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New Price-based Bilateral Ad-valorem Equivalent Estimates of Non-tariff Measures

BY ALEXEY KRAVCHENKO,[a] ANNA STRUTT,[b] CHORTHIP UTOKTHAM[c] AND YANN DUVAL[d]

As global applied tariffs continue to decline, and the stock of non-tariff measures continues to increase, applied international trade researchers increasingly seek to evaluate the effects of non-tariff measure (NTM) policies. This, however, requires their quantification – a non-trivial estimation task that needs to be undertaken at a disaggregated level. Estimation of ad-valorem-equivalents (AVEs) of NTMs is generally conducted using one of two approaches: price-based or quantity-based. This study uses a price-based approach to estimate AVEs at the Harmonised System (HS) six-digit level. Bilateral Global Trade Analysis Project (GTAP) sector-specific AVEs are obtained by aggregating the derived AVE estimates, using HS-GTAP sector concordance and HS six-digit level bilateral trade flows as weights. A key advantage of the price-based estimation method used in this study is that the AVEs can be directly used in the GTAP model, without the need to adjust them based on import-demand elasticities. Derived AVEs estimated in this study are also importer/partner-specific and rely on counts of NTMs rather than simply instances of NTMs. This paper provides GTAP-consistent estimates and aggregation code to facilitate custom GTAP aggregations of AVEs, as well as replicable, open source code that can be altered based on users' assumptions or particular research needs.

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[a] Trade Policy and Facilitation Section (TPFS), Trade, Investment and Innovation Division (TIID), United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Rajadamnern Nok Avenue Khwaeng Bang Khun Phrom, Phra Nakhon, Bangkok 10200, Thailand (e-mail: kravchenkoa@un.org).
[b] Waikato Management School, University of Waikato, Private Bag 3105, Hamilton, New Zealand (e-mail: astrutt@waikato.ac.nz) .
[c] TPFS, ESCAP (e-mail: utoktham@un.org)
[d] TPFS, ESCAP (e-mail: duvaly@un.org)

1. Introduction

During the past two decades, thanks to multilateral, regional and unilateral efforts, global applied tariffs have approximately halved. At the same time, the number of non-tariff measures (NTMs), as evidenced by the growing number of new notifications to the World Trade Organization (WTO), has risen significantly in the Asia-Pacific region (see Figure 1). These notifications of NTMs include both sanitary and phytosanitary (SPS) and technical barriers to trade (TBT) measures, which have tended to increase over time while tariffs have progressively reduced. As such, NTMs have become a key concern for traders as well as for trade policymakers. However, quantifying the economic effects of NTMs is a much more challenging task than for tariffs, including because some NTMs may increase the volume of trade (Cadot et al, 2018). For example, when consumers (and regulators) are confident with export partners' own procedures, along with sanitary and phytosanitary regulations, it may boost demand. In general, however, NTMs tend to increase trade costs to traders and producers as they require additional steps or requirements such as testing, obtaining certification or ensuring mandatory standards compliance.

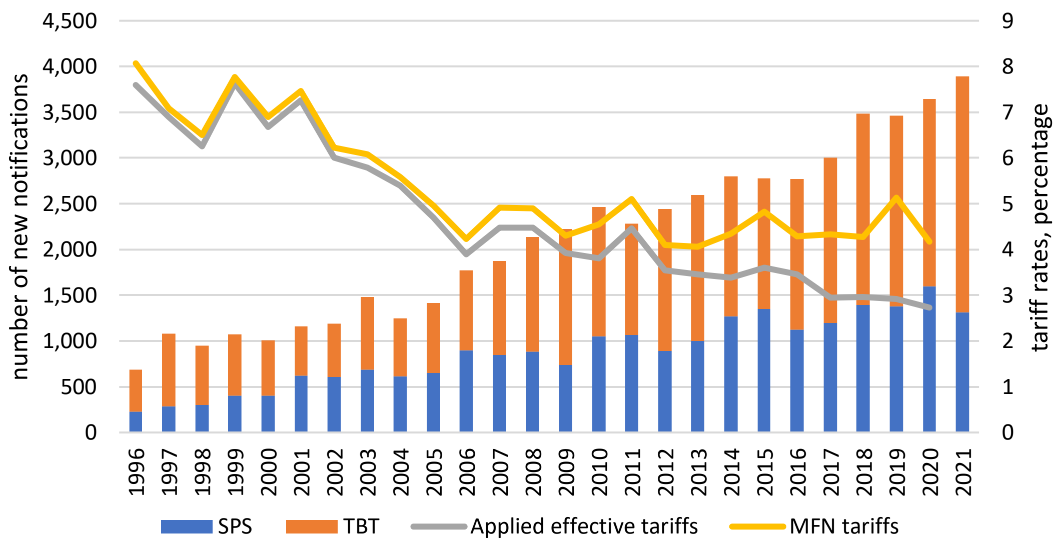

Figure 1. Average MFN and effectively applied tariffs and annual new notifications to WTO of SPS and TBT measures in the Asia-Pacific region

Notes: There are no reliable data on how many of the new notifications to WTO come into force, as only proposed or amended NTMs are notified. However, it is often assumed that the majority of them do enter into force, and the trend of the stock of NTMs is essentially cumulative across the years.

Source: Authors' calculations based on data from I-TIP (WTO) and World Bank World Integrated Trade Solutions (WITS), Accessed February 2022.

Many NTMs, particularly technical measures, serve legitimate and important public policy objectives, such as protection of human, animal and plant health, as well as protection of the environment. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the United Nations Conference on Trae and Development (UNCTAD) (2019) estimated that nearly half of NTMs directly and positively address such public policy objectives, as envisaged in the Sustainable Development Goals. As such, outright removal of NTMs will not be the optimal solution in some cases. Furthermore, not having adequate NTMs in place or their poor implementation may impose significant costs on the economy. Examples include SPS measures to address the spread of African Swine Flu in the Asia-Pacific region in 2018-2019, which caused Chinese inflation to rise above the 3% government target as a significant portion of consumer spending went on pork and pork-based products (Bloomberg, 2018), as well as the spread of the bacterial disease *Pseudomonas syringae pv. actinidiae* (PSA) among New Zealand kiwifruit orchards in 2010, which was estimated to cause a more than $500 million loss to the growers (Greer & Saunders, 2012).

Therefore, in many cases NTMs are very necessary, but policymakers can reduce costs associated with them. The Organisation for Economic Co-operation and Development (OECD) (2016) suggests that there are three types of costs arising from NTMs: information costs, conformity assessment costs and specification costs. Information costs are associated with finding information on NTMs and related procedures; conformity assessment costs include those associated with proving that products meet the required standards; and specification costs are associated with changing product/production processes in order to meet NTMs of importing countries. As such, reducing costs associated with NTMs can be addressed through each of the above components. Addressing information costs requires a greater degree of transparency and notification. Conformity assessment costs may be addressed through mutual recognition arrangements and specification costs can be minimized through NTM harmonization (rather than elimination), as well as adherence to international standards (see Chapter 3 of ESCAP and UNCTAD, 2019) and a focus on reducing regulatory heterogeneity (OECD, 2017).

Through addressing each component of the costs associated with NTMs it is, in principle, possible to effectively achieve intended public policy objectives while minimizing the trade costs. Addressing these components must, however, include careful cost-benefit analysis. As noted at the outset, NTMs are often more complex, less transparent and, due to their technical nature, may be much more difficult to monitor and challenge than tariffs. Despite these challenges, reductions in the costs imposed by NTMs offer large potential gains from reform and it is important to model these as well as possible. This study aims to support research in this area through providing ad-valorem tariff equivalents (AVEs) of NTMs in a form that facilitates large-scale modelling efforts, including with the Global Trade Analysis Project (GTAP) model.

The structure of this paper is as follows. Section 2 provides an overview of the taxonomy of non-tariff measures. Section 3 provides a brief literature review of studies examining the estimation of the costs of non-tariff measures and outlines the estimation methodology and data cleaning used in this study. Section 4 presents the estimated results, as well as discussing using the dataset in a computable general equilibrium (CGE) framework such as GTAP.

2. NTMs at a glance

The early discussion regarding NTMs can be traced back to the creation of the General Agreement on Tariffs and Trade (GATT) in 1947, in which related provisions are laid out in the official text.[1] However, for a long time, there was no commonly accepted definition of NTMs. It was only in 2006, when UNCTAD established the Group of Eminent Persons on Non-tariff Barriers (NTBs) and the Multi-Agency Support Team (MAST),[2] that a broad but widely accepted concept of NTMs emerged:

"NTMs are policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD, 2012).

In contrast to this rather succinct definition, the universe of NTMs exhibits enormous diversity and complexity. For example, some NTMs target the price of goods, such as administrative pricing, variable charges, anti-dumping and countervailing measures etc., while others target the quantity of goods, such as non-automatic licensing, quotas, import prohibitions etc. Some NTMs target the characteristics of goods, such as technical standards and labelling requirements etc. There are also NTMs that do not target goods directly, but instead affect different processes, such as customs procedures and administrative practices, government procurement policies and so on. NTMs are often (wrongfully) compounded with procedural obstacles, such as delays in getting documentation, testing facilities, informal payments, and so on. Such procedural obstacles are not NTMs, but exist because of NTMs. At times it is not the NTMs themselves that are

[1] For example, GATT Article VII on Customs Valuation, Article XI on General Elimination of Quantitative Restrictions, and Article XX on General Exceptions allow NTMs under specific circumstances.

[2] The MAST team comprises eight international organizations – the Food and Agriculture Organization of the United Nations (FAO), International Monetary Fund (IMF), International Trade Centre (ITC), Organization for Economic Cooperation and Development (OECD), United Nations Industrial Development Organization (UNIDO), UNCTAD, the World Bank and WTO.

the problems for traders, but rather these associated procedural obstacles (see ESCAP and UNCTAD, 2019; ESCAP and ITC, 2019 for more details).

Over a period of time, MAST has developed a coding system to provide a base to collate and tally NTMs. The objective of the International Classification of Non-Tariff Measures (ICNTM) is to provide information and clarification on new and existing measures to improve their comparability across countries (UNCTAD, 2016). The ICNTM serves as a common language for categorizing NTMs. It is officially endorsed by the United Nations Statistics Division (UNSD, 2012) as the International Classification of NTMs for data collection across countries and for reporting on internationally comparable data on NTMs. As shown in Table 1, NTMs are categorized via a hierarchical tree into 16 chapters from A to P. Each chapter consists of three further levels of sub-branches.[3] Chapters A to O are import-related measures, whereas chapter P concerns exports only. In accord with the definition, the classification only acknowledges the existence of an NTM, and does not pre-judge its legitimacy, adequacy, necessity, or whether or not it is discriminatory.

Table 1. Classification of NTMs in the UNCTAD Trade Analysis and Information System (TRAINS)

Imports	Technical measures	A.	Sanitary and phytosanitary measures
		B.	Technical barriers to trade
		C.	Pre-shipment inspection and other formalities
	Non-technical measures	D.	Contingent trade-protective measures
		E	Non-automatic licensing, quotas, prohibitions and quantity-control measures other than for SPS or TBT
		F	Price-control measures, including additional taxes and charges
		G	Finance measures
		H	Measures affecting competition
		I	Trade-related investment measures
		J	Distribution restrictions
		K	Restrictions on post-sales services
		L	Subsidies (excluding export subsidies under P7)
		M	Government procurement restrictions
		N	Intellectual property
		O	Rules of origin
Exports		P	Export-related measures

Source: UNCTAD (2019)

[3] For example, under chapter A (SPS), the A2 level contains "Tolerance limits for residues and restricted use of substances", which further contains more detailed classification, such as A21, "Tolerance limits for residues of or contamination by certain (non-microbiological) substances".

According to this classification system, the first three chapters are technical measures. Chapter A (SPS) and B (TBT) include tolerance limits for residuals and restricted use of substances; hygienic requirements; labelling, marketing and packaging requirements; product identity requirements; specification on production and post-production; and conformity of assessment procedures etc. Chapter C on pre-shipment inspection and other formalities covers requirements on direct consignment, pass-through at certain ports, and import monitoring and surveillance.

Chapters D to O of the ICNTM classification are various non-technical measures. In Chapter D, contingent trade protective measures consist of anti-dumping, countervailing, and safeguard measures. The steel and aluminium tariffs recently imposed by the United States, as well as the tit-for-tat tariffs spat between the United States and China, are not ordinary customs tariffs - they are classified as contingent trade-protective measures, which means the policy implications and remedy tools are different to those of ordinary customs tariffs. Chapter E deals with measures aimed at restricting the quantity of goods, such as non-automatic licensing, quotas, prohibitions etc. Chapter F covers price controls on imported goods such as, for example, minimum import prices, reference prices, and seasonal duties. Chapter G concerns financial measures, such as advance payment requirements, multiple exchange rates, and measures that affect terms of payment. Measures affecting competition are given in chapter H such as, for example, importing by state trading enterprises. Chapter I on trade-related investment measures consists of local content requirements and trade balancing measures. Distribution restrictions in chapter J include geographical distribution measures and limits on resellers. Chapters K to O contain measures related to after-sales servicing, subsidies, government procurement restrictions, intellectual property rights and rules of origin.

Finally, Chapter P covers all export-related non-tariff measures, including: technical measures imposed on exports;[4] export formalities; export licenses, quotas, prohibitions, other quantitative restrictions; price controls; state-trading enterprises; export support measures; and measures on re-exports etc. They are as diverse as import-related measures (UNCTAD, 2016).

NTMs are national regulations. As such, the only true comprehensive sources of policy regulations that could "potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD, 2012) are national repositories of legislative acts. However, member states of the WTO, under certain circumstances, are also required to notify the

[4] For example, when exporting live animals from Kyrgyzstan, "exporting animals must be quarantined for 30 days" [Government of the Kyrgyz Republic Decree of June 18, 2015 No. 377, "On the approval of priority veterinary and sanitary requirements for the prevention of animal diseases."]

WTO Secretariat of new or changed NTMs. For example, under notification procedures of the WTO SPS Agreement "*…**[when]the content of a proposed sanitary or phytosanitary regulation is not substantially the same as the content of an international standard**, guideline or recommendation, and if the regulation may have a significant effect on trade of other Members, **Members shall: (a) publish a notice** at an early stage in such a manner as to enable interested Members to become acquainted with the proposal to introduce a particular regulation…*".[5] In other words, only SPS measures that deviate from international standards are required to be notified to the WTO (although the WTO now actively encourages all measures to be notified). In addition, to build a comprehensive overview of the stock of NTMs across the world, UNCTAD in collaboration with other international agencies, regularly collects data on NTMs through systematically examining officially published national legislation. For a more detailed discussion on the nuances of using different sources of NTMs, see the first chapter of ESCAP and UNCTAD (2019). The current study uses UNCTAD's TRAINS database since it is the most comprehensive data currently available. This database includes measures that are not notified to the WTO (whether by omission, because they existed before the notification procedure was adopted, a country is not a WTO member or because only measures that are different to international standards are required to be notified), as well as covering some economies that are not WTO members.

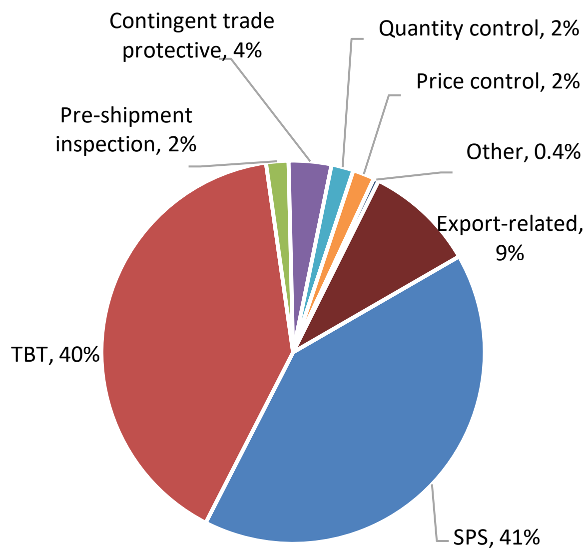

Figure 2. NTMs globally, by type

Source: ESCAP and UNCTAD 2019, based on the UNCTAD TRAINS database, accessed 15 May 2019.

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[5] https://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm

The majority of measures in the database are SPS and TBT measures (Figure 2). Globally, 41 per cent of measures in the database are SPS and 40 per cent are TBTs. The third-largest category, export-related measures, accounts for 9 per cent of measures globally. Notably, NTMs in Chapters J to O have not been actively collected yet, but are included in the database if reported.

3. Data and methodology

In recent literature, estimation of AVEs of NTMs is typically classified into 2 approaches: quantity-based (Kee, Nicita and Olarreaga, 2009; Beghin, Disdier & Marette, 2015; Kee & Nicita, 2016) or price-based (Cadot and Gourdon, 2015; Cadot et al, 2015; Ing and Cadot, 2019). The current study uses a price-based model to observe the effect of different types of NTMs on price, i.e. the study estimates AVEs of NTMs as a result of the imposition of NTMs. A key contribution of this study to current literature is that the bilateral AVEs of NTMs are estimated, rather than just average AVEs of NTMs imposed on the rest of the world by each country, as is currently common in the literature. The derived estimates allow for partner and sector-specific AVEs of NTMs to be readily incorporated into the GTAP model, permitting assessment of the impacts of NTM harmonization policies at the bilateral, plurilateral or regional level, among other scenarios aiming to study the effects of NTMs. An advantage of the price-based estimation method used here is that it is not necessary to adjust derived AVE estimates to use these estimates in the GTAP model, whereas quantity-based estimation requires values of import demand elasticities,[6] which, if different to those used in the GTAP model, results in inconsistencies. A further advantage of using the price-based approach is that it avoids the contentious practice of interacting country-specific continuous variables, such as GDP per capita, as a proxy for country-specific fixed effects - see box 1 in Cadot, Gourdon and Van Tongeren (2018) for a discussion. Unlike-quantity based estimation, however, since derived prices by definition are only available for non-zero trade flows, zero trade flows data are not used in estimation. As such, price-based estimation potentially misses capturing "prohibitive" NTMs. A further disadvantage is that c.i.f. import prices may in some cases miss NTM-related costs after the products have arrived at their trade partner destination. Furthermore, as described later in section 3.1(a) on price data, derived unit values are themselves at times questionable, and as such due caution must be exercised when interpreting results. Finally, quantity-based estimation also allows for estimation of "negative" AVEs where NTMs actually facilitate trade, for example providing regulators and consumers with confidence that products are of high standards (see Beghin, Disdier & Marette, 2015) – something that price-based

[6] Notable exceptions are Webb et al. (2017) and Webb et al. (2020), where estimates of the impact of NTMs on trade quantity flows are used to directly calibrate the GTAP model.

methods are unable to estimate. However, the data and code compiled for this paper can be adjusted according to researchers' needs if such an assumption is regarded as too restrictive for their purposes.

The estimation approach of AVEs of NTMs in this study is based on Ing and Cadot (2019), where a price-based model is applied with the use of NTM counts, rather than a dummy indicator variables of whether there are any NTMs in a particular ICNTM chapter affecting trade in a certain product.[7]

This section describes the data sources as well as cleaning procedures and main assumptions, together with the estimation framework. The code to aggregate AVEs to match a GTAP aggregation, using the methods and assumptions in this paper, is available as an online addendum to this paper. However, the complete underlying dataset used in estimation of the AVE dataset, together with the estimation code (in R) and detailed explanation are available at https://r.tiid.org/AVEs - users are welcome to adjust estimation assumptions described in this paper according to their needs. Making the full dataset available to other researchers enables replication as well as offering opportunities to researchers who wish to explore the impacts of imposing different assumptions or estimation methods.

3.1. Data

(a) Prices and trade data

Unit values of bilateral import flows, a proxy for import prices, were obtained at the six-digit Harmonised System (HS) level by dividing bilateral trade values by respective quantities (at HS six-digit level), with trade data sourced from the World Bank's World Integrated Trade Solution (WITS) platform for the year 2015. This method of obtaining proxies for unit prices, however, comes with its own caveats: studies have shown outliers (whether due to aggregation, input errors or other reasons) may significantly affect resultant derived estimates if not accounted for (Berthou & Emlinger, 2011; Gaulier & Zignago, 2012; Jian et al, 2022). To systematically remove this apparent bias, the top 5% of derived price values were removed.[8] Sensitivity analysis conducted showed that threshold setting below this level did not significantly affect the results, but researchers may wish to assume other thresholds. Another option would be to use CEPII's Trade prices database

[7] See Cadot and Gourdon (2015) and Cadot et al. (2015) for detailed discussion on the use of dummy variables of NTMs.

[8] UNCTAD and World Bank (2018), on the other hand, chose to exclude the top and bottom 0.5% of the distribution of derived statistics. If desired, future researchers may adjust the assumption made in the current study by using the full database to retain all values, but truncate both bottom and top prices, and/or choose a different cut off point.

(Berthou & Emlinger, 2011)[9] which employs a unique decomposition method to evaluate the reliability of data based on mirror analysis (i.e. comparing exports from A to B with imports of B from A). However, such derived prices come with their own distribution in the dependent variable, and would introduce their own set of statistical nuances.[10]

Trade data were obtained only for the economies for which NTM data are available (108 economies, with the European Union disaggregated into 28 economies[11]). For 100 economies, trade data were available in the H4 version (2012), five were available in the H3 version (2007) and three economies were only available in the H2 version (2002) – see appendix Table A.1 for details. For the economies for which trade data were not available in the H4 (2012) version, concordance was conducted using the WITS concordance tables.[12] Notably, only one-to-one concordance was carried out since one-to-many, many-to-one and many-to-many relationships obfuscate trade values and quantities that are required to derive proxy import prices. From H3 (2007) to H4 (2012), one-to-one concordance covered 91.9% of HS6-level product lines, and from H2 (2002) to H4 (2012) one-to-one concordance covered 81.8% of HS6-level product lines.

Furthermore, not all recorded bilateral import flows contained quantity information and records with missing quantity information were omitted. Additionally, in some instances different countries reported different quantity types for the same HS6 codes (for example, kg vs number of items – see COMTRADE methodological note).[13] In such cases, records with the majority type of quantity types were retained, with the minority types further truncated from the analysis.[14]

(b) NTMs

NTM data were obtained from UNCTAD's TRAINS database (for a data overview, see UNCTAD, 2017).[15] The database contains NTM data at the HS six-digit level following HS 2012 classification (with more than 5,000 product lines), covering 82 economies, including European Union as a single economy. It includes

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[9] Updated data for 2021 are available at http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=2

[10] If desired, users are welcome to reconcile the dataset and code available in this study with the trade price indices database to obtain alternative estimates based on these unit prices.

[11] Since the reference year for estimation was 2015, UK was left as part of the block.

[12] https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp

[13] https://comtrade.un.org/data/MethodologyGuideforComtradePlus.pdf

[14] However, the rows with missing/inconsistent quantities were retained in the underlying database developed for the analysis, should subsequent researchers wish to use the quantity method (obviating the need for quantity data).

[15] https://trains.unctad.org/Forms/Analysis.aspx

information on imposing economies, affected economies, and the year in which the measure went into effect or was withdrawn (for some), and counts of NTMs. NTMs are classified according to ICNTM classification system detailed earlier. For the purposes of this study, NTMs are considered at the chapter level (i.e. one digit). As such, the total number of measures for each NTM chapter is derived by aggregating all 3-digit NTMs for each NTM chapter for each individual product. UNCTAD's TRAINS database only has non-zero instances of measures. As such, for any importing economies for which NTM data were available in the UCNTAD TRAINS database, if that economy registered a non-zero import flow with any partner economy but had no corresponding bilateral NTM record, it was assumed that there were no NTMs imposed by that importing country on that particular imported product originating from that partner country (i.e. trade values are used in estimation together with zero counts of NTMs).

Unilateral and bilateral sets of NTMs were combined together and expanded into bilateral sets.[16] This differs to other studies, for example, Cadot et al. (2018), which assumed that all NTMs face all trade partners with the same effect. Furthermore, only NTMs that were in effect for 2015 were used. Notably, different economies in the TRAINS dataset had different years of data collection, with some countries having NTMs collected across multiple years. To get the required cross-sectional dataset for this study, NTM data that were the closest to 2015 were used (see appendix Table A.2 for details). NTM data product codes that were not in HS4 (2012) were converted using the concordance tables – notably, unlike for trade data which only allowed one to one concordance between HS versions for products, all types of relationships were used (many to one, many to many), and as such there was no data attrition.

For the purposes of estimating the ad-valorem equivalent of NTMs, this study distinguishes between two main types of NTMs, namely, technical (Chapters A-C) and non-technical (Chapters D-O) measures. As such, all bilateral NTMs were summed up across technical and non-technical chapters (i.e. Chapters A to C for technical and the rest, excluding chapter P, for non-technical).[17]

(c) Tariffs

To control for the effects of tariffs, simple average tariff data is used, which is obtained at HS six-digit level (HS 2012 classification) from the World Bank's WITS

[16] Unilateral NTMs are applied by one country to imports from all countries while bilateral NTMs are applied by one country to one or more other countries (e.g. restrictions due to SPS reasons on imports of pork from African Swine Flu affected countries).

[17] Notably, the underlying database reports NTMs in individual NTM chapters, and as such, researchers are welcome to adjust the available code to estimate AVEs at a more granular level.

platform and the WTO tariff download facility.[18] The primary tariff data are WITS, since this database includes ad-valorem estimates of non-ad valorem duties. Where data for 2015 were missing, the latest year available was used. Next, to address missing data, the tariff data were supplemented by tariffs from the WTO tariff download facility, from 2015 or the latest year. Both WITS and WTO tariffs used the lowest of MFN and preferential (whether due to GSP or trade agreements). In cases where tariff data were in versions other than HS 2012, HS 2012 rates were approximated by conducting a concordance between reported versions to HS 2012, and in the small number of cases of multiple matching six-digit tariff lines, a simple average was taken. Finally, in cases of any other missing bilateral tariff data (a very limited number of cases), the highest tariff for the imposing country for a particular product was used.[19]

(d) Standard gravity variables

Bilateral distance, contiguity, landlockedness, and common language are obtained from Mayer and Zignago (2011). Data on the presence of regional trade agreements (RTAs) is acquired from de Sousa (2012), with the latest trade agreement data expanded up to 2015.[20] The data on bilateral distance, contiguity, and common language were manually expanded to fill in values missing from the dataset.

(e) Other variables calculated

In case researchers wish to employ alternatives to the specifications in the subsequent methodological section, the underlying database also includes potential instrumental variables, including value trade flows (as opposed to prices) as well as trade shares.

The underlying datasets used to run regressions estimating AVEs of NTMs consists of 5,203 csv files, each corresponding to a single HS2012 classification product. In total, 6,515,643 data rows were available with information on NTMs, tariffs and dataflows. Of these, 5,819,718 had information on quantities that enabled derivation of prices,[21] trimmed down further to 5,526,205 by removing the top 5% of prices in each HS code (as described above). A detailed description of the variables and data sources is available in appendix Table A.3. Due to issues of multiple quantity types and collinearity, some further records are dropped in

[18] http://tariffdata.wto.org/

[19] i.e. if Afghanistan had a tariff on HS 010121 for some countries (where MFN tariff was not available either) but not for China, in case of non-zero trade in HS 010121, the highest tariff imposed by Afghanistan for HS 010121 was used.

[20] While the original methodological paper was dated 2012, the database has been updated for 2015 based on the RTAs notified to the WTO.

[21] The records are still included in the underlying database should researchers wish to use a volume-based approach.

estimation (5,517,691 records were used in running 96 regressions – described in the section below).

3.2 Methodology

Let indices i, j, and k be importer i, exporter j, product k, respectively. Let p_{ijk} be the unit-value of good k imported from j to i. Let $NTM_{ijk}^{Technical}$ and $NTM_{ijk}^{nonTechnical}$ be the count of technical and non-technical NTMs imposed on product k by importer i from the trade partner j, and let $tariff_{ijk}$ be the tariff rate on product k imposed by importer i on the trade partner j. To control for country- and pair-specific characteristics in the model, let: δ_i and δ_j be importer and exporter fixed effects, respectively, were introduced. Such fixed effects account for effects of countries' certain characteristics not included by the model (such as GDP, GDP per capita, and virtually anything else specific to each importer/exporter), but which vary across countries. These absorb the influence of all omitted variables that differ from one country to the next (Stock & Watson, 2007). Since this is a cross sectional dataset (only one year), no time-specific fixed effects were included. Other control variables commonly used in gravity models included $dist_{ij}$, $contig_{ij}$, $comlang_{ij}$, $landlocked_{ij}$, and RTA_{ij} being distance between a pair of countries, contiguity (whether they share a common border), common official language, whether either is landlocked, and RTAs that importer i and exporter j share, respectively.

Due to the significant size of the underlying database and resultant computational capacity limitations, the models are estimated at the HS2 level (chapter). This still, however, allows for regression to also include HS6 product-specific fixed effects, ρ, thereby controlling the influence of all product-specific omitted variables. The model specification used in this estimation is as follows:

$$\begin{aligned}\ln p_{ijk} = \beta_0 + \beta_1\delta_i + \beta_2\delta_j + \beta_3\rho_k + \beta_{\theta_{ij}}\theta_{ij} + \beta_4 NTM_{jik}^{Technical} \\ + \beta_5 NTM_{jik}^{nonTechnical} + \beta_{6i}\left(NTM_{jik}^{Technical} \times \delta_i\right) \\ + \beta_{7i}(NTM_{jik}^{nonTechnical} \times \delta_i) + \beta_8 tariff_{ijk} + \varepsilon_{ijk}\end{aligned} \tag{1}$$

where

δ	are country i and j fixed effects
ρ	is the HS6 product fixed effects dummy variable (since regressions are estimated at chapter-level (i.e. there are 96 separate regressions)
θ	is the pair characteristics (i.e. distance, contiguity, landlocked status, common language, and RTA)

$NTM_{jik}^{Technical}$	is the count of separate non-tariff measures from chapters A to C imposed by j on imports of product k from j
$NTM_{jik}^{nonTechnical}$	is the count of separate non-tariff measures from chapters A to C imposed by j on imports of product k from j
$tariff_{ijk}$	is the applied tariff (MFN or lowest preferential, if available) imposed by j on imports of product k from j

Following this formula, the marginal AVEs of technical NTMs imposed by country i on product k is defined as:

$$AVE_{ik}^{Technical}[\text{marginal}] = (\exp(\beta_4 + \beta_{6i}) - 1) \times 100 \tag{2}$$

A similar approach is used to derive the marginal AVEs of non-technical measures. Note that the coefficient on the interaction terms (β_{6i}) depends on the importer only – the marginal AVE is not dependent on the partner economy. Effects of the bilateral stock of NTMs were estimated by multiplying the marginal effects of coefficients and interaction terms by the bilateral stock of NTMs for product j, i.e. the AVE of the stock on technical NTMs imposed by i on imports of k from j:

$$AVE_{ik}^{Technical}[\text{total}] = \left(\exp\left(\beta_4 \times NTM_{ijk}^{Technical} + \beta_{6i} \times NTM_{ijk}^{Technical}\right) - 1\right) \times 100 \tag{3}$$

As such, these AVEs estimates can now be interpreted as the overall effect of NTMs imposed by i on imports of k from j. Unlike the marginal effect, slight differences in the stock of NTMs facing imports from different economies brings in bilateral variation.

As per Cadot and Gourdon (2015), exponential transformation in AVE calculations could lead to extremely large and uninterpretable AVEs. To address this issue, this study applies a hyperbolic tangent function to limit the upper bound of AVEs to 100%, as well as to leave any AVE estimates whose values are between 0% and 100% minimally changed:

$$AVE_{ijk}^{Technical}[\text{total}] = \tanh\left(\left(\exp\left(\beta_4 \times NTM_{ijk}^{Technical} + \beta_{6i} \times NTM_{ijk}^{Technical}\right) - 1\right)\right) \times 100 \tag{4}$$

Finally, following UNCTAD and World Bank (2018), negative AVEs are replaced with zeros as the estimation does not account for the positive effect of

NTMs on trade costs. The model is estimated for each chapter, comprising of a set of HS six-digit level products, i.e. 96 regressions are performed (chapters 98+ are omitted as products in those chapters are very heterogenous and have missing or meaningless quantities, and chapter 77 is empty but reserved for future use). Coefficients with p-values above 0.1 are set as zero in the AVE calculation. Finally, limited sample sizes of some products in certain economies raises the issue of collinearity. For instance, if there is only one imported trade flow of a certain product for an economy, it is mathematically impossible to separate the effects of NTMs from country-specific fixed effects. In such cases, the observations were dropped (as opposed to recorded as zeros). This is an important point since a missing AVE does not imply a zero AVE (which is either negative or not statistically significant).

4. Estimated AVEs of NTMs and GTAP concordance

4.1 Overall results

Summary statistics for the 96 OLS regressions run (one for each HS chapter, i.e. two digits – the level at which each individual regression was run) are presented in appendix Table A.4. Chapter-level coefficients on technical and non-technical measures are presented in columns β_4 and β_5, respectively, with coefficients with p-values below 0.1 (using distance-clustered robust standard errors) highlighted in bold. Coefficients on technical and non-technical measures interacted with reporter fixed effects, β_{6i} and β_{7i}, are omitted for brevity considerations, with corresponding columns depicting the share of significant coefficients (p-value below 0.1) in total coefficients estimated. The table also presents the number of observations used in each regression, as well as adjusted R squared.

The derived global import-weighted average AVEs of technical and non-technical measures, using the data and methodology described above, are 7.18% and 6.06%, respectively. These results are broadly in line with other studies. For example, Kee, Nicita and Olarreaga (2009) estimate mean weighted AVEs of NTMs to be 10%. More recently, UNCTAD and World Bank (2018) estimate AVEs of approximately 11% for technical measures, and 9% for other measures. Figure 3 shows a summary of the derived AVEs, by broad sectors.[22] Plant and plant-based products have the highest levels of AVEs of NTMs, followed by the mining, chemicals, and motor vehicle and transport sectors. Notably, the mining sector's high AVEs are predominantly due to non-technical measures, such as licensing and contingent trade-protective measures. One omission of the parsimonious model used in the estimation is the export-related measures. As many primary sector dependant economies rely on export taxes to finance their budgets it is

[22] For full concordance between these sectors and GTAP sectors, see appendix Table A.4.

possible that export-related NTMs, if introduced to the model, may partially explain further price discrepancies.[23]

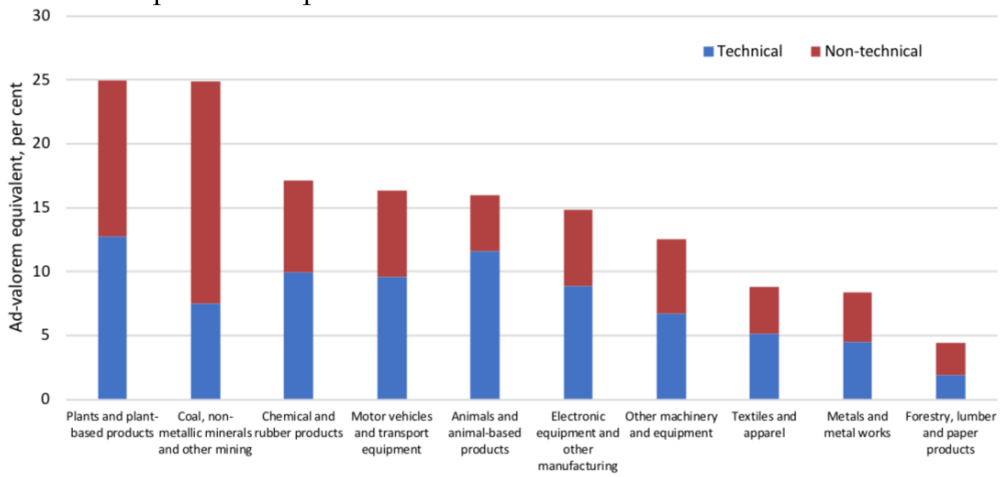

Figure 3. Global average import-weighted AVEs of NTMs, by aggregate sector

Source: Authors' calculations

In terms of level of development, proxied by income classification using World Bank classifications, figure 4 shows that paradoxically, AVEs of NTMs, particularly those of technical measures, tend to decrease with countries' levels of income (on average) – even as countries with higher income tend to have more NTMs in place. This is in line with UNCTAD and World Bank (2018), who also note that import-weighted AVEs are lower for higher-income economies. As discussed by ESCAP and UNCTAD (2019), this is most likely due to higher income countries' economies having relatively more efficient trade facilitation measures in place, despite higher-income economies usually imposing significantly more NTMs on trade partners (and fewer instances of associated procedural obstacles, such as time delays with certification, lack of or expensive testing and certification facilities, unusually high payments e.g. "bribes"). This was further confirmed by an ESCAP and ITC (2019) study, which showed that countries with higher levels of trade facilitation implementation, as measured by the United Nations Global Survey on Digital and Sustainable Trade Facilitation,[24] tend to have relatively fewer instances of "burdensome NTMs", as reported by ITC private sectors surveys on NTMs – see figure 5.

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[23] Mirrored export-related measures are included in the underlying dataset for possible estimation by other researchers.

[24] See https://untfsurvey.org/ - global data available for 2015, 2017, 2019 and 2021.

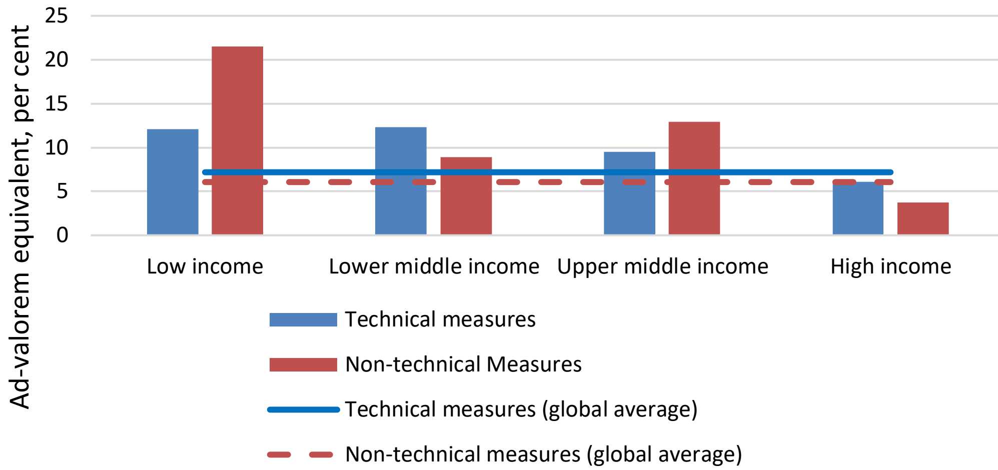

Figure 4. Average import-weighted AVEs of NTMs, by income level

Source: Authors' calculations

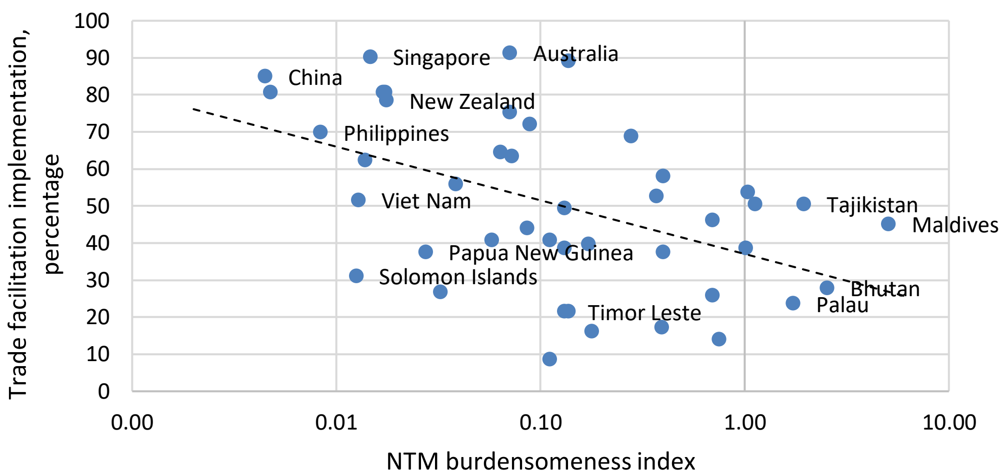

Figure 5. Trade facilitation implementation and NTM "burdensomeness" of 44 Asia-Pacific economies

Notes: NTM "burdensomeness" is calculated as the ratio between NTM incidence (by implementing economies) and export trade values in these economies in 2015.

Source: Box 2.7 in Chapter 2 of ESCAP & UNCTAD (2019).

Detailed analysis of bilateral values is beyond the scope of this paper (there are over 16,000 bilateral values at the aggregate level); however, table 2 summarises estimated trade-weighted AVEs by broad income levels bilaterally. The results show that technical AVEs of NTMs for high income economies are generally around 7% and lower in the case of high income to high income economy trade. Interestingly, technical AVEs of NTMs of low income to low income economies are quite low, suggesting that trade between low income economies does not suffer overall from high costs associated with these NTMs. In terms of non-technical NTMs, low-income economies seem to impose the highest costs, perhaps in an attempt to extract income from trade activities in lieu of tariffs (controlled for in the equation). In all cases, however, caution should be exercised when drawing conclusions as these aggregates are trade-weighted, and may be driven by trade composition. Furthermore, it may be the case that some NTMs are so prohibitive that they restrict trade in certain products altogether, thereby significantly attenuating the estimates.

As noted, the bilateral dimension at the country level in this estimation is obtained by factoring in the number of technical and non-technical NTMs that countries impose on their individual trade partners (see equation 4 and corresponding explanation). While the majority of NTMs countries impose affect all trade partners uniformly, some are specific to only certain trade partners (or groups of), such as, requiring traceability certification to ensure minerals from certain countries are not "conflict", i.e. proceeds from those minerals do not fund conflicts. Ideally, partner fixed effects interactions with coefficients on NTMs can be introduced to improve bilateral dimensionality, but due to computational limitations constraining us to run 96 regressions in lieu of one, this exploration is left to future research.

Table 2. Summary of bilateral trade-weighted AVEs, by broad income levels

Technical NTMs					
		importer			
		Low income	Lower middle income	Upper middle income	High income
trade partner	Low income	3.28	18.81	8.26	7.77
	Lower middle income	12.45	9.97	10.92	7.91
	Upper middle income	10.97	17.39	8.71	7.43
	High income	13.70	9.53	9.47	5.34

Non-technical NTMs					
		Importer			
		Low income	Lower middle income	Upper middle income	High income
trade partner	Low income	6.75	24.40	10.51	6.81
	Lower middle income	20.84	12.24	13.56	5.73
	Upper middle income	23.23	7.51	10.41	3.47
	High income	21.95	8.94	13.29	3.70

Source: Authors' calculations

4.2 Aggregating AVEs to be used in GTAP

To use estimated AVEs in the GTAP framework, AVEs were aggregated according to GTAP sectors and regions. Using appropriate concordance tables,[25] HS six-digit product codes and respective AVEs were matched with GTAP sectors, and individual economies were matched with GTAP regions. When averaging across sectors or regions, bilateral imports for each product were used as weights. Notably, as described above, statistically insignificant AVEs at the 10% level were assumed to be zero. Furthermore, not all economies for which import data existed were used in estimation of these AVEs (due to the lack of available NTM data).

As outlined in Section 3.2, due to small sample issues resulting in multicollinearity with fixed effects variables, some further observations were dropped in the estimation process. As aggregation for GTAP sectors was done across multiple six-digit HS codes, it would have been misleading to include weighted averages if much of the data were dropped. Suppose, for example, country A imported a total $100 million worth of products from country B across 20 six-digit HS codes that correspond to one particular GTAP sector. Data limitations (for example with economy B the major supplier of some products) meant that bilaterally, only trade values that added up to $5 million could be used for estimation of AVEs of NTMs (even though all $100 million worth or products had some sort of NTMs imposed on them by country A). As such it could be misleading to say that on average all the $100 million worth of products faced AVEs of NTMs that were estimated using only 5% of the data. To address this limitation, import shares of bilateral imports used in estimation of the total bilateral imports for each sector were calculated - in cases where the share of data used in estimation was less than 30% of total bilateral imports for that particular sector, AVEs were assumed to be not representative of the bilateral imports for those sectors and removed from subsequent analysis.

4.3 Filling in missing values

Where there are NTMs in place, but AVEs cannot be estimated due to data constraints, assuming a zero value may be considered inappropriate. Therefore, a careful filling exercise was undertaken to address this issue. The disaggregated GTAP NTM AVE database could theoretically have up to 1,117,200 rows (sector*reporter*partner). Due to NTM data availability limitations (as well as lack of scope for omitting trade of services) only 192,036 rows have AVEs estimated for technical NTMs and 168,458 rows have non-technical NTMs. However, the counts for non-missing NTMs are 218,713, meaning that 192,036/218,713 and 168,458/218,713 have been estimated, while the balance, due to singularity or small sample issues, for example, were omitted, resulting in "missing values" (as opposed to zeros). To accommodate filling missing estimates, an auxiliary

[25] https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp

regression was run on the available estimates, with the resulting coefficients, where significant, used to calculate those for missing values:

$$AVE_{ik}^{Technical} = \beta_1 NTM_{ijk}^{Technical} + \beta_2\left(NTM_{ijk}^{Technical} \times i\right) + \beta_3\left(NTM_{ijk}^{Technical} \times k\right) \quad (5)$$

Coefficients β_1, β_2 and β_3 were subsequently used to estimate the missing values of bilateral AVEs at the disaggregated GTAP sector level. After this filling exercise, 210,249 out of 218,713 (an additional 18,213 rows of AVEs) technical NTMs and 189,029 out of 218,713 (an additional 14,108 rows of AVEs) values were available for technical and non-technical measures, respectively. The remainder of missing AVEs with a non-zero count of NTMs remained not filled due to the auxiliary regression coefficient not being significant or insufficient data for estimation of the filling regression, such as zero (as opposed to missing) NTMs for certain reporter/sector combinations. Extreme values above 100 were removed using a hyperbolic function approach, similar to the process in the initial estimation. NTM estimates using this auxiliary regression are indicated in the dataset, both for technical and non-technical NTM estimates.[26]

4.4 Using the NTM database in global modelling

Supplementary files provided alongside this paper may assist researchers wishing to use these bilateral estimates of NTM in their own work. A database that maps to all regions and sectors in GTAP is available, along with an aggregation utility that enables generation of a database matching an aggregation of the GTAP Data Base proposed by the researcher. In addition, for researchers wishing to replicate generation of the full NTM database or to modify underlying assumptions, the full dataset and code are available, as noted above and described in the replication and aggregation instructions that accompany this paper in the supplementary files.

5. Conclusion and future directions

This study estimated the AVEs of NTMs using a price-based approach. A key advantage of using a price-based approach is that estimates are derived directly from the coefficients of the model and import demand elasticities are not needed. Any modelling of NTMs at the global level should rely on defensible estimates of AVEs, preferably at the bilateral and sector-specific level for detailed analysis. It should also make appropriate assumptions for implementing changes in these

[26] Some gaps may remain when estimates are aggregated to the bilateral GTAP regions and sectors. However, researchers are free to modify and make their own assumptions on how these should be implemented.

NTMs in the model (see Walmsley and Strutt, 2021).[27] GTAP modellers may choose to split the cuts between importer and exporter costs, with careful attention given to using the most appropriate modelling mechanisms (Walmsley and Strutt, 2021). Detailed analysis of the underlying data could be used to help reveal the extent to which costs are likely to fall primarily on importers or exporters (see Webb et al., 2020). Though, in the absence of further evidence, a useful starting point may be to follow the rule of thumb suggested by Webb et al. (2020), whose detailed empirical work suggested that in the data they explored, the burden of NTMs fell approximately equally between importers and exporters.

While simplifying assumptions are required to develop estimated AVEs of NTMs for use with large-scale models such as GTAP, the current paper and associated supplementary material offers comprehensive, disaggregated estimates of AVEs, that can be aggregated to the GTAP level. It also offers a fully replicable methodology that can be extended or altered, according to the needs and judgement of the researcher. We believe this contribution represents a significant advance; however, we note that this remains an evolving field of research, with much room remaining for future improvements to data and modelling. While our current paper makes an 'off-the-shelf' version of NTM estimates available to researchers, we encourage researchers to continue developing improved estimates tailored to the needs of their own research. For this reason, we make the underlying dataset and code available. Many advances should be possible in future, including estimating one regression (rather than 96) and utilizing the time dimension of the NTM data (the most recent NTM data update includes multiple observations for many countries). Such estimation could potentially allow for "true" bilateral data by having enough degrees of freedom to introduce trade partner fixed effects. This, however, would require significant additional effort and computational resources.

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[27] Ensuring appropriate shocks to the AVE's of NTMs are carefully calculated for implementation in the GTAP model (for guidance on this, please see the supplementary appendix materials in Walmsley and Strutt, 2021).

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Appendix

Table A.1. Import trade data HS versions for 2015, by economy

Reporter ISO3s	HS version
ARE; ARG; AUS; BEN; BFA; BGD; BHR; BHS; BLR; BOL; BRA; BRN; BWA; CAN; CHE; CHL; CHN; CIV; CMR; COL; CPV; CRI; DZA; ECU; ETH; GIN; GTM; HKG; HND; IDN; IND; ISR; JAM; JOR; JPN; KAZ; KGZ; KHM; KOR; KWT; LAO; LBN; LKA; MAR; MEX; MMR; MUS; MYS; NER; NIC; NPL; NZL; OMN; PAK; PAN; PER; PRY; PSE; QAT; RUS; SAU; SEN; SGP; SLV; TGO; THA; TUN; TUR; URY; USA; VNM; ZWE; AUT; BEL; BGR; HRV; CYP; CZE; DNK; EST; FIN; FRA; DEU; GRC; HUN; IRL; ITA; LVA; LTU; LUX; MLT; NLD; POL; PRT; ROM; SVK; SVN; ESP; SWE; GBR	H4 (2012)
ATG; GMB; GUY; SUR; TTO	H3 (2007)
AFG; BRB; PHL	H2 (2002)

Source: WITS database, accessed November 2019.

Table A.2. NTM data used in estimation by economy, HS version and year collected

Reporter ISO3s	HS version	Data collection year
BRN; IDN; KHM; LAO; MMR; MYS; PHL; SGP; THA; VNM	H5 (2017)	2015
ARE; ARG; AUS; BHR; BHS; BOL; BRA; CAN; CHE; CHL; CMR; COL; CRI; CUB; ECU; ETH; EUN; GRD; GTM; HND; JAM; JPN; KWT; MEX; MRT; NIC; NZL; OMN; PAN; PER; PRY; SLV; URY; VEN	H4 (2012)	2015
BRB; DMA; GUY; SUR; TJK; TTO	H3 (2007)	2015
CHN; DZA; HKG; ISR; JOR; KOR; LBN; LKA; MAR; PAK; PNG; QAT; RUS; SAU; TUN; TUR	H4 (2012)	2016
ATG	H3 (2007)	2016
CPV; LBR; PSE; USA	H4 (2012)	2014
BEN; GHA; MLI; NER; TGO	H3 (2007)	2014
BGD	H5 (2017)	2017
BLR; BWA; IND; KAZ; KGZ; MUS; ZWE	H4 (2012)	2017
GMB; NGA	H3 (2007)	2013
AFG; BFA; CIV; NPL; SEN	H3 (2007)	2012
GIN	H2 (2002)	2012

Note: The underlying NTM dataset had nearly 13 million records. Note that the vast majority of these NTMs had "world" as partner, and as such the dataset was further extended to create bilateral counts to match trade flows.

Source: UNCTAD, 2017.

Table A.3. Underlying dataset used to derive AVEs

column name	Explanation/source
ReporterISO3	Importer ISO3 code
PartnerISO3	Partner (exporter) ISO3 code
ProductCode	Six-digit HS code (H4 – 2012 version)
QtyToken	Qty type as reported in COMRTADE (see table 3 in https://comtrade.un.org/data/MethodologyGuideforComtradePlus.pdf)
TradeValue	Bilateral import value in 2015, as reported in COMTRADE
Price	TradeValue / quantity
Rta	Whether countries are part to the same trade agreement. Source: de Sousa (2002). Note the original dataset was extended – if missing RTA relationships, it was assumed there were none (i.e. missing data changed to zeros)
ln_gdp_i	Natural log of GDP per capita of reporter. Source: World Bank (WB) World Development Indicators (WDI)
ln_gdp_j	Natural log of GDP per capita of trade partner. Source: WDI
ln_gdppc_i	Natural log of GDP per capita of reporter, per capita. Source: World Bank (WB) World Development Indicators (WDI)
ln_gdppc_j	Natural log of GDP per capita of trade partner, per capita. Source: WDI
Dist	Distance between reporter and partner. Source: Mayer and Zignago (2011). Note for this and other variables from Mayer and Zignago (2011) missing data from some countries that had NTM data were manually added.
Contig	Whether reporter and partner share a border. Source: Mayer and Zignago (2011).
comlang_off	Whether reporter and partner share the same language. Source: Mayer and Zignago (2011).
llocked	Whether reporter or partner are landlocked. Source: Mayer and Zignago (2011).
A - P	Count of individual NTMs for each chapter imposed by reported on imports of those particular products (for chapter P for exports). Source: UNCTAD (2017). Note that P chapter is inverse, meaning it is the number of export measures imposed by trade partner when exporting to the reporter.
applied	Applied tariff rates (lowest among preferential, MFN or general) imposed by importer on that product from partner. Source: WB WITS and WTO.
share_reporter	Reporter's share of world trade of that particular product – can potentially be used as pseudo as an interaction term with NTMs as a pseudo country-specific effects (see Cadot et al. (2018), to obtain bilateral estimates of AVEs).
share_partner	Partner's share of world trade of that particular product – can potentially be used as pseudo as an interaction term with NTMs as a pseudo country-specific effects (see Cadot et al. (2018), to obtain bilateral estimates of AVEs).
A_i – P_i	Instruments for NTM Chapters. NTMs of type m (and tariffs) imposed on product k by five closest countries with importer i are used as an instrument. Notably, the five "closest" countries were sorted by whether they shared a border and language, followed by closeness in distance.[a]
instrument_tr	Instrument for tariff rates, similar as for NTMs descried above.

Notes: The underlining datasets used to run regressions estimating AVEs of NTMs consists of 5,203 csv files, each corresponding to a single HS2012 classification product. Note that due to issues of multiple quantity types and collinearity, some further records are dropped in estimation, but left in the underlying dataset should researcher wish to adjust them. Each file (representing individual HS code) contains fields described in the following table.

[a] Relying on contiguity alone would be problematic for island countries, whereas relying on distance alone would, for example, mean that Hong Kong, China's five closest countries exclude mainland China.

Table A.4. Summary of regressions' output

HS	β_4	β_5	β_{6i}	β_{7i}	n	$\bar{R}^2$	HS	β_4	β_5	β_{6i}	β_{7i}	n	$\bar{R}^2$
01	0.037	0.637	25/82	28/54	5,585	0.795	49	0.040	0.137	3/13	8/19	44,205	0.326
02	**0.009**	0.190	30/98	10/69	24,189	0.567	50	**-3.584**	**1.434**	8/47	10/17	3,996	0.473
03	**-0.015**	**0.163**	55/99	42/74	64,241	0.523	51	**-0.139**	**0.336**	52/72	14/28	15,443	0.559
04	**-0.021**	0.053	51/96	11/75	25,391	0.481	52	**-3.298**	**1.293**	77/78	36/37	70,937	0.499
05	**0.214**	**0.229**	60/84	33/67	6,766	0.448	53	**1.237**	**-0.321**	61/71	12/38	10,217	0.604
06	**-0.034**	**0.986**	41/80	52/64	11,463	0.667	54	**0.877**	-0.050	49/50	6/12	54,316	0.417
07	0.202	-0.863	78/96	64/68	50,009	0.517	55	**-5.774**	**2.219**	58/58	21/23	56,337	0.507
08	**0.357**	**0.510**	86/92	48/67	55,262	0.581	56	-0.100	**0.158**	6/66	9/18	39,698	0.292
09	0.044	-0.135	8/91	15/65	40,694	0.458	57	**-0.666**	**0.302**	1/60	12/19	24,535	0.437
10	0.736	**-3.646**	90/94	67/67	14,107	0.527	58	0.050	**0.190**	22/63	11/22	35,945	0.361
11	0.360	0.243	73/82	1/50	20,461	0.422	59	**0.715**	-0.133	47/51	4/11	28,141	0.380
12	0.003	-0.040	22/103	19/83	29,059	0.626	60	**-0.071**	**0.290**	31/53	10/14	28,381	0.305
13	0.008	**-0.836**	17/82	52/60	9,223	0.362	61	-0.005	**0.093**	27/63	25/56	210,219	0.505
14	0.889	0.029	5/63	7/12	3,191	0.357	62	0.004	**0.097**	31/66	30/58	227,663	0.475
15	**-0.039**	-0.061	40/99	27/84	31,187	0.466	63	0.002	**0.073**	19/80	37/71	84,158	0.443
16	-0.001	-0.057	19/95	24/70	26,112	0.486	64	0.007	0.139	15/66	11/55	51,728	0.446
17	-0.529	-0.210	75/83	15/66	19,046	0.436	65	0.020	**-0.715**	23/60	47/53	15,068	0.315
18	**0.871**	**0.272**	79/79	27/46	16,574	0.409	66	**0.105**	-0.066	8/52	13/43	6,448	0.434
19	-0.136	**-0.261**	1/91	27/54	33,634	0.415	67	0.032	-0.306	23/54	6/21	8,877	0.527
20	**0.367**	-0.081	91/95	8/56	61,774	0.413	68	0.200	0.046	13/72	27/59	58,770	0.628
21	0.160	-0.167	9/93	13/61	30,674	0.378	69	**2.626**	**-1.129**	64/65	20/21	42,303	0.534
22	**0.042**	0.300	53/98	29/86	36,097	0.600	70	-1.069	0.078	55/68	11/36	82,417	0.444
23	-0.448	0.171	0/86	11/59	12,992	0.510	71	**0.069**	**0.799**	34/65	45/66	33,921	0.670
24	**0.407**	-0.002	15/81	32/69	7,985	0.673	72	0.777	-0.262	3/67	16/56	122,744	0.524
25	**-1.745**	**0.663**	88/92	53/77	42,782	0.305	73	**-0.147**	**0.401**	65/75	41/57	215,383	0.422
26	**4.432**	**-1.514**	48/48	22/32	9,019	0.536	74	**3.337**	**-1.394**	63/63	46/48	49,940	0.294
27	-0.107	0.003	0/94	4/88	26,845	0.497	75	**0.775**	-0.558	23/44	15/32	9,742	0.349
28	-0.137	**0.113**	10/89	27/86	101,188	0.557	76	0.681	-0.380	2/68	15/63	56,246	0.397
29	-0.016	**-0.043**	24/96	41/89	192,247	0.609	78	2.691	-0.936	46/48	27/30	4,273	0.462
30	**-0.031**	**0.128**	45/103	29/86	45,352	0.416	79	2.819	-1.178	48/49	34/34	7,021	0.424
31	-0.061	-0.155	26/75	15/58	16,121	0.381	80	-0.937	0.371	1/42	8/26	3,785	0.322
32	-0.483	0.112	0/81	4/69	65,193	0.381	81	**-3.271**	**0.944**	53/55	50/52	15,909	0.544
33	-0.003	0.055	36/83	4/68	61,379	0.479	82	**0.028**	-0.074	30/64	14/27	116,982	0.503
34	**-0.014**	-0.035	25/84	7/71	48,620	0.319	83	0.005	-0.127	16/54	11/18	79,168	0.332
35	-0.005	0.042	6/91	4/66	20,313	0.413	84	-0.295	**0.124**	7/84	50/85	559,937	0.733
36	0.420	-0.123	32/77	14/75	4,821	0.475	85	**-0.048**	-0.004	60/86	44/83	444,557	0.584
37	-0.005	-0.123	12/45	16/39	11,255	0.439	86	-0.592	0.242	0/49	9/40	9,142	0.776
38	0.004	0.000	12/97	27/91	75,111	0.572	87	**-1.213**	**0.455**	90/95	61/85	113,654	0.911
39	0.321	-0.118	2/85	23/78	229,928	0.442	88	**-3.125**	**1.010**	43/44	11/21	10,473	0.744
40	-0.832	0.301	73/80	54/74	125,496	0.654	89	**0.632**	0.094	33/39	11/38	5,987	0.620
41	-0.011	**0.964**	35/77	51/60	19,104	0.611	90	**-1.221**	**0.476**	80/83	69/77	182,641	0.584
42	**0.027**	0.053	28/65	22/52	48,197	0.382	91	-0.055	**0.195**	25/60	29/65	33,449	0.519
43	0.035	0.083	17/55	17/47	6,034	0.509	92	0.014	**0.188**	15/56	28/56	15,608	0.617
44	0.010	-0.069	29/85	24/75	74,415	0.841	93	0.048	**-0.820**	15/59	10/58	8,441	0.656
45	-1.205	-0.120	2/61	1/10	4,791	0.282	94	-0.216	0.034	0/71	4/62	86,281	0.709
46	-0.175	0.022	0/42	2/5	8,826	0.273	95	0.016	0.050	26/75	23/67	39,443	0.598
47	0.256	-0.004	12/44	5/13	7,262	0.479	96	-0.000	0.031	31/78	24/72	66,851	0.678
48	-0.128	0.051	7/69	29/52	139,853	0.458	97	0.053	1.860	39/52	12/21	6,443	0.528

Note: Bolded HS two-digit (chapter) level coefficients in columns β_4 and β_4 are significant with p-value below 0.1. The ratios presented in columns β_{6i} and β_{7i} represent the number of significant coefficients with p-value below 0.1 over the total number of respective coefficients estimated. Robust clustered standard errors using distance are used for significance testing.

Table A.5. Concordance between GTAP sectors and sectors used in Figure 3

Summary sector	**Original GTAP sector**[a]
Other machinery and equipment	Other Machinery & Equipment
Plants and plant-based products	Paddy Rice; Wheat; Other Grains; Veg & Fruit; Oil Seeds; Cane & Beet; Plant Fibres; Other Crops; Vegetable Oils; Processed Rice; Sugar; Other Food; Beverages and Tobacco products
Animals and animal-based products	Cattle; Other Animal Products; Raw milk; Fishing; Cattle Meat; Other Meat; Milk
Petroleum and coke	Petroleum & Coke
Coal, non-metallic minerals and other mining	Coal; Other Mining; Non-Metallic Minerals
Textiles and apparel	Wool; Textiles; Wearing Apparel; Leather
Metals and metal works	Iron & Steel; Non-Ferrous Metals; Fabricated Metal Products
Motor vehicles and transport equipment	Motor vehicles and parts; Other Transport Equipment
Electronic equipment and other manufacturing	Electronic Equipment; Other Manufacturing
Forestry, lumber and paper products	Forestry; Lumber; Paper & Paper Products
Chemical and rubber products	Chemical Rubber Products
Oil and Gas	Oil; Gas

[a] See www.gtap.agecon.purdue.edu/databases/v10/v10_sectors.aspx#Sector65 for further details of GTAP sectors