers. The third quadrant shows that the marginal effect of RD on the forward GVC trade is negative and statistically significant at the 5% level only for high-income economies independently of the trade partner. By contrast, the marginal effect estimated for the developing exporters is not statistically significant.

These findings demonstrate that the impact of regulatory distance on GVC-trade measures is not homogenous but is, at least, associated with the trade partners' level of development. Interestingly, we see more negative marginal effects for developing (low-middle and upper-middle income) than developed importing markets. This fact is especially valid when we look at the total GVC-related trade, where the marginal effect of RD for developing countries that address an upper-middle income market is remarkably negative.

¹⁹ Although the marginal effect for developing exporters interacting with low-income importers, presents a p -value of 0.078.

Figure A 3: Average marginal effects of regulatory distance by exporter's and importer's level of income



Notes: The average marginal effects are plotted with 95 percent confidence intervals. GVCs refers to total GVC-related trade (or GVCs participation), GVCB refers to Backward GVC-related trade (or backward GVCs participation), and GVCF refers to Forward GVC-related trade (or forward GVCs participation). Exporters are classified by GNI per capita, following the World Bank Atlas method. Source: Author's calculation.

Similarly, when we consider the backward GVC trade, the marginal effect of RD for a developing exporter touches almost -20% , and it is approximately -15% for low-middle and upper-middle income importing economies, respectively.

The policy implications of these results are particularly relevant in the context of regional value chains (RVCs) and South-South integration. Indeed, especially for the least-developed economies, RVCs are easier to penetrate, less resource-intensive, and less controlled by leading firms than international value chains. Moreover, increasing intra-regional trade, especially intra-industry trade, can reduce external output shocks and is a key to a successful penetration in GVCs (Brixio et al., 2015). However, as this section shows, the bilateral regulatory distance among developing countries might be a considerable barrier for non-high income economies willing to build and climb RVCs.