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Patterns of regulatory heterogeneity in international trade: Intensity, coverage, and structure

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Abstract

With falling tariffs the role of regulatory heterogeneity in international trade has become central in recent debates about regional integration and trade costs. In describing the NTM incidence few studies explicitly take into account the specific nature of underlying regulatory differences. We propose distinguishing regulatory heterogeneity with respect to the intensity, coverage, and structure of regulations, and present indicators reflecting each one of these dimensions. Enabled by detailed product-level regulatory data based on coded reviews of national legislation, we illustrate the different channels of regulatory heterogeneity on the country- and sector-level. The findings motivate a separate treatment of the different heterogeneity dimensions in the assessment of non-tariff measures in international trade.

KEYWORDS
non-tariff measures, regulatory heterogeneity, trade policy

JEL CLASSIFICATION
F13, F15

1 | INTRODUCTION

The past fifty years have seen an unparalleled process of reducing traditional tariff barriers to international trade. With relatively low tariffs in place, the potential welfare gains associated with trade cost reductions have shifted the attention to so-called non-tariff measures (NTMs). Quite broadly, these are defined as policy measures " … that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD, 2017c, p. 3). This broad definition includes at-the-border trade policy instruments, as well as behind-the-border policies traditionally not thought of as trade-related measures. Analysis of such an enlarged "trade" policy space requires systematically collected NTM data with wide geographic scope, and a set of indicators highlighting different aspects of countries' regulatory profiles.

The main objective of this paper is to provide a descriptive account of international patterns of NTMs by using a diverse set of indicators. We focus on (standard-like) technical measures complemented by two types of non-technical measures. The majority of these measures is imposed by the importer in a non-discriminatory fashion across origin countries, that is, like most-favored nation (MFN) tariffs these measures are applied equally to all exporters. Technical measures include sanitary and phytosanitary measures (SPS), technical barriers to trade (TBT), and pre-shipment inspections, while the two non-technical measure groups comprise quantity- and price-based measures.[1]

We differentiate the NTM incidence along three dimensions: (1) intensity, (2) coverage, and (3) structure. First, regulatory intensity describes the stringency of regulation, which can be proxied by the number of measures imposed on a product, or specified by actual requirements related to the product itself (e.g., a maximum residue limit of a pesticide on agricultural or food products) or production process (e.g., sanitation requirements for a factory) implied by the underlying policy. Second, coverage relates to the scope of "what is affected" by a measure or measure group. Typically, this concerns the value of trade, number of trading partners, or number of products. Third, structural regulatory heterogeneity describes differences with respect to what type of measures are imposed on a given product and to what degree these may depend on each other. This requires relatively detailed information on the NTM incidence, which is not necessarily the case for indicators reflecting intensity and coverage. Combining all three heterogeneity dimensions results in a relatively comprehensive display of a country's regulatory footprint.

The contribution of this study is twofold. First, we extend the set of NTM indicators currently used in the literature in accordance with the three heterogeneity dimensions of cross-country regulatory differences (for overviews see Disdier & Fugazza, 2020; Gourdon, 2014; UNCTAD, 2017c). Particularly, we complement the set of indicators related to regulatory structure and provide a principal component analysis (PCA) based variance decomposition of cross-country differences in regulatory stringency. The developed database contains a comprehensive set of indicators addressing the three heterogeneity dimensions for total trade and the following sectoral aggregations: 2-digit Harmonized System (HS), the Global Trade Analysis Project (GTAP) aggregates, Broad Economic Categories (BEC) Rev. 4, a 15 sectors aggregation of the HS provided by the World Customs Organization (WCO), and the ISIC Rev. 3 based classification of the International Trade and Production Database for Estimation (ITPDE, Borchert et al., 2020).[2] Indicators are differentiated by broad measure groups and more detailed aggregates, and with respect to whether they are imposed in an MFN or bilateral fashion. Moreover, most indicators are calculated for the years 2000-2016 or 2012-2016, and cover 155 or 119 reporting countries, depending on whether the underlying source data is retrieved from the WTO notifications or NTMTRAINS, respectively.

Second, with the set of indicators at hand, we analyze international patterns of NTMs and derive stylized facts. While the majority of the analysis is carried out on the basis of NTMTRAINS data, we contrast results with WTO notification-based data where applicable. We first conduct the analysis on the country-level and subsequently highlight differences in the NTM incidence across sectors.

The constructed dataset can be used in multiple ways. For example, the different types of indicators provide the basis for a comprehensive descriptive analysis as presented in Section 4. Furthermore, gravity equations can be augmented by one or more of the NTM indicators representing different interpretations of the source of NTM-related trade costs. In addition, indicators for structural regulatory differences can function as determinants for preferential trade agreements (PTA) or specific (sets of) PTA provisions related to the NTMs, or can highlight how NTMs shape global value chains and vice versa.

We proceed as follows: In Section 2 we shortly describe the properties of NTM data, as well as the data used for this paper. Section 3 presents the sets of indicators for each of the three heterogeneity dimensions, while Section 4 illustrates broad patterns of NTMs by country- and sector-level. Section 5 summarizes and concludes the analysis.

2 | DATA

Consistent with the wide definition of NTMs, information about or related to them can be found in multiple places. These include inventories of legislation, notification portals, business surveys, import refusal data, reviews of legislation, or international agreements. The interpretation of the given information differs by type of source. For example, while legislative inventories and notification portals describe the de jure state, complaint registers, data on import refusals, or business surveys are likely to provide more information about enforcement and trade restrictiveness implications of measures.

Given the array of possible sources, the actual properties of NTM information takes several forms:

- Binary variables indicating the existence of a measure;
- Numerical indicators capturing the main property of a measure (e.g., maximum residue limits, percentage of foreign equity ownership, etc.);
- Text of the actual regulation (or description thereof);
- Categorical variables that classify measures into predefined categories (e.g., whether a measure is discriminatory or not);
- Ordinal variables implying a ranking along a chosen dimension, for example, level of trade restrictiveness, or status of implementation;
- Computed indicators processing original information, for example, count or frequency ratios.

For an overview of NTM data and further information on its concepts see Rau and Vogt (2019). Which data is suitable for a given study depends on the underlying research question, as well as the geographic, sectoral/product, and temporal scope of the analysis. Studies using very specific regulatory data are usually constrained to a sector or set of products because collecting such data is resource intensive (e.g., Otsuki et al., 2001; Winchester et al., 2012).

This study analyzes the global NTM incidence globally across multiple sectors, which constrains us to the use of two databases. First, we use WTO notification data obtained from Ghodsi et al. (2017), who augment the original notifications retrieved from the WTO I-TIP portal by adding missing HS codes based on text-matching techniques. These data are available from 1995 onward, that is, since the notification mechanism has been in place, although particularly developing WTO members require more time to establish the institutional capacity to notify regulatory changes. With respect to time information we prefer the entry-into-force over the notification date. In addition, using WTO document identifiers we cross-check the data of Ghodsi et al. (2017), who retrieve notified NTMs from the I-TIP portal, with notification information obtained from the SPS and TBT Information Management System (IMS). In some cases this leads to adjustments with respect to the partners affected by a measure.

Second, as our main data source we use UNCTAD's NTMTRAINS, which contains information on NTMs based on full regulatory reviews. The base dataset (Stata researcher file v.12 retrieved from `trains.unctad.org`) includes measures collected between 2012 and 2018.[3] For this paper, we consolidate the data to 2016 by taking cross-sections collected for 2016 or the latest year available prior to 2016. If data are only available for 2017 and/or 2018 we retrieve the earlier year and remove those measure types introduced after 2016.[4] Both databases use the above-mentioned MAST NTM classification to categorize regulatory information (UNCTAD, 2019). Table 1 presents a consolidated version of the classification for import related measures covered by this study with more details and a listing of export-related measures provided in Appendix B. Chapters A to C are generally referred to as technical measures, while all other MAST chapters classify non-technical measures. With the exception of internal non-discriminatory charges the latter are exclusively imposed on imports, or in other words they are imposed "at-the-border". By contrast, this is rarely the case for technical measures, which very likely apply to foreign and domestic firms in a similar fashion.[5] Thus, SPS and TBT measures are mostly "behind-the-border" measures, usually designed to address non-trade-related policy objectives such as the protection of human or animal life, or technical regulations that specify product characteristics or requirements related to production processes.

NTMTRAINS categorizes measures at a very detailed level, while WTO notifications are only available at the level of notification requirement corresponding to the MAST chapter level. Consequently, comparing the information contained in the two databases is only possible by aggregate measure groups.[6] In absence of a common, unique identifier (e.g., an ID of the national legislation from the official gazettes) merging the two databases in order to for example, increase overall country coverage, is not possible unless the researcher is willing to make numerous assumptions. For example, one needs to assume that WTO notified entry-into-force dates as well as products affected by the measure match those recorded in the legislative reviews. However, oftentimes the entry-into-force date is not available and only the notification date is provided. Another problem that particularly pertains to analyses based on regulatory intensity/stringency is that, even if one successfully merges notifications and NTMTRAINS data on the basis of product codes, dates, and whether a measure is SPS or TBT, a notification may contain multiple measures that would be recorded separately in NTMTRAINS. For example, NTMTRAINS codes differences between labeling and packaging requirements for SPS and TBT measures. A corresponding regulation for a given product that contains both requirements may be notified together, but is coded separately in NTMTRAINS, leading to a count of 2 for NTMTRAINS and 1 for the WTO notifications. This means that in a consolidated database sector-level indicators for regulatory intensity are not comparable across observations.

TABLE 1 MAST classification for import-related measures.

MAST chapter	MAST codes	Description
A–Sanitary and phytosanitary measures (SPS)	A10-12	SPS prohibition/restriction
	A13	System approach
	A14-5	SPS auth/registration
	A2	SPS tolerance and use
	A31-2	SPS labels and marking
	A33	SPS packaging
	A4	Hygiene
	A5	Post-prod. Treatment
	A6	SPS Process control
	A81	Registration and approval
	A82	SPS testing
	A83	SPS certification
	A84	SPS inspection
	A85	SPS product documentation
B–Technical barriers to trade (TBT)	B10-1	TBT prohibition/restriction
	B14-5	TBT auth/registration
	B2	TBT tolerance and use
	B31-2	TBT labels and marking
	B33	TBT packaging
	B4	TBT process control
	B6	Product identity
	B7	Product performance
	B81	Registration and approval
	B82	TBT testing
	B83	TBT certification
	B84	TBT inspection
	B85	TBT product documentation
C–Pre-shipment inspections (PSI)	C1	Pre-shipment inspection
	C2-3	Transport route
	C4	Import license (formality)
E–Non-automatic import licensing, quotas, prohibitions, quantity-control and other restrictions not including SPS and TBTs	E11	Licenses economic
	E12	Licenses non-economic
	E2	Quotas
	E3	Prohibitions
	E5	Export restraints
	E6	Tariff-rate quotas
F–Price-controls, including additional taxes and charges	F1-2	Price control
	F3-6	Charges related to trade
	F7	Internal Non-discr. Charges

3 | NTM INDICATORS

This section reviews and extends the set of descriptive indicators based on binary data found in the literature, which we will use to illustrate international, cross-sectoral patterns of NTMs in Section 4.[7] This contrasts studies with for example, a narrow geographical and/or product scope, which are more likely to incorporate detailed regulatory information. In those cases the underlying policy data used to construct NTM indicators are a relatively accurate reflection of the sector-/product-specific regulatory substance. Given adequate detail in the measures' definition even a dummy variable signalling the presence of a measure is in most cases sufficiently informative.[8] However, data on specific policy instruments becomes less comparable and dummy variables become less meaningful the further we aggregate products into sectors. In that case, indicators presented in this section gain relevance and present a more feasible account of cross-country and cross-sector variation than a dummy.

We adopt a notation commonly used for gravity models of trade, where o is the origin country (i.e., exporter) and d the destination country (i.e., importer). Consequently, for all import-related measures, destination country d is the reporting/imposing country, while the origin country o is the reporter for measures on exports. Each number of measures M is of type A and levied on a product i defined at the 6-digit level of the HS. When aggregating to product groups or sectors we use index k. Furthermore, each measure enters into force at a year t and is assumed to continue being in force unless a date of withdrawal is provided.[9] Lastly, measures M of type A can be aggregated to measure groups (e.g., MAST chapters), which are indexed by g. That is, A_g signals measure A being part of group g with G number of different measures A_g. For example, a single MFN-type TBT testing requirement imposed by the USA on the product with 6-digit HS code 081020 translates into the following: USA is destination country d, the world is origin o, 081020 is product i, which is part of a higher aggregate k (e.g., vegetable products), M is 1, A_g is a TBT testing requirement with MAST code B82, and g is an aggregate measures group (e.g., conformity assessment, TBT, or technical measures).

3.1 | Intensity

Indicators of regulatory intensity reflect the stringency with which policy makers regulate products. Similar to previous studies we assume that the number of measures, of the same or different type, constitutes a suitable proxy for stringency (Cadot & Malouche, 2012; Gourdon, 2014; UNCTAD, 2017a). This assumes that a combination of measures increases the likelihood that corresponding policy objectives (e.g., consumer health and safety) are achieved—stringency regarding policy objectives—that each additional measure increases regulatory compliance costs—stringency regarding costs[10]—and for the subset of quality-related technical measures, a higher number of measures reflects increasing constraints on endogenous quality choices of firms—stringency regarding product quality.[11]

The NTM count C_{dkg} is the total number of measure-product combinations imposed by destination country d, for products i in sector k, and measures M_{di} in group g.

$$C_{dkg} = \sum_{g=1}^{G} \sum_{i=1}^{k} M_{di}^{A_g}. \tag{1}$$

A measure can affect multiple products and a product can be affected by multiple measures. Thus, C_{dkg} is interpreted as the total NTM incidence. However, C_{dkg} is an increasing function

of the number of products i in sector k and consequently can be misleading when comparing NTM footprints across different sectors. This problem is addressed by the prevalence score PS_{dkg}, which is the average number of measure per product in a given aggregate k. It is calculated by dividing the NTM count by the total number of 6-digit products i in a given sectoral aggregation k.

$$PS_{dkg} = \frac{\sum_{g=1}^{G}\sum_{i=1}^{k} M_{di}^{A_g}}{\sum_{i=1}^{k} D_i}. \tag{2}$$

Both indicators can be bilateralized by adding subscript o, which would further differentiate between MFN-type and bilaterally imposed measures. For example, C_{odkg} would then be the number of measure-product combinations imposed by country d on imports from o in sector k.[12]

3.2 | Coverage

In contrast to indicators reflecting regulatory intensity, indicators capturing the coverage, or scope, of NTMs are (a) the share of products covered by at least one measure (frequency index), and (b) the share of trade covered by at least one NTM (coverage ratio). Both coverage indicators are invariant to regulatory intensity.

The frequency index FI_{dkg} is defined as the number of products affected by at least one measure of group g, divided by the total number of products in aggregate k—that is, the share of products i in aggregate k.

$$FI_{dkg} = \frac{\sum_{i=1}^{k} \mathbb{1}(M_{di}^{A_g} > 0)}{\sum_{i=1}^{k} D_i}. \tag{3}$$

This implies that the wider the measure group g is defined, the more likely a product is affected by at least one measure (i.e., $\mathbb{1}(M_{dig} > 0)$ equals 1). This means that FI_{dkg} increases with wider definitions of g. In addition to the frequency index, the coverage ratio CR_{dkg} defines the volume of trade affected by at least one NTM divided by the total volume of trade in sector k.

$$CR_{dkg} = \frac{\sum_{i=1}^{k} \mathbb{1}(M_{di}^{A_g} > 0) X_{di}}{\sum_{i=1}^{k} X_{di}}. \tag{4}$$

Similar to the frequency index, CR_{dkg} increases with wider definition of measure groups. Furthermore, as it is usually the case with trade-weighted indexes the coverage ratio is highly sensitive to measures that are trade restrictive or even prohibitive like an import ban that would render the nominator to zero.[13]

3.3 | Structure

Indicators representing regulatory structure require relatively detailed information on NTMs because variation in the indicator is caused by differences in types of measures rather than number or coverage thereof. A basic indicator of regulatory structure is the unique number of measures

U_{dkg} defined by the average number of unique measures of a certain type per product i in sector k for a given measure group g.

$$U_{dkg} = \frac{\sum_{g=1}^{G}\sum_{i=1}^{k} \mathbb{1}(M_{di}^{A_g} > 0)}{\sum_{i=1}^{k} D_i}.$$

Dividing U_{dkg} by the corresponding prevalence score results in the share of unique measures vis-a-vis all measures. Thus, a value of one means that on average all imposed measures are different, while lower values translate to a regulatory profile characterized by many measures of the same kind.

3.3.1 | Regulatory distance

Bilateral regulatory differences are captured by distance indexes that represent trade costs as a function of similar/different regulatory requirements abroad compared to the home market. For a firm operating in origin country o_1 technical measures imposed by destination country d present a fixed cost related to for example, product design. If a firm is required to comply to the same (or similar) types of measures at home, (part of) these fixed costs are likely to be already incurred. In such a case, trade costs are lower relative to an exporter located in country o_2 with a more dissimilar regulatory profile compared to d—that is, the fixed costs of exporting from o_2 to d are at least as high as exporting from o_1 to d. This relationship even holds if measures differ with respect to their specific requirements assuming that any experience with complying to a certain type of measure is better than being completely inexperienced. For example, for a labeling requirement imposed by country d and o_1, but not by country o_2, we assume that the related fixed costs for firms in o_1 are equal to or lower than for firms in o_2, even if the information required on labels in d and o_1 differ. This makes the indicators of regulatory distance applicable to binary policy information.

Within this context trade is a function of the types of measures imposed in countries o and d and is facilitated by increasing type similarity. In order to operationalize the concept we define A_g^o as the set of different types of measures imposed by country o and A_g^d as the set of the types of measures imposed by country d (see e.g., Lesot et al., 2009). From this we derive the number of measures types:

- In common: $|A_g^o \cap A_g^d|$, denoted a.
- Only imposed by o, but not d: $|A_g^o - A_g^d|$, denoted b.
- Only imposed by d, but not o: $|A_g^d - A_g^o|$, denoted c.
- Imposed by neither country: $|\overline{A}_g^o \cap \overline{A}_g^d|$, denoted d.

While indicators a, b, c, and d are informative in their own right, they also provide the basis for constructing the regulatory distance indicators presented in Table 2. The application base for each indicator depends on the underlying definition of regulatory distance. While Sokal and Michener-based (or simple matching) measures decrease with the joint presence and absence of measures (also used by UNCTAD, 2017a), Jaccard distances only decrease with two countries having actual measures in common, that is, joint presences.[14]

TABLE 2 Distance measures.

Name	Indicator	Description
Jaccard (J)	$D^{J}_{odig} = 1 - \frac{a}{a+b+c}$	Symmetric *odig* level indicator decreasing in joint presence of measures
Simple matching (S)	$D^{S}_{odig} = 1 - \frac{a+d}{a+b+c+d}$	Symmetric *odig* level indicator decreasing in joint presence and absence of measures
Jaccard overlap	$RO^{J}_{odig} = 1 - \frac{a+b}{a+b+c}$	Asymmetric *odig* level indicator decreasing in joint presence of measures and measures imposed by *o* but not by *d*
SM overlap	$RO^{S}_{odig} = 1 - \frac{a+b+d}{a+b+c+d}$	Asymmetric *odig* level indicator decreasing in joint presence and absence of measures and measures imposed by *o* but not by *d*
a-*c* difference	$D^{Dif}_{odig} = a - c$	Asymmetric *odig* level indicator increasing in joint presences and decreasing in measures imposed by *d* but not by *o*
Jacc/SM intensity	$D^{Int}_{odig} = D_{odig} * \frac{C_{oig}+C_{dig}}{2}$	Symmetric *odig* level indicator that increases with distance and average counts of measures between *o* and *d*
Jacc/SM intensity (*d*)	$D^{Int_d}_{odig} = D_{odig} * C_{dig}$	Asymmetric *odig* level indicator that increases with distance and counts of measures in *d*

Note: In contrast to indicators of intensity and coverage, distance measure are defined on the product-level.

Similar to standard gravity distance variables simple matching and Jaccard distance measures are symmetric. However, firms with relatively high compliance capacity operating in a complex regulatory environment may find it easier to export to a country with a lower regulatory footprint. To capture this asymmetry, we define the distance measures above as a decreasing function of *b*, that is, measures only imposed by the exporter *o*. This is similar to what UNCTAD (2017b) defines as regulatory overlap. Such overlap measures can be based on simple matching and Jaccard distance measures.[15] Furthermore, we define the asymmetric *a*-*c* difference to relate the number of measures imposed by *o* and *d* to measures only imposed by the destination country. The indicator decreases in the number of measures imposed by country *d* that are additional to measures imposed on the home market of the exporter.

Distance measures can further incorporate regulatory stringency and be weighed by the average number of measures between the origin and destination country, as well as total number of measures at the destination country. The combined indices increase in the number of NTMs but at a lower rate for country pairs with a similar regulatory structure.

3.3.2 | Interdependence

A driver of regulatory similarity is by design the co-occurrence of specific measures across different countries. In order to identify how meaningful co-occurrences of two measures are, we employ indicators used in association analysis (see for example Hastie et al., 2017). By this we aim to identify patterns of co-occurrences that point towards particular regulatory designs (e.g., are measures restricting the use of certain substances accompanied by testing requirements).

As a basis we determine for each product i and different measures A_1 and A_2 the number of countries that impose both measures, given that at least 2 countries impose either A_1 or A_2. The share of these countries among countries that impose at least 1 measure is referred to as support, or $P(A_1 \cap A_2)$.[16] The degree to which one measure is implied by the other is the confidence defined by $P(A_1 \cap A_2)/P(A_1)$. The confidence indicator adjusts the probability with which A_1 and A_2 jointly occur by the probability of A_1. Consequently, confidence is an estimate of $P(A_2|A_1)$. It decreases in high occurrence of A_1 and takes into account that co-occurrence may simply be a function of A_1's high incidence. Thus, a statement such as that A_1 implies A_2 is further qualified. To what degree A_1 and A_2 are associated is referred to as lift ($P(A_2|A_1)/P(A_2)$), which adjusts the conditional probability of A_2 on A_1 by the probability of measure A_2 being present. Any value of the lift higher than 1, implying that $P(A_2|A_1) > P(A_2)$, signals a relatively high association of the measures. For example, if 20% of countries impose measures A_1 and A_2 at the same time the support is 0.2. If A_1 is imposed by 30% of the countries, the corresponding confidence index will be 0.67, which means that in 67% of the cases when A_1 was present A_2 was imposed, as well. Adjusting for the unconditional probability of A_2 (e.g., 0.25) the lift index is then 2.7.

We pool products in a given sector k to derive association measures for sectoral or total aggregates. In order to adjust the association indicators to their relevance within a sector we multiply them with the share of products they apply to, that is, we additionally provide a version of the support, confidence, and lift that takes into account the number of unregulated products. In case of the support, the derived index ($Sup_{kA_1A_2}$) is comparable to the sector-level frequency index presented above, averaged over all countries that have at least on measure in place (FI_{kg}). While $Sup_{kA_1A_2}$ is measure-specific (e.g., support of B81 and B33), the share of products affected by any measure is defined over measure group g, in this case defined on the MAST chapter level. As a result, the relevance of the support vis-a-vis the frequency index FI_{kg} is determined by comparing the average share of products to which the rule applies to the share of products affected by at least one measure within the MAST chapter. This is captured by $Sup_{kA_1A_2}/FI_{kg}$. By construction this ratio is defined for the interval [0,1] with 1 meaning that A_1 and A_2 are always imposed when any measure (incl. A_1 and A_2) of the MAST chapter in question is present. Analogously, a value of 0.5 implies that A_1 and A_2 are imposed in 50% of the cases when at least on NTM of group g is imposed.

In summary, we differentiate between three sets of NTM indicators corresponding to different regulatory heterogeneity dimensions: intensity, coverage, and structure. Measures of regulatory intensity reflect the degree to which multiple measures, including many of the same type, are imposed on a product, while coverage indicators highlight the pervasiveness of NTMs across different products and trade values. In addition, indicators describing regulatory structure focus on regulatory heterogeneity with respect to the types of measures imposed and to what degree they may be complementary. We present these indicators acknowledging that the underlying binary data provides little information about the actual policy substance. This is a general constraint for NTM analyses with a broad sectoral and geographic scope. Due to the sparseness of NTM data the usefulness of the indicators increases with higher aggregation of the data, while on the product-level, dummy variable research designs are likely to be preferable.

3.4 | Aggregation

Aggregation in an NTM-context relates to the weight assigned to product i in sector k, or measure M^{A_g} in an index for measure group g, or both. Indicators presented above assign equal weights to

products and measures with the exception of the coverage ratio, which introduces trade weights to the frequency index. In this section we present how trade weights are used to aggregate products into sectors, as well as how a principal component analysis (PCA) can be used to define variance-based weights to aggregate sub-indexes of specific measure groups.[17]

3.4.1 | Trade-weighted aggregation

Count and prevalence indexes presented above weigh products equally when aggregating to k. Such an aggregation is likely to give too much weight to products that may not be relevant as imports for destination country d. In order to address this problem we follow an approach from the tariff literature and weigh NTM indicators by trade. The approach differentiates between measures applied on an MFN-basis and those imposed bilaterally. Thus, the total NTM incidence between two countries in a given indicator Z and sector k is captured by:

$$Z^{TW}_{odkg} = \sum_{i=1}^{k} w_{di} Z_{dig} + w_{odi} Z_{odig} \quad \text{with} \quad w_{di} = \frac{\sum^{o} X_{odi}}{\sum^{o} \sum_{i=1}^{k} X_{odi}} \quad \text{and} \quad w_{odi} = \frac{X_{odi}}{\sum_{i=1}^{k} X_{odi}}.$$

Here, w_{di} and w_{odi} refer to the share of product i in sector k's imports of country d, from all countries or specific origin country o, respectively. While w_{di} is used with NTMs that are applied in an MFN-fashion, w_{odi} is used with bilaterally applied measures. This avoids "bilateralizing" MFN measures via trade weights.[18]

Similar to atheoretical tariff aggregation, trade-weighted aggregations of NTM indicators suffer problems of endogeneity when measures are very trade restrictive or promoting (Anderson & Peter Neary, 2005). To alleviate this problem weights can be constructed on the basis of world trade. However, this leads to the loss of country-specific information with respect to the structure of trade. Alternatively, Bouët et al. (2008) create reference group-based weights to aggregate tariffs, that is, weights based on average trade of a reference group of countries. The idea is to determine what a country typically should import given the trade profile of a group of similar countries, for example, determined by their GPD per capita. Thus, assuming that not all countries of the reference group impose trade restrictive/prohibitive measures on product i, C_{dig} and C_{odig} still receive positive weights even if one of the reference group's countries imposes prohibitive measures.

3.4.2 | Variance-based measure aggregation

In the absence of expert opinion based weighting schemes, contribution-to-variance-based weighing offers an alternative to aggregate single NTMs to higher level measure groups (see Nicoletti et al., 2000).[19] The calculated weights contain valuable information about where cross-country regulatory differences are most prevalent, that is, they help to identify key measures in particular sectors across countries.

To obtain weights we perform a principal component analysis (PCA) on the covariance matrix of NTM sub-indexes and retrieve the contribution of each component to the overall variance in the data, as well as the contribution of each sub-index to the variance of each component.[20] More specifically, the PCA is based on an eigenvalue decomposition of the square covariance matrix Σ, that is, $\Sigma V = \Lambda V$ with Λ the diagonal matrix of eigenvalues and V the matrix of corresponding

eigenvectors. The eigenvalues λ_a captures the contribution of each component to the overall variance (i.e., $C_a^w = \lambda_a / \sum_i \lambda_i$), while the Hadamard product matrix $W = ((\Lambda V)^2 \circ 1/(\lambda^T)^2) * 100$ gives us the contribution of each variable to the respective variation in the components (see e.g., Husson et al., 2011. Here, w_{C_a} lists the contribution of each variable to component a, and a row vector w_{V_b} lists the contribution of a variable b to each of the components. The weights for composite NTM indicators are then calculated by:

$$w_{V_b} = \sum_a w_{C_a} C_a \quad \text{and} \quad NTM_{AGG} = \sum_b w_{V_b} NTM_b \quad \text{with} \quad \sum w_{V_b} = 1.$$

The covariance matrix Σ is calculated on the basis of centered prevalence scores—that is, if A is the data matrix with centered prevalence scores then $\Sigma = A^T A$. Usually, prior to performing a PCA, vectors of data matrix A (i.e., variables) are standardized. This procedure is applicable when variables are measured in different units. By using prevalence scores we already work with variables measured by the same units (average number of measures) and thus do not need to standardize. Furthermore, the advantage of prevalence scores over simple counts is that we adjust for the number of products in a given aggregation. Thus, we avoid that high counts are a function of the sectoral aggregation.[21]

A possible downside of this approach is that the calculation of the weighting scheme is sample dependent. Thus, adding or removing a country from the sample changes aggregation weights, which contrasts for example, expert opinion based approaches with constant weights per measure.

4 | PATTERNS OF NTMS

In the following we make use of the indicators described above to highlight patterns of NTMs in international trade and summarize the main findings in stylized facts. We focus on overall country- and sector-level patterns using NTMTRAINS and WTO notification data consolidated by Ghodsi et al. (2017). In Section 4.1, we provide aggregate and country-level comparisons of WTO notifications based on the mapping described in Section 2. Due to notification requirements under the SPS and TBT Agreements the analysis focuses on SPS and TBTs when WTO notification data is presented and is expanded to other import-related measures otherwise (see Table 1). Section 4.2 illustrates patterns of NTMs across sectors.

4.1 | Country level

> **Stylized Fact I.** The majority of technical measures are formally applied in a non-discriminatory fashion across trading partners.

Overall, in the period from 2000 to 2016 countries consistently notified new or changes to existing SPS and TBT measures to the WTO, with the overwhelming majority of measures being imposed in a non-discriminatory fashion across all trading partners. This is captured by Figure 1, which shows the stock of WTO-notified SPS and TBT measures—expressed as the average number of measures per product—carried over time in total (left) and differentiated by whether measures applied bilaterally (i.e., with partner countries specifically targeted) and on a MFN-basis

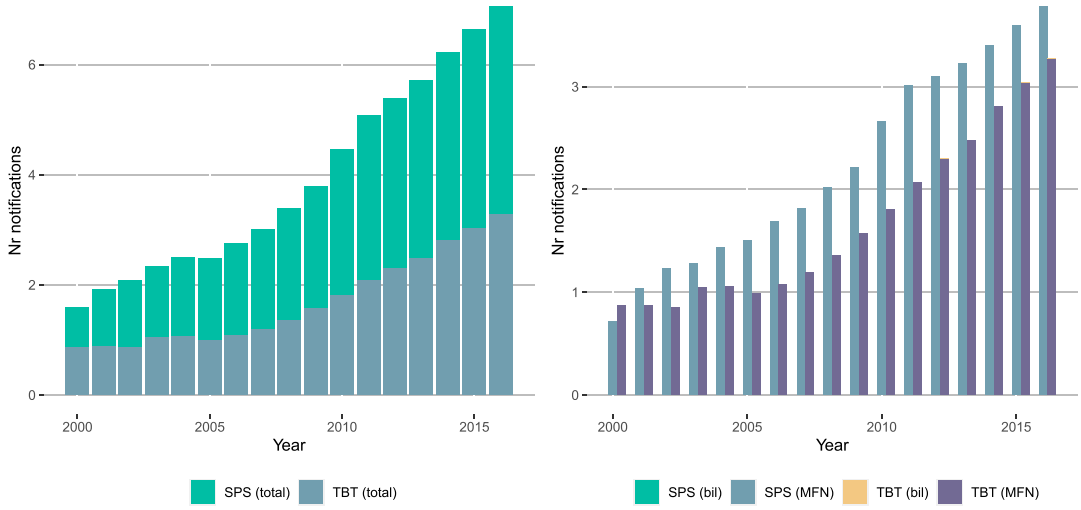

FIGURE 1 WTO SPS & TBT notifications over time. (1, Data retrieved from Ghodsi et al. (2017); 2, Average number of notifications per product.) [Colour figure can be viewed at wileyonlinelibrary.com]

(i.e., to all partners alike). Bilateral measures targeting specific trade partners only playing a very small role in aggregate and are mainly comprised of either STCs (all TBTs and ca. 25% of SPS) or SPS emergency measures (ca. 25%). While emergency measures are trade restrictive by design (e.g., an import ban as a pest control measure), STCs are based on complaints by WTO member(s) about an overly restrictive measure by another WTO member, pointing toward de facto discriminatory application of the measure. Their small share is in line with the WTO SPS and TBT agreements, which state that measures shall not arbitrarily or unjustifiably discriminate between trading partners. Moreover, it is likely that the bulk of MFN-type measures applies to domestic firms (national treatment), as well, because technical, standard-like measures are primarily set according to a regulatory objective instead of a trade-restrictive objective.

A comparison between the two global NTM datasets on the country-level reveals that the NTM incidence of SPS and TBT measures notified to the WTO and identified in the legislative reviews positively correlates, despite noticeable differences between the two databases for some countries. This is shown by Figure 2, which maps countries' SPS and TBT counts contained in NTMTRAINS and WTO notifications against each other. We observe the following: First, for each measure group there are a number of countries, which do not notify SPS and TBT measures at all. Among them are relatively large countries like Ethiopia, Algeria, Cote d'Ivoire, or Belarus. However, NTMTRAINS regulatory reviews indicate that many of these countries should have a relatively high NTM incidence (e.g., Cambodia has a similar count index as Canada). Second, SPS counts are generally higher for review-based data, which suggests that either countries under-notify, or that the more detailed coding of NTMTRAINS data results in a higher count per se. Third, TBT counts are similar for some countries in both databases (e.g., Switzerland, Australia, or China), while others are relatively far away from the 45 degree line (e.g., Israel, Morocco, Pakistan). This significantly changes the ranking of countries in terms of their implied regulatory stringency. For example, Israel is one of the more stringent countries based on WTO notification data but in the lower third of countries based on the legislative reviews. Fourth, in terms of income level, clear patterns emerge in terms of (a) higher income countries notify more actively to the WTO, (b) low income countries have a low regulatory footprint, and for TBTs tend to severely under-notify, and

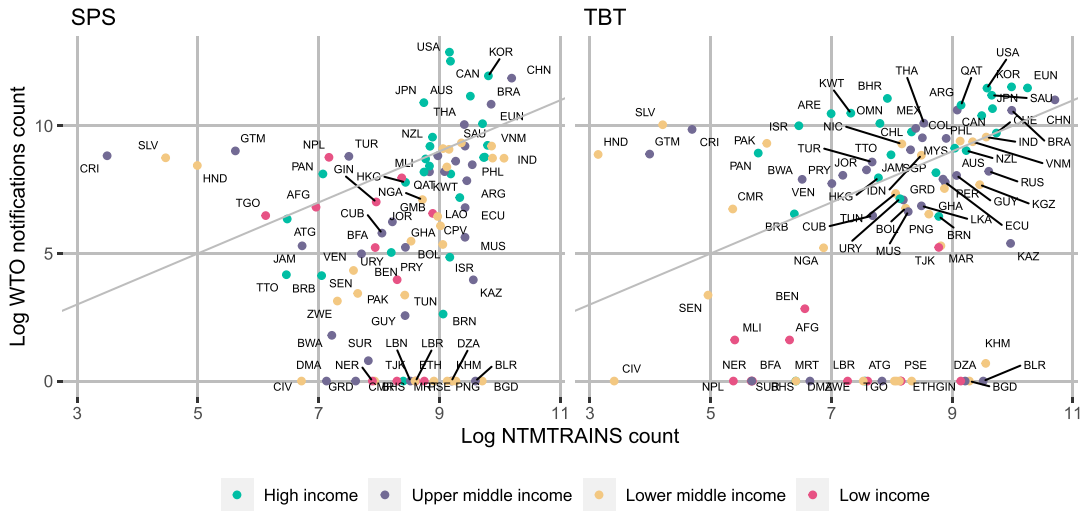

FIGURE 2 NTMTRAINS versus WTO notifications by country, 2016. (1, Data retrieved from Ghodsi et al. (2017); 2, Average number of notifications per product.) [Colour figure can be viewed at wileyonlinelibrary.com]

(c) a clear contrast of the regulatory footprint is difficult to establish between high, upper-middle, and lower-middle income countries. Overall, the apparent differences should be kept in mind when comparing sector- or aggregate-level analyses of SPS and TBT measures using different data-sources.

The independent legislative reviews in NTMTRAINS are a useful source to assess WTO members' notification behavior, particularly for those countries not notifying at all. 20 years after the notification mechanism was put in place some countries seem to have addressed early concerns regarding notification compliance and quality of WTO members' notifications (see e.g., Cadot & Malouche, 2012), while others are still not participating in, or struggling with for example, the institutional capacity requirements of this transparency mechanism. Especially low and lower middle income countries tend to under-notify, which would support the lacking-institution hypothesis.

> **Stylized Fact II.** Regulatory stringency positively correlates with income levels—high and middle income countries impose more measures per product than low income countries. However, broad measure groups comprise similar shares in the total NTM incidence across income groups.

On average regulatory stringency increases with income, while the composition of different groups of NTMs is relatively similar across income groups (see Figure 3). High and middle income countries impose approximately twice as many measures per product compared to low income countries—3.4 to 4.1 for lower middle to high income versus 1.7 for low income countries. The majority of measures across all income groups are SPS and TBT measures comprising ca. 75% of all measures per product. Quantity- and price-based measures (14% to 18%) as well as pre-shipment inspections (3% to 13%) constitute only a small share of total measures, but are the types of policies exclusively targeted at international trade. Trade-related charges, licensing requirements, and prohibitions for economic reasons are the most prominent policies among non-technical measures. In contrast to licensing requirements for economic reasons, some non-technical measures

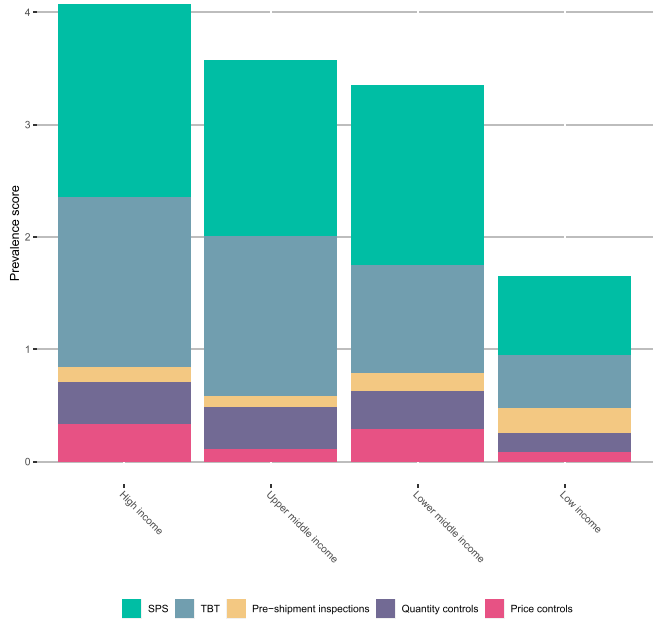

FIGURE 3 Comparison of measures by income group. (1, Data—NTMTRAINS; 2, Guinea was removed from price-based measures. It exerts disproportional influence on the average low-income country prevalence score, which drops from 0.7 to 0.1 price-control measures per product when excluding Guinea.) [Colour figure can be viewed at wileyonlinelibrary.com]

are trade-restrictively designed with a legitimate policy objective in mind. For example, many import prohibitions are imposed for non-economic reasons (e.g., an import ban of alcohol or print media with pornographic content for religious or moral reasons) and are sometimes even tied to international agreements. This concerns for example international conventions on wild life, arms or drug trade, dual use goods, or chemicals that can act as precursors.

> **Stylized Fact III.** Structural regulatory differences follow regional patterns with countries from the same region showing a more similar regulatory structure.

Similarity in regulatory stringency does not necessarily translate into an equal regulatory structure in terms of the types of measures imposed. Figure 4 plots the Jaccard distance for technical measures, as well as the average number of uniquely imposed measures mapped against the average number of all measures differentiated by region. Countries that are geographically close or in the same region tend to impose similar types of technical measures. For example, we can identify a Latin American bloc (e.g., Uruguay, Brazil, Chile, Nicaragua, Argentina, or Jamaica) in the lower part of the figure, East Asian & Pacific countries that are located close to each other, as well as a cluster of countries that share a Soviet past (Russia, Belarus, or Kazakhstan) and a cluster of countries that impose few regulations (Sub-Sahara African countries). Additionally, the right-hand side of Figure 4 highlights that countries' regulatory structure differs in terms of whether they impose the same types of measures multiple times—countries further away from the 45 degree line—or impose a unique set of measure types—countries closer to the 45 degree line. By combining the two sides of Figure 4 we can for example, infer that Korea and Brazil are relatively similar in terms of uniqueness and prevalence, but exhibit a comparably high regulatory distance. Thus, they impose different types of measures. This example emphasizes that the

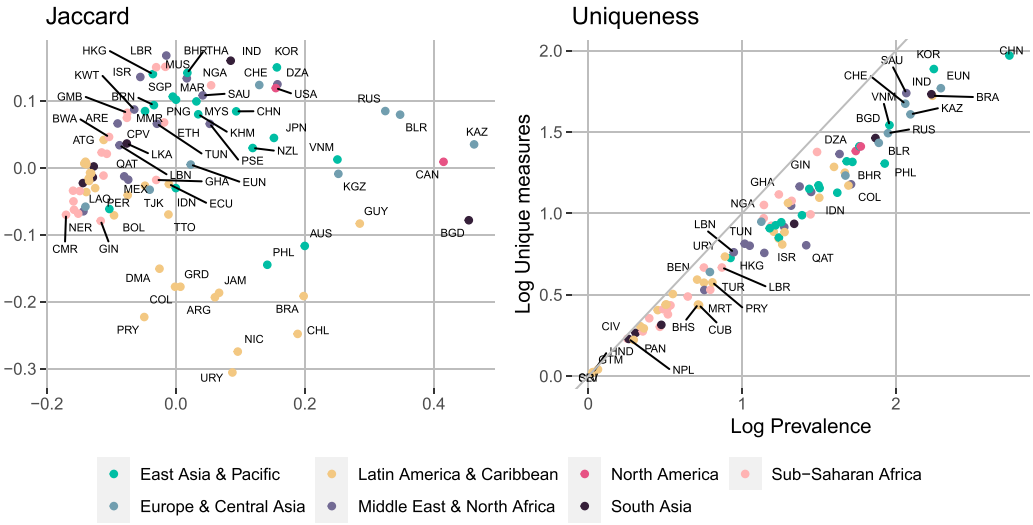

FIGURE 4 Structural heterogeneity of technical measures, 2016. (1, Data—NTMTRAINS; 2, The LSH figure is based on the first two dimensions derived from multi-dimensional scaling (MDS) of the Jaccard distance matrix for technical measures.) [Colour figure can be viewed at wileyonlinelibrary.com]

countries' NTM profile is complex and multifaceted, which requires a nuanced set of indicators to properly account for regulatory differences.

> **Stylized Fact IV.** Among technical measures, there are distinguishable joint occurrences of specific measures suggesting regulatory complementarity.

Specific pairs of technical measure types occur jointly relatively more often than others, which indicates measures interdependence and resembles a form of regulatory system. Figure 5 transforms the association measures developed in Section 3 into heatmaps and identifies frequent measure associations via the confidence index ($P(A_2|A_1)$, the lift ($P(A_2\ |A_1)/P(A_2)$), and a weighted version of the confidence index. First, we observe multiple relationships of measure pairs where the presence of A_1 (y-axis) implies the presence of A_2 (x-axis) in 60% to 80% of the cases. SPS process control measures often imply the presence of SPS substance tolerance and use limits (A2), hygiene (A4), as well as SPS certification requirements (A83). Similarly, SPS certification and inspection requirements (A83, A84) come with post-production treatment obligations (A5), and TBT substance tolerance and use limits imply with a high likelihood TBT labeling and marking, product performance, and testing requirements. Second, we find a generally high association between two measures ($P(A_2|A_1)/P(A_2)$) for SPS testing and packaging requirements (A82 and A33), SPS process control and TBT product identity (A6 and B6), as well as SPS and TBT registration and approval requirements (A81 and B81). Third, comparing the confidence index with its weighted counterpart shows that the distinctive pattern of joint occurrences of SPS measures is not visible anymore for the weighted confidence index. This coincides with the strong proliferation of SPS measures for agricultural products, which represent a small share in the number of total products. By contrast, patterns of joint occurrences of TBT measures still hold for the weighted confidence index, which is consistent with the widespread use of TBTs across all sectors. Thus, the identified associations between different measure types and implied regulatory systems are likely to be more pronounced on the sectoral level and across different country groups, as suggested by the geographic clusters of regulatory distances in Figure 4.

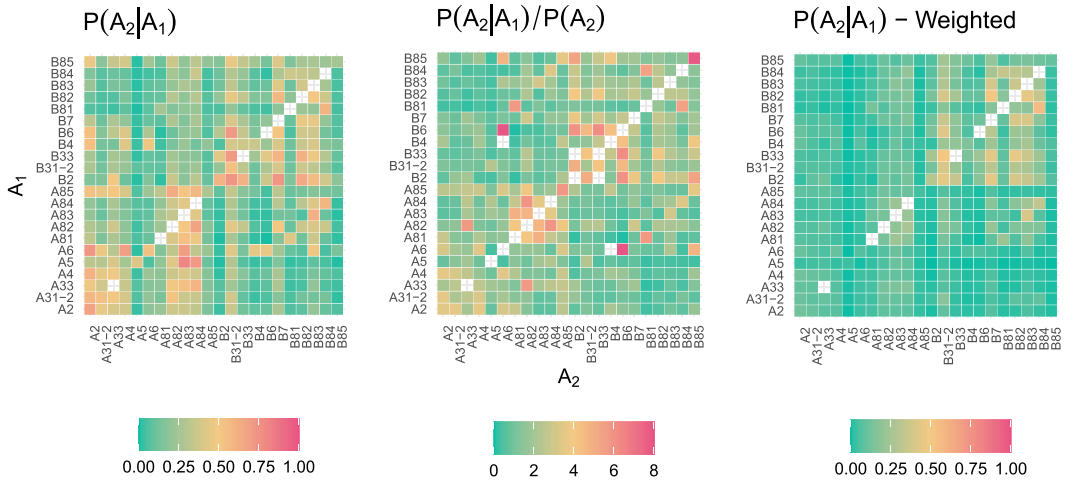

FIGURE 5 Association of SPS and TBT measures, 2016. (1, Data—NTMTRAINS; 2, y-axis and x-axis represent measures A_1 and A_2, respectively' 3, For the confidence index $P(A_2|A_1)$ the interpretation is as follows: $A_1 \rightarrow A_2$, that is, the degree to which A_2 measures come with A_1 measures; 4, Measures were averaged to the sub-categories presented in Appendix B; 5, RHS figure is weighted by the share of products to which joint occurrence applies; 6, Measure legend based on the MAST classification presented in Table 1 and Appendix B: A2 SPS tolerance and use, A31-2 SPS labels and marking, A33 SPS packaging, A4 SPS hygiene, A5 SPS post-production treatment, A6 SPS process control, A81 SPS registration and approval, A82 SPS testing, A83 SPS certification, A84 SPS inspection, A85 SPS documentation, B2 TBT tolerance and use, B31-2 TBT labels and marking, B33 TBT packaging, B4 TBT process control, B6 TBT Product identity, B7 TBT product performance, B81 TBT registration and approval, B82 TBT testing, B83 TBT certification, B84 TBT inspection, B85 TBT product documentation.) [Colour figure can be viewed at wileyonlinelibrary.com]

4.2 | Sectoral level

This section highlights sectoral heterogeneity of NTM patterns. It includes a PCA-based variance decomposition of regulatory stringency to illustrate which specific measure groups contribute most to cross-country differences in NTMs. Overall, the results suggest that there is significant sectoral heterogeneity across all indicators embedded in the total averages presented in the last section.

> **Stylized Fact V.** Agri-food sectors are across almost all measure groups consistently the most regulated sectors in terms of regulatory intensity and coverage.

SPS and TBTs are the most prevalent NTMs, with agri-food sectors the most regulated in terms of regulatory stringency and coverage. Table 3 depicts the average regulatory intensity and coverage by sector for five import-related measure groups, as well as export-related measures. By measure group we can identify the following main patterns: First, SPS measures cover 16% of all products and 24% of total trade value. The high total incidence is driven by a high prevalence for animal, vegetable and food products with approximately 7 to 15 measures per product. By contrast, SPS measures play a limited role in manufacturing industries and extractive sectors. Second, TBTs cover significantly more products (30%) and trade (44%) than SPS measures. They cover products more evenly across sectors, while the number of measures is highest for agri-food products, chemicals, textiles and clothing, transport, and machinery and electronics.

Third, pre-shipment inspections are the least used technical measure covering only 10% of all products and ca. 14% of trade, with the highest number of measures imposed in agri-food

TABLE 3 Regulatory intensity and coverage per MAST chapter and sector, 2016.

	SPS (A)				TBT (B)				Pre-shipment inspections			
Sector	**Count**	**Prevalence**	**Frequency**	**Coverage**	**Count**	**Prevalence**	**Frequency**	**Coverage**	**Count**	**Prevalence**	**Frequency**	**Coverage**
Animal	2981.58	15.37	0.84	0.87	791.83	4.08	0.62	0.69	153.47	0.79	0.33	0.33
Vegetable	2475.45	7.66	0.70	0.83	751.88	2.33	0.51	0.63	146.87	0.45	0.30	0.36
FoodProd	1287.02	7.11	0.74	0.73	495.21	2.74	0.60	0.61	60.62	0.33	0.22	0.21
MinFuel	19.38	0.11	0.05	0.07	100.13	0.59	0.19	0.47	13.57	0.08	0.06	0.19
Chemicals	336.47	0.44	0.13	0.23	1339.40	1.76	0.33	0.49	67.72	0.09	0.06	0.12
PlastiRub	55.41	0.29	0.13	0.16	166.55	0.88	0.24	0.32	18.03	0.10	0.09	0.12
HidesSkin	80.27	1.08	0.34	0.45	75.46	1.02	0.32	0.39	10.81	0.15	0.11	0.12
Wood	186.46	0.82	0.17	0.27	154.20	0.68	0.25	0.35	27.90	0.12	0.10	0.15
TextCloth	141.18	0.17	0.07	0.18	873.36	1.08	0.40	0.49	114.43	0.14	0.13	0.13
Footwear	24.39	0.44	0.18	0.27	52.47	0.95	0.39	0.55	5.84	0.11	0.10	0.14
StoneGlas	23.44	0.12	0.05	0.04	112.82	0.59	0.22	0.26	17.71	0.09	0.08	0.12
Metals	48.95	0.08	0.05	0.07	245.90	0.42	0.16	0.20	38.99	0.07	0.06	0.06
MachElec	70.49	0.09	0.07	0.07	914.53	1.20	0.31	0.34	85.09	0.11	0.08	0.10
Transport	21.73	0.16	0.11	0.15	166.14	1.26	0.36	0.39	15.40	0.12	0.10	0.13
Misc	79.02	0.21	0.10	0.15	328.20	0.85	0.25	0.34	31.31	0.08	0.08	0.10
Total	7572.86	1.50	0.16	0.24	6019.94	1.19	0.30	0.44	712.99	0.14	0.10	0.14

TABLE 3 Continued

	Quantity-control (E)				Price-based (F)				Export-related (P)			
Sector	**Count**	**Prevalence**	**Frequency**	**Coverage**	**Count**	**Prevalence**	**Frequency**	**Coverage**	**Count**	**Prevalence**	**Frequency**	**Coverage**
Animal	205.49	1.06	0.40	0.44	401.16	2.07	0.59	0.58	1335.54	6.88	0.73	0.72
Vegetable	159.35	0.49	0.27	0.33	376.69	1.17	0.46	0.56	894.56	2.77	0.56	0.62
FoodProd	85.10	0.47	0.27	0.28	134.58	0.74	0.34	0.38	387.93	2.14	0.51	0.48
MinFuel	38.75	0.23	0.14	0.43	47.62	0.28	0.14	0.40	332.28	1.95	0.29	0.54
Chemicals	426.77	0.56	0.29	0.42	294.58	0.39	0.16	0.25	1757.03	2.31	0.22	0.35
PlastiRub	25.75	0.14	0.11	0.11	68.47	0.36	0.17	0.22	102.69	0.54	0.23	0.20
HidesSkin	38.35	0.52	0.31	0.32	48.56	0.66	0.34	0.43	148.87	2.01	0.45	0.45
Wood	43.81	0.19	0.12	0.26	109.31	0.48	0.23	0.32	541.17	2.37	0.28	0.25
TextCloth	176.38	0.22	0.18	0.19	324.35	0.40	0.24	0.32	611.94	0.76	0.31	0.25
Footwear	18.28	0.33	0.24	0.35	36.09	0.66	0.39	0.51	41.32	0.75	0.37	0.40
StoneGlas	25.88	0.14	0.12	0.22	67.23	0.35	0.19	0.26	342.44	1.80	0.25	0.25
Metals	66.36	0.11	0.10	0.10	199.97	0.34	0.15	0.18	230.65	0.39	0.19	0.17
MachElec	416.02	0.55	0.33	0.34	311.00	0.41	0.21	0.26	1127.00	1.48	0.43	0.38
Transport	63.29	0.48	0.31	0.34	58.90	0.45	0.25	0.29	1066.45	8.08	0.37	0.35
Misc	119.78	0.31	0.20	0.24	139.58	0.36	0.19	0.23	304.88	0.79	0.25	0.25
Total	1681.37	0.33	0.20	0.29	1478.46	0.29	0.13	0.17	4852.83	0.96	0.25	0.28

Note: 1, Data—NTMTRAINS.

sectors, textiles and clothing, and hides and skins. Fourth, among non-technical import measures quantity-control policies are the most prevalent and cover more products and trade than the more concentrated SPS measures. Besides the highly regulated agri-food sectors, quantity controls are imposed on ca. 30% of all chemical, hides and skin, machinery and electronic, and transport products, affecting approximately 32% to 42% of imports in these sectors. In addition, price-based measures are the least used import measure besides the aforementioned pre-shipment inspections. Considering that Guinea makes up ca. 25% of all counts, the relative importance of these types of measures is even less than Table 3 suggests.[22]

Fifth, measures on exports are mainly composed of technical measures (e.g., authorization requirements or conformity assessments) with quantity control measures for non-technical reasons, as well as measures on re-exports playing a smaller role. Thus it is not surprising to see a high incidence for those sectors that are also heavily affected by technical import measures, for example, agricultural and food products, chemicals, and the transport sector. Overall, Table 3 shows that SPS, TBT, and quantity-control measures are the most relevant import measures across all sectors, with agri-food sectors clearly displaying the highest NTM incidence in terms of intensity and coverage.

> **Stylized Fact VI.** For each sector, the majority of cross-country variation in regulatory stringency is captured by a small subset of measures.

The specific drivers of cross-country differences in regulatory intensity widely differ across sectors, with SPS authorization and registration, tolerance and use restrictions, certification, and inspection requirements, and TBT labels and marking obligations dominant in agri-food sectors, and with TBT product performance, labels and marking, and certification requirements prominent in manufacturing sectors. This is summarized by Table 4, which shows the percentage contribution of each measure subgroup to the variance in regulatory stringency of all import measures (see Appendix B for a mapping of subgroups).[23] This means for example, that 9.4% of cross-country variation of animal products' regulatory stringency is caused by SPS measures that define tolerance limits and/or restrict the use of certain materials, and thus contribute most to regulatory differences in this sector. The weights correlate with the underlying intensity indicators. However, if all countries had the same underlying prevalence score, irrespective of the level, the weight in Table 4 would be zero.

Overall, technical measures cause most of cross-country variation of import measures (ca. 66% in total), which is in line with the descriptive indicators presented in Table 3 and the country-level analysis of the previous section. However, sectoral differences are significant. Particularly, for agricultural and food products differences in the intensity of import measures across countries are primarily caused by technical measures. By contrast, non-technical measures are relatively more relevant for stones and metals and chemical and plastics products, albeit that technical measures are still responsible for the majority of cross-country variation. Furthermore, in terms of technical versus non-technical measures there are little differences between intermediate and consumption products. This also holds for most measure subgroups, with the exception of more heterogeneity in TBT labeling and marking, and product performance measures for consumption goods.

Importantly, a handful of measures explains more than half of the variation in regulatory intensity across manufacturing sectors, while the set of measures imposed on agri-food sectors is more diverse. For total trade, TBT labeling and marking requirements (16%), charges related to trade (24%), differences in licensing (4.8%), TBT certification (4.5%) and product performance (4%) requirements account for ca. half of total variation. However, on the sectoral level, for agri-food sectors, we observe relatively more variation in SPS authorization and registration

TABLE 4 PCA-based variance decomposition of MFN-type import measures, 2016.

Measure	Animal	Vegetable	Food-Prod	Chemicals & plastics	Skins & wood	Footwear & clothing	Stone & metals	Mach-Elec	Transport	Consumption	Inter-mediate
SPS prohibition/restriction	0.8	0.2	0.2	0.4	1.7	0.2	0.5	0.6	0.0	0.3	0.4
System approach	0.8	0.8	0.8	0.1	0.1	0.0	0.0	0.0	0.0	0.3	0.2
SPS auth/registration	7.3	10.0	7.1	0.8	6.3	1.5	0.0	0.0	0.2	2.9	4.0
SPS tolerance and use	9.4	8.8	10.1	0.5	0.1	0.0	0.1	0.0	0.0	3.9	2.0
SPS labels and marking	6.0	5.0	7.4	0.5	0.9	1.0	0.2	0.6	0.0	2.6	1.6
SPS packaging	1.8	3.0	2.1	0.1	0.5	0.1	0.0	0.0	0.0	0.8	0.7
Hygiene	5.6	4.6	5.3	0.3	0.3	0.0	0.0	0.0	0.0	2.0	1.2
Post-prod. Treatment	0.7	1.5	0.8	0.0	1.1	0.0	0.0	0.0	0.0	0.3	0.4
SPS Process control	7.2	5.0	4.9	0.2	0.6	0.2	0.0	0.0	0.0	2.0	1.5
SPS registration and approval	1.3	1.6	2.4	0.1	0.6	0.7	0.0	0.0	0.0	0.8	0.5
SPS testing	3.9	5.8	3.4	0.6	0.8	0.1	0.0	0.0	0.0	1.5	1.8
SPS certification	6.5	5.7	3.6	0.5	4.8	0.3	0.0	0.7	0.3	1.8	2.7
SPS inspection	7.7	6.8	6.9	0.8	4.2	0.2	0.2	0.1	0.1	2.4	2.9
SPS product documentation	2.9	2.6	3.6	0.4	0.5	0.1	0.0	0.0	0.0	1.1	0.8
Other SPS	5.9	3.9	3.2	0.2	3.5	0.2	0.1	0.0	0.1	1.6	2.1
TBT tolerance and use	0.7	0.6	0.8	1.1	1.0	4.0	0.4	0.7	1.1	1.9	0.7
TBT labels and marking	7.7	8.1	12.3	18.1	10.5	24.4	16.4	12.1	13.2	16.5	12.2
TBT packaging	0.5	0.6	0.7	2.2	0.2	0.7	0.3	1.3	0.0	0.6	1.2
TBT process control	0.8	0.9	1.0	5.6	0.9	0.5	1.3	2.8	0.7	1.2	4.0
Product performance	2.0	2.6	2.6	4.4	0.9	4.0	4.5	12.7	18.1	7.8	4.2
TBT registration and approval	0.2	0.3	0.5	2.2	0.9	1.6	1.8	0.6	3.8	1.3	1.3

TABLE 4 Continued

Measure	Animal	Vegetable	Food-Prod	Chemicals & plastics	Skins & wood	Footwear & clothing	Stone & metals	Mach-Elec	Transport	Consumption	Inter-mediate
TBT testing	0.4	0.4	0.6	3.7	1.5	3.0	1.8	6.0	6.7	3.1	2.3
TBT certification	2.6	3.1	2.8	3.5	7.8	5.6	4.7	10.5	6.1	5.0	4.4
TBT inspection	2.0	2.1	2.2	4.3	5.1	2.2	2.6	4.9	3.3	2.6	3.7
TBT product documentation	0.6	1.0	1.1	4.3	1.5	2.3	1.3	4.3	2.2	2.8	2.6
Other TBT	1.1	1.1	1.4	1.2	1.7	3.0	1.5	1.1	2.5	2.3	1.7
PSI	2.3	2.0	1.5	3.0	5.1	5.8	6.6	3.4	3.5	3.4	3.3
Licenses	2.9	2.5	2.8	5.2	7.6	4.1	1.2	12.0	9.7	4.5	5.8
Licenses economic	0.4	0.2	0.2	2.1	0.5	1.9	1.4	1.4	1.8	0.9	1.9
Prohibitions	0.1	0.1	0.1	1.0	0.9	1.4	0.6	4.9	2.5	0.9	1.3
Other quantity	0.2	0.1	0.1	0.1	0.6	0.1	0.1	1.1	0.6	0.3	0.3
Charges related to trade	7.2	8.9	7.1	26.5	23.0	25.7	43.1	15.1	19.9	16.2	21.4
Intern. Non-discr. Charges	0.3	0.2	0.5	4.8	3.5	3.6	7.4	2.4	2.9	3.6	4.3
Other price-based	0.0	0.1	0.1	1.0	0.7	1.6	1.7	0.5	0.7	0.6	0.8
Technical	88.8	88.0	89.1	59.2	63.2	61.6	44.5	62.5	61.9	72.9	64.2
Non-technical	11.2	12.0	10.9	40.7	36.8	38.4	55.5	37.5	38.1	27.1	35.8
Top 5	39.3	42.6	44.1	60.3	55.1	65.5	82.8	62.4	67.6	50.1	48.1

Note: 1, Data—NTMTRAINS; 2, Weights for the following sectors are averaged: MinFuel, Chemicals, and PlastiRub to Chemicals & Plastics; HidesSkin and Wood to Skins & Wood, StoneGlas and Metals to Stone & Metals, and TextCloth and Footwear to Footwear & Clothing; 3, For a more detailed description of measures groups see Appendix B; 4, We use the BEC classification to identify consumption and intermediate products.

requirements, tolerance and use restrictions, labeling and marking, and inspection requirements. Whereas for machinery and electronics, and transport products sectors, TBT product performance and certification requirements, and licensing measures are the most relevant ones. Moreover, charges related to trade contribute to cross-country differences in regulatory stringency across all manufacturing sectors. The results presented in Table 4 illustrate that the relevance of different measures types varies relatively strongly across sectors. Thus, any sector-level trade cost estimates for more aggregate measures groups are likely to be driven by different measures depending on the sector at hand.

In terms of structural regulatory heterogeneity, the patterns of relatively higher intra-regional regulatory similarity identified by Figure 4 hold across all sectors. This is highlighted by Table 5, which shows the degree to which countries differ in terms of the structure of sectoral regulations. For this, we use the Jaccard distance for all technical measures (SPS, TBT, and pre-shipment inspections), which means that regulatory distance decreases only with joint presences of measures.[24] We identify across all sectors similar regional patterns in terms of within versus between regional differences because the average intra-regional distance is generally lower than the average between-regional distance. This difference is relatively high for stone and metal, transport, and agri-food sectors. Moreover, the lowest between-regional distances across most sectors can be observed for Europe & Central Asia, Asia & Pacific, and North America. By contrast, Latin America & Caribbean countries impose a heterogeneous set of technical measures, which not only differs from other regions but also results in the highest intra-regional regulatory distance. This potentially leads to relatively higher NTM-related trade costs for exporters of this region, for example, to geographically close and large markets of the USA and Canada.

On the sectoral level, we observe that the big manufacturing blocs (Asia, Europe, North America) impose more similar regulation in manufacturing sectors compared to other regions. As a consequence, manufacturers that export within or between these regions are less likely to face different regulations in export markets compared to their home market. By contrast, firms in Africa & Middle East operate in a low regulatory environment at home and may face unfamiliar compliance requirements in these export markets. Furthermore, regulatory distances are largest for chemicals and plastics, stone and metals, as well as transport products. To a large degree this is caused by lower shares of minerals and fuels, and stone and metal products being covered by technical measures—compare frequency ratios presented in Table 3. Lastly, agri-food products are consumed and/or produced by more countries than manufactures, and additionally contain relatively more consumer-sensitive products. Both circumstances require governments to either regulate production processes or impose regulation that specifies final product quality. This leads to a higher incidence and variety of technical measures. However, regulatory differences presented in Table 5 illustrate that the types of measures imposed in these sectors are more similar across all regions compared to manufacturing sectors.

The identified patterns of structural regulatory differences across sectors and regions lend further support to including indicators of structural differences when describing patterns of NTMs and their potential effect on trade. Structural differences are likely to represent an impact channel that is distinct from intensity indicators such as prevalence, count or indicators related to regulatory coverage. In an extreme case two countries imposing for example, five different measures would have the same count or prevalence score, suggesting a similar regulatory profile, but would also be separated by the highest regulatory distance, suggesting a very different regulatory profile. Thus, in isolation neither indicator is sufficient to describe cross-country differences or similarities of NTMs.

TABLE 5 Regulatory heterogeneity between regions, per sector, 2016.

		Animal	Vegetable	FoodProd	Chemicals & plastics	Skins & wood	Footwear & clothing	Stone & metals	MachElec	Transport	Total
Africa & Middle East		0.78	0.77	0.86	0.96	0.92	0.91	0.97	0.93	0.96	0.92
Asia & Pacific		0.72	0.73	0.75	0.94	0.90	0.88	0.96	0.90	0.92	0.89
Europe & Central Asia		0.63	0.65	0.70	0.81	0.79	0.76	0.88	0.63	0.76	0.76
Latin America & Caribbean		0.90	0.84	0.92	0.96	0.92	0.85	0.97	0.93	0.95	0.92
North America		0.60	0.60	0.65	0.83	0.86	0.72	0.73	0.87	0.68	0.75
Average intra-regional distance		0.73	0.72	0.78	0.90	0.88	0.83	0.90	0.85	0.85	0.85
Africa & Mid. East	Asia & Pacific	0.77	0.76	0.83	0.95	0.91	0.91	0.97	0.92	0.95	0.91
Africa & Mid. East	Eur. & Central Asia	0.76	0.76	0.83	0.95	0.91	0.90	0.97	0.90	0.94	0.90
Africa & Mid. East	Latin America & Car.	0.86	0.83	0.91	0.96	0.92	0.91	0.97	0.93	0.96	0.92
Africa & Mid. East	North America	0.77	0.78	0.83	0.95	0.92	0.89	0.97	0.90	0.94	0.90
Asia & Pacific	Eur. & Central Asia	0.72	0.72	0.76	0.92	0.89	0.86	0.95	0.86	0.89	0.87
Asia & Pacific	Latin America & Car.	0.85	0.83	0.90	0.95	0.91	0.87	0.97	0.92	0.94	0.91
Asia & Pacific	North America	0.69	0.70	0.72	0.90	0.87	0.84	0.92	0.87	0.86	0.85
Eur. & Central Asia	Latin America & Car.	0.85	0.83	0.91	0.94	0.90	0.83	0.97	0.90	0.94	0.90
Eur. & Central Asia	North America	0.71	0.73	0.75	0.86	0.85	0.76	0.88	0.77	0.78	0.80
Latin America & Car.	North America	0.85	0.86	0.91	0.94	0.90	0.82	0.95	0.90	0.94	0.89
Average between-regional distance		0.78	0.78	0.83	0.93	0.90	0.86	0.95	0.89	0.91	0.89
% diff. intra- versus between-regional distance		6.9%	8.2%	7.0%	3.7%	2.3%	4.0%	5.0%	4.1%	6.5%	4.6%

Note: 1, Data—NTMTRAINS; 2, Jaccard distance measures used; 3, Regions Sub-Saharan African and Middle East & North Africa were combined to Africa & Middle East, and regions South Asia and East Asia & Pacific were combined to Asia & Pacific; 4, Regulatory distances for the following sectors are averaged: MinFuel, Chemicals, and PlastiRub to Chemicals & Plastics; HidesSkin and Wood to Skins & Wood, StoneGlas and Metals to Stone & Metals, and TextCloth and Footwear to Footwear & Clothing; 5, Colors are differentiated based on within-sector differences, except for average intra- and between-regional distances for which colors are based on cross-sector differences. Color coding for relatively low (green) to relatively high (brown) regulatory distance.

5 | CONCLUSION

The paper presents the most commonly used NTM indicators to describe international patterns of NTMs across countries and sectors. We organize indicators into three categories—stringency, coverage, structure—and illustrate that each of these categories describes a distinct dimension of a country's NTM profile. Particularly, for standard-like, quality-increasing NTMs, which increase trade cost and potentially imply positive demand-side effects, too, this categorization may lead to new insights into the empirical assessment of NTM trade effects. Furthermore, we extend the set of existing indicators by introducing metrics from association analysis to demonstrate joint occurrences of specific measures and by applying a standard PCA to highlight which groups of measures drive cross-country variation in regulatory stringency. All indicators presented and used in this study are publicly available for multiple sectoral classifications and ready to use in descriptive and/or empirical work.

The descriptive analysis identifies a set of stylized facts about international patterns of NTMs. Overall, countries continuously legislate, which leads to a constantly changing regulatory environment. The overwhelming majority of measures is imposed in a non-discriminatory fashion across all trading partners. In addition to classical border measures imposed only on foreign firms, regulatory differences in standard-like measures imply a bilateral trade costs dimension that adds complexity to policy-making. Thus, imposing MFN-type regulations not only results in different trade cost effects across foreign exporters, but also changes the position of domestic firms vis-a-vis export markets. These effects are likely to be heterogeneous across sectors.

The concepts and indicators presented in this paper are in part determined by the constraints of global NTM databases. In contrast to binary data points, more detailed information about the regulatory burden implied by NTMs (e.g., specific certification requirements, actual tolerance limits, etc.) would allow us to construct more accurate indicators (see e.g., Winchester et al., 2012). However, the combination of geographic scope, diversity of products, and complexity of regulation pose an almost insurmountable challenge to consistently collect more detailed regulatory data. Furthermore, we only focus on de jure measures while private and international standards play an increasing role in international trade (see e.g., Schmidt & Steingress, 2019). Private standards and/or standards set by public organizations can enter official regulations by reference. However, a record of the extent with which policy makers introduce such standards in legislation is a question for future research and data collection efforts.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Upon reasonable request from corresponding author.

ENDNOTES

[1] These are definitions based on the classification of NTMs established by the Multi-Agency Support Team (MAST). The MAST group consists of: Food and Agriculture Organization of the United Nations (FAO), International Trade Centre (ITC), Organization for Economic Cooperation and Development (OECD), United Nations Conference on Trade and Development (UNCTAD), United Nations Industrial Development Organization (UNIDO), World Bank, and World Trade Organization (WTO).

[2] Concordance for ITPDE first release.

[3] Although for some countries NTM data were collected for multiple years, for most countries the database only covers a single year.

[4] NTMTRAINS provides a year variable indicating the earliest year a certain type of measure was introduced. However, it does not provide information on the development of the number of measures in force other than for the year the data were collected.

[5] An exception are SPS and TBT prohibitions, restrictions, authorization and registration requirements for importers, as well as pre-shipment inspections, all of which only affect imports.

[6] We map regularly notified SPS and TBTs, emergency SPS, SPS and TBT STCs, and pre-shipment inspections into MAST chapters A to C. Furthermore, quantity control measures (MAST chapter E) in the WTO I-TIP portal include general quantitative restrictions, tariff-rate quotas, and licensing measures.

[7] A full description of accompanying datasets can be found in Appendix A.

[8] See for example Shingal et al. (2021), Winchester et al. (2012), and Xiong and Beghin (2014) with a focus on regulation specific to agri-food products or McFadden (2022) on OECD standards for tractors.

[9] Note that for brevity we omit time subscripts in the text.

[10] These costs may be fixed (e.g., changes in product design due to limits in substance use) or variable (e.g., veterinary certificates required for each shipment) and accumulate over the total set of measures.

[11] This affects market participation, particularly of low quality and productivity firms (e.g. Disdier et al., 2023).

[12] In our database we separate count and prevalence scores into MFN-type and bilateral measures with total measures imposed by d on o being the sum of the two (see Appendix A).

[13] Similar to intensity indicators we differentiate between the share of products/trade affected by bilateral and MFN-type measures. Products affected by bilateral or MFN-type measures may overlap, which require that the total incidence is determined by the union set of products/trade affected by bilateral and/or MFN-type measures. In many cases, products affected by bilateral measures are also affected by at least one MFN-type measure, which leads to the MFN-share value being equal to the total-share value.

[14] Symmetric distance indicators can be used for clustering procedures that work with distance matrices (e.g., k-medoids or hierarchical clustering). Clustering on pre-aggregated measure groups (e.g., a count index for measure group g) changes the interpretation from grouping countries based on structural heterogeneity to grouping countries based on regulatory stringency. Prior aggregation enables the use of clustering algorithms that work with other distance metrics (e.g., k-means based on the Euclidean distance).

[15] Note that regulatory overlap indicators most likely capture firm characteristics beyond compliance capacity. For example, Macedoni and Weinberger (2022) show that imposing stricter standards leads to a reallocation from small/unproductive firms towards larger/productive firms.

[16] That is, we exclude countries that neither impose A_1, nor A_2.

[17] For theoretical aggregation methods of tariffs and non-tariff measures that integrate trade elasticities into the weighing scheme see Anderson and Peter Neary (2005) and Disdier et al. (2015) and Kee et al. (2009), respectively.

[18] Using time-invariant weights ensures that changes over time are solely determined by changes in measures and not trade. In this context, constructing trade-weights from averages over multiple years address potential reporting gaps and outlier observations that may occur in a single year.

[19] For services NTMs, the World Bank and OECD provide Services Restrictiveness Indexes (STRI) that are based on hierarchical weighting schemes informed by sector/country expert advice.

[20] It is possible to use the first components of a PCA on a set of measures, or even across variables from different data sources, directly as an NTM indicator. In a gravity regression this can be a useful strategy when generally wanting to control for the presence of NTMs, but not focusing on the interpretation of coefficients.

[21] Note, that the same procedure can also be applied to aggregate measures applied bilaterally or, more generally, to a subset of countries. The matrix A would then be an origin-destination-sector subset with measures applied

by one destination. Measures only applied on an MFN basis are canceled out by centering. Consequently, only bilateral measures are retained by such a composite index.

[22] NTMTRAINS records that nearly 100% of Guinea's imports, as well as almost 90% of all products are covered by a price-based measure. Compared to a much lower incidence in other countries this may point to data collection issues for this economy.

[23] We use the prevalence score as a basis for the variance decomposition.

[24] Thus, a value of 1 indicates that a country pair does not impose any measures that are the same, which includes cases where neither country imposes any measures at all. Theoretically, the indicator ranges from [0, 1], but due to the sparseness of NTM data the lowest distance value is only 0.6.

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APPENDIX A. DATASETS

Tables A1 to A5 list the datasets used for this paper. All datasets are available for the following sectoral aggregations:

- Harmonize d System (HS) 2-digit,
- GTAP sectoral aggregation of GTAPv10,
- Broad Economic Categories (BEC) Rev. 4,
- World Customs Organization (WCO) 15 sectors aggregation of the HS,
- ISIC Rev. 3 based classification of the International Trade and Production Database for Estimation (Borchert et al., 2020),
- Total.

The datasets can be downloaded from this [REPOSITORY].

A.1 Descriptive indicators, NTMTRAINS

- The dataset is available in a bilateralized and reporter-based (i.e., aggregated over affected countries) version. The bilateralized version is trade-flow directed, which means that for import measures the destination country (iso_d) is the imposing country, while for export measures the origin country (iso_o) is the imposing country.
- In the bilateralized version we map into a grid of all reporting countries and 240 possibly affected countries.
- Indicators are calculated for the following NTM categories: Technical measures, non-technical measures, MAST chapters, and PCA categories presented in Appendix B (Table B1).
- EU member-states are split out as reporter and affected country, depending on their entry date.

A.2 Descriptive indicators, WTO notifications

TABLE A1 Dataset: Descriptive indicators, NTMTRAINS.

Variable	Description
iso_o	ISO3 character country code of origin
iso_d	ISO3 character country code of destination
year	Year of cross-section
classification	Sectoral classification
sector	Sectoral code
ntm_cat	MAST-based measure aggregation
hs_lines	Number of HS lines in sector
bi_count	Number of 6-digit-product-measure combinations (bilateral)
mfn_count	Number of 6-digit-product-measure combinations (MFN)
tot_count	Number of 6-digit-product-measure combinations (total)
bi_prodcov	Number of unique 6-digit products covered by at least 1 measure (bilateral)
mfn_prodcov	Number of unique 6-digit products covered by at least 1 measure (MFN)
tot_prodcov	Number of unique 6-digit products covered by at least 1 measure (total)
bi_prev	Prevalence score, average number of measures per product (bilateral)
mfn_prev	Prevalence score, average number of measures per product (MFN)
tot_prev	Prevalence score, average number of measures per product (total)
bi_freq	Frequency index, share of products covered by at least 1 measure (bilateral)
mfn_freq	Frequency index, share of products covered by at least 1 measure (MFN)
tot_freq	Frequency index, share of products covered by at least 1 measure (total)
bi_cov	Coverage ratio, share of trade covered by at least 1 measure (bilateral)
mfn_cov	Coverage ratio, share of trade covered by at least 1 measure (MFN)
tot_cov	Coverage ratio, share of trade covered by at least 1 measure (total)
bi_unique_m	Average number of unique measures per product (bilateral)
mfn_unique_m	Average number of unique measures per product (MFN)
tot_unique_m	Average number of unique measures per product (total)
bi_unique_sh	Share of unique measures in all measures (bilateral)
mfn_unique_sh	Share of unique measures in all measures (MFN)
tot_unique_sh	Share of unique measures in all measures (total)

TABLE A2 Dataset: descriptive indicators, WTO notifications.

Variable	Description
iso_o	ISO3 character country code of origin
iso_d	ISO3 character country code of destination
year	Year (preference for year into force over year of notification)
classification	Sectoral classification
sector	Sectoral code
ntm_cat	MAST-based measure aggregation or WTO notification requirement
hs_lines	Number of HS0 lines in sector
bi_count	Number of 6-digit-product-measure combinations (bilateral)
mfn_count	Number of 6-digit-product-measure combinations (MFN)
tot_count	Number of 6-digit-product-measure combinations (total)
bi_prodcov	Number of unique 6-digit products covered by at least 1 measure (bilateral)
mfn_prodcov	Number of unique 6-digit products covered by at least 1 measure (MFN)
tot_prodcov	Number of unique 6-digit products covered by at least 1 measure (total)
bi_count_cum	Cumulative number of 6-digit-product-measure combinations until year (bilateral)
mfn_count_cum	Cumulative number of 6-digit-product-measure combinations until year (MFN)
tot_count_cum	Cumulative number of 6-digit-product-measure combinations until year (total)
bi_cum_prodcov	Cumulative number of unique 6-digit products covered by at least 1 measure until year (bilateral)
mfn_cum_prodcov	Cumulative number of unique 6-digit products covered by at least 1 measure until year (MFN)
tot_cum_prodcov	Cumulative number of unique 6-digit products covered by at least 1 measure until year (total)
bi_freq	Frequency index, share of products covered by at least 1 measure based on cum_prodcov from 2006 onwards (bilateral)
mfn_freq	Frequency index, share of products covered by at least 1 measure based on cum_prodcov from 2006 onwards (MFN)
tot_freq	Frequency index, share of products covered by at least 1 measure based on cum_prodcov from 2006 onwards (total)
bi_cum_cov	Coverage ratio, share of trade covered by at least 1 measure based on cum_prodcov from 2006 onwards (bilateral)
mfn_cum_cov	Coverage ratio, share of trade covered by at least 1 measure based on cum_prodcov from 2006 onwards (MFN)
tot_cum_cov	Coverage ratio, share of trade covered by at least 1 measure based on cum_prodcov from 2006 onwards (total)

- We use the WTO Notifications database by Ghodsi et al., 2017, who retrieve the original notifications data from WTO's I-TIP portal and impute missing HS codes.
- Countries affected by specific notifications are cross checked against the information in the SPS and TBT Information Management System (IMS) of the WTO, and corrected where necessary.
- The dataset is available in a bilateralized and reporter-based (i.e., aggregated over affected countries) version.
- In the bilateralized version we map into a grid of all reporting countries and 240 possibly affected countries.
- Indicators are calculated for the following NTM categories: Technical measures, non-technical measures, MAST chapters, and Notification requirement.
- EU member-states are split out as reporter and affected country, depending on their entry date. Thus, notifications in the data submitted by individual member-states are included.

A.3 Structural heterogeneity

- Distance indicators are calculated for the following NTM categories: All import measures, technical measures, SPS, TBT, and non-technical measures.
- For technical measures the set of measures excludes non-specific categories like broad chapters (e.g., A000) or "not elsewhere specific (nes)" coded measures.

TABLE A3 Dataset: structural heterogeneity indicators.

Variable	Description
iso_d	ISO3 character country code of destination
iso_o	ISO3 character country code of origin
year	Year (preference for year into force over year of notification)
sector	Sectoral code (variable named after sectoral classification)
measure	NTM measures included in distance metric (SPS, TBT, technical, non-technical, all)
jacc_*	Jaccard distance
sm_*	Simple matching distance
ro_jacc_*	Asymmetric regulatory overlap based on Jaccard distance
ro_sm_*	Asymmetric regulatory overlap based on simple matching distance
jacc_intense_*	Jaccard distance interacted with average number of measures between country pair
sm_intense_*	Simple matching distance interacted with average number of measures between country pair
jacc_intense_d_*	Jaccard distance interacted with number of measures imposed by destination country
sm_intense_d_*	Simple matching distance interacted with number of measures imposed by destination country

- Jaccard distance assumed to be 1 when no measures present, that is, assumption that is can only decreases in joint presence of measures.
- EU member-states are split out and intra-EU distance is set to zero.

A.4 Co-occurrences of measures

- We retrieve the full set of pair-wise measure combinations for each 6-digit product using the Apriori algorithm and average by sectoral classification.
- The Jaccard distance is based on the transpose of the underlying country-measure matrix used for the distance indicators presented in Table A3. Thus, two measures are "closer" the more common countries use them jointly.

A.5 PCA-based variance decomposition

- The underlying basis of the PCA are the reporter-based prevalence scores for the more detailed measure categories presented in Appendix B. Using those scores, the sample groups for the PCA are: All, import, and export measures, technical and non-technical measures, and MAST chapters A, B, C, E, F. That is, the variance is decomposed for these groups and weights add up to one for each group g and sector k.

TABLE A4 Dataset: co-occurrences of measures, 2016.

Variable	Description
LHS	Antecedent measure (If A is present …) as MAST NTM code
RHS	Consequent measure (… then B) as MAST NTM code
ntm_pair	Symmetric pair ID of joint measures
sector	Sector code
classification	Sectoral classification
N	Number of 6-digit products in sector
support	Support index, average share of countries with joint occurrence of measure
confidence	Confidence index
lift	Lift index
count	Number of countries imposing joint measures
prod	Number of 6-digit products covered by joint measures
tot_measures	Average number of unique measures imposed across all countries per product
avg_measures	Average number of measure imposed on product
nr_reporters	Average number of reporters per product
dist	Jaccard distance between measure pair
freq_desc	Frequency index for MAST chapter
freq_support	Ratio of support divided by frequency index
relevance_support	freq_rule/freq_desc
freq_confidence	
freq_lift	

TABLE A5 Dataset: PCA-based variance decomposition, 2016.

Variable	Description
sector	Sector code
classification	Sectoral classification
group	Group of measures
measure	Detailed measure groups (see Appendix B)
var_weight_mfn	PCA-based weight for MFN measures
var_weight_tot	PCA-based weight for total measures

APPENDIX B. NTM MAPPING

TABLE B1 Non-tariff measure mapping.

ntmcode	MAST description	PCA category	pca_code
A000	Sanitary and phytosanitary measures	Other A	A_nes
A100	Prohibitions/restrictions of imports for SPS reasons	SPS prohibition/restriction	A10-12
A110	Prohibitions for sanitary and phytosanitary reasons	SPS prohibition/restriction	A10-12
A120	Geographical restrictions on eligibility	SPS prohibition/restriction	A10-12
A130	Systems approach	System approach	A13
A140	Special authorization requirement for SPS reasons	SPS auth/registration	A14-5
A150	Registration requirements for importers	SPS auth/registration	A14-5
A190	Prohibitions/restrictions of importsfor SPS reasons n.e.s.	Other A1	A1_nes
A200	Tolerance limits for residues and restricted use of substances	SPS tolerance and use	A2
A210	Tolerance limits for residues of or contamination by certain (non-microbiological) substances	SPS tolerance and use	A2
A220	Restricted use of certain substances in foods and feeds and their contact materials	SPS tolerance and use	A2

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
A300	Labeling, marking and packaging requirements	Other A3	A3_nes
A310	Labeling requirements	SPS labels and marking	A31-2
A320	Marking requirements	SPS labels and marking	A31-2
A330	Packaging requirements	SPS packaging	A33
A400	Hygienic requirements	Hygiene	A4
A410	Microbiological criteria of the final product	Hygiene	A4
A420	Hygienic practices during production	Hygiene	A4
A490	Hygienic requirements n.e.s.	Hygiene	A4
A500	Treatment for elim. of plant and animal pests in the final prod or prohibition of treatment	Post-prod. Treatment	A5
A510	Cold/heat treatment	Post-prod. Treatment	A5
A520	Irradiation	Post-prod. Treatment	A5
A530	Fumigation	Post-prod. Treatment	A5
A590	Treatment for elim. of plant and animal pests in the final prod, n.e.s.	Post-prod. Treatment	A5
A600	Other requirements on production or post-production processes	SPS Process control	A6
A610	Plant growth processes	SPS Process control	A6
A620	Animal raising or catching processes	SPS Process control	A6
A630	Food and feed processing	SPS Process control	A6
A640	Storage and transport conditions	SPS Process control	A6
A690	Other requirements on production or post-production processes, n.e.s	SPS Process control	A6
A800	Conformity assessment related to SPS	Other A8	A8_nes
A810	Product registration and approval requirement	Registration and approval	A81
A820	Testing requirement	SPS testing	A82
A830	Certification requirement	SPS certification	A83
A840	Inspection requirement	SPS inspection	A84
A850	Traceability requirements	SPS product documentation	A85

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
A851	Origin of materials and parts	SPS product documentation	A85
A852	Processing history	SPS product documentation	A85
A853	Distribution and location of products after delivery	SPS product documentation	A85
A859	Traceability requirements, n.e.s.	SPS product documentation	A85
A860	Quarantine requirement	Other A8	A8_nes
A890	Conformity assessment related to SPS n.e.s.	Other A8	A8_nes
A900	SPS measures n.e.s.	Other A	A_nes
B000	Technical barriers to trade	Other B	B_nes
B100	Import authorization/licensing related to technical barriers to trade	TBT prohibition/restriction	B10-1
B140	Authorization requirement for TBT reasons	TBT auth/registration	B14-5
B150	Registration requirement for importers for TBT reasons	TBT auth/registration	B14-5
B190	Import authorization/licensing related to technical barriers to trade not elsewhere specified	Other B1	B1_nes
B200	Tolerance limits for residues and restricted use of substances	TBT tolerance and use	B2
B210	Tolerance limits for residues of or contamination by certain substances	TBT tolerance and use	B2
B220	Restricted use of certain substances	TBT tolerance and use	B2
B300	Labeling, marking and packaging requirements	Other B3	B3_nes
B310	Labeling requirements	TBT labels and marking	B31-2
B320	Marking requirements	TBT labels and marking	B31-2
B330	Packaging requirements	TBT packaging	B33
B400	Production or Post-Production requirements	TBT process control	B4
B410	TBT regulations on production processes	TBT process control	B4

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
B420	TBT regulations on transport and storage	TBT process control	B4
B490	Production or Post-Production requirements n.e.s.	TBT process control	B4
B600	Product identity requirement	Product identity	B6
B700	Product quality, safety or performance requirements	Product performance	B7
B800	Conformity assessment related to TBT	Other B8	B8_nes
B810	Product registration/approval requirements	Registration and approval	B81
B820	Testing requirement	TBT testing	B82
B830	Certification requirement	TBT certification	B83
B840	Inspection requirement	TBT inspection	B84
B850	Traceability information requirements	TBT product documentation	B85
B851	Origin of materials and parts	TBT product documentation	B85
B852	Processing history	TBT product documentation	B85
B853	Distribution and location of products after delivery	TBT product documentation	B85
B859	Traceability requirements, n.e.s.	TBT product documentation	B85
B890	Conformity assessment related to TBT n.e.s.	Other B8	B8_nes
B900	TBT Measures n.e.s.	Other B	B_nes
C000	Pre-shipment inspection and other formalities	Other C	C_nes
C100	Pre-shipment inspection	PSI	C1
C200	Direct consignment requirement	Transport route	C2-3
C300	Requirement to pass through specified port of customs	Transport route	C2-3
C400	Import monitoring and surveillance requirements and other automatic licensing measures	Import license (formality)	C4
C900	Other formalities, n.e.s.	Other C	C_nes
E000	Non-automatic licensing, quotas, prohibitions and quantity control measures	Other E	E_nes

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
E100	Non-automatic import-licensing procedures	Licenses	E1
E110	Licensing for economic reasons	Licenses economic	E11
E111	Licensing procedure with no specific ex-ante criteria	Licenses economic	E11
E112	Licensing for specified use	Licenses economic	E11
E113	Licensing linked with local production	Licenses economic	E11
E119	Licensing for economic reasons n.e.s.	Licenses economic	E11
E120	Licensing for non-economic reasons	Licenses non-economic	E12
E121	Licensing for religious, moral or cultural reasons	Licenses non-economic	E12
E122	Licensing for political reasons	Licenses non-economic	E12
E123	Licensing for the protection of the environment	Licenses non-economic	E12
E124	Licensing for security reasons	Licenses non-economic	E12
E125	Licensing for the protection of public health	Licenses non-economic	E12
E129	Licensing for non-economic reasons n.e.s.	Licenses non-economic	E12
E200	Quotas	Quotas	E2
E210	Permanent	Quotas	E2
E211	Global allocation	Quotas	E2
E212	Country allocation	Quotas	E2
E220	Seasonal quotas	Quotas	E2
E221	Global allocation	Quotas	E2
E222	Country allocation	Quotas	E2
E230	Temporary	Quotas	E2
E231	Global allocation	Quotas	E2
E232	Country allocation	Quotas	E2
E300	Prohibitions other than for SPS and TBT reasons	Prohibitions	E3
E310	Prohibition for economic reasons	Prohibitions	E3
E311	Full prohibition (import ban)	Prohibitions	E3
E312	Seasonal prohibition	Prohibitions	E3
E313	Temporary prohibition, including suspension of issuance of Licenses	Prohibitions	E3
E314	Prohibition of importation in bulk	Prohibitions	E3

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
E316	Prohibition of used, repaired or remanufactured goods	Prohibitions	E3
E319	Prohibition for economic reasons, n.e.s.	Prohibitions	E3
E320	Prohibition for non-economic reasons	Prohibitions	E3
E321	Prohibition for religious, moral or cultural reasons	Prohibitions	E3
E322	Prohibition for political reasons (embargo)	Prohibitions	E3
E323	Prohibition for the protection of the environment	Prohibitions	E3
E324	Prohibition for security reasons	Prohibitions	E3
E325	Prohibition for the protection of public health	Prohibitions	E3
E329	Prohibition for non-economic reasons, n.e.s.	Prohibitions	E3
E500	Export restraint arrangement	Export restraints	E5
E510	Voluntary export restraint arrangements (VERs)	Export restraints	E5
E511	Quota agreement	Export restraints	E5
E512	Consultation agreement	Export restraints	E5
E513	Administrative co-operation agreement	Export restraints	E5
E590	Export restraint arrangements n.e.s.	Export restraints	E5
E600	Tariff Rate Quotas	TRQs	E6
E610	WTO bound TRQs	TRQs	E6
E611	Global allocation	TRQs	E6
E612	Country allocation	TRQs	E6
E620	Other tariff-rate quotas included in other trade agreements	TRQs	E6
E621	Global allocation	TRQs	E6
E622	Country allocation	TRQs	E6
E900	Quantity control measures n.e.s.	Other E	E_nes
F000	Price control measures including additional taxes and charges	Other F	F_nes
F100	Administrative measures affecting customs value	Price control	F1-2

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
F110	Minimum import prices	Price control	F1-2
F120	Reference prices	Price control	F1-2
F190	Other administrative measures affecting the customs value, n.e.s.	Price control	F1-2
F200	Voluntary export price restraints (VEPRs)	Price control	F1-2
F300	Variable charges	Charges related to trade	F3-6
F310	Variable levies	Charges related to trade	F3-6
F320	Variable components	Charges related to trade	F3-6
F390	Variable charges n.e.s	Charges related to trade	F3-6
F400	Customs Surcharges	Charges related to trade	F3-6
F500	Seasonal duties	Charges related to trade	F3-6
F600	Additional taxes and charges levied in connection to services provided by the Government	Charges related to trade	F3-6
F610	Custom inspection, processing and servicing fees	Charges related to trade	F3-6
F620	Merchandise handling or storing fees	Charges related to trade	F3-6
F630	Tax on foreign exchange transactions	Charges related to trade	F3-6
F640	Stamp tax	Charges related to trade	F3-6
F650	Import license fee	Charges related to trade	F3-6
F660	Consular invoice fee	Charges related to trade	F3-6
F670	Statistical tax	Charges related to trade	F3-6
F680	Tax on transport facilities	Charges related to trade	F3-6
F690	Additional charges n.e.s.	Charges related to trade	F3-6
F700	Internal taxes and charges levied on imports	Intern. Non-discr. Charges	F7
F710	Consumption taxes	Intern. Non-discr. Charges	F7
F720	Excise taxes	Intern. Non-discr. Charges	F7
F730	Taxes and charges for sensitive product categories	Intern. Non-discr. Charges	F7
F790	Internal taxes and charges levied on imports n.e.s.	Intern. Non-discr. Charges	F7
F800	Decreed Customs Valuations	Other F	F_nes
F900	Prince control measures n.e.s	Other F	F_nes
P000	Export related measures	Other P	P_nes

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
P100	Export measures related to sanitary and phytosanitary measures and technical barriers to trade	Technical authorization	P_nes
P110	Authorization or permit requirements to export, for technical reasons	Technical authorization	P11-12
P120	Export registration requirements for technical reasons	Technical authorization	P11-12
P130	Production and post-production requirements to export	Technical quality	P13-15
P140	Product quality, safety, or performance requirements	Technical quality	P13-15
P150	Labeling, marking, or packaging requirements	Technical quality	P13-15
P160	Conformity assessments	Conformity assessment	P16
P161	Testing requirements	Conformity assessment	P16
P162	Inspection requirements	Conformity assessment	P16
P163	Certification required by exporting country	Conformity assessment	P16
P169	Conformity-assessment measures not elsewhere specified	Conformity assessment	P16
P170	Export prohibition for sanitary and phytosanitary reasons	Other P	P_nes
P190	Technical export measures not elsewhere specified	Other P	P_nes
P200	Export formalities	Export formalities	P2
P210	Requirements to pass through specified port of customs for exports	Export fomalities	P2
P220	Export monitoring and surveillance requirements	Export formalities	P2
P290	Export formalities not elsewhere specified	Export formalities	P2
P300	Export Licenses, export quotas, export prohibition and other restrictions other than SPS and TBT	Non-technical measures	P3
P310	Export prohibition	Non-technical measures	P3
P320	Export quotas	Non-technical measures	P3

TABLE B1 Continued

ntmcode	MAST description	PCA category	pca_code
P330	Licensing, permit or registration requirements to export	Non-technical measures	P3
P390	Export restrictions not elsewhere specified	Non-technical measures	P3
P400	Export price-control measures, including additional taxes and charges	Prices and charges	P4
P410	Measures implemented to control the prices of exported products	Prices and charges	P4
P420	Export taxes and duties	Prices and charges	P4
P430	Export charges or fees levied in connection with services provided	Prices and charges	P4
P490	Export price-control measures, taxes and charges not elsewhere specified	Prices and charges	P4
P500	State trading enterprises, for exporting; other selective export channels	STE	P5
P510	State trading enterprises, for exporting	STE	P5
P590	Other selective export channels, n.e.s.	STE	P5
P600	Export-support measures	Subsidies	P6
P700	Measures on Re-export	Re-export	P7
P900	Export measures n.e.s.	Other P	P_nes