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A Comparison of Approaches to Modelling Non-Tariff Measures

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Non-tariff measures (NTMs) are a prominent feature of many recent free trade agreement (FTA) negotiations. The implementation of NTMs within computable general equilibrium (CGE) models has been relatively simple to date, with modelers generally incorporating NTMs as tariff equivalents via export or import taxes or as import-augmenting technological (iceberg) change. Our study compares and contrasts two new methods with the traditional mechanisms used. The first new method is the willingness to pay method developed by Walmsley and Minor (2020); and the second, introduced here, provides a new mechanism for adjusting the exporters' production costs directly, referred to as the export cost method. We find that the choice of mechanism can have important consequences for the estimated impact of changes in NTMs, with mechanisms that raise productivity leading to larger changes in real GDP than those that treat NTMs as associated with economic rents or demand shocks. We emphasize the importance of careful consideration being given to the nature of the NTMs being investigated, the econometric estimates of the associated trade costs, and the CGE model mechanisms being used to assess the impacts of changes in NTMs.

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1. Introduction

Reducing the potential barriers to trade that non-tariff measures (NTMs) can create has been a prominent feature of many recent free trade agreement (FTA) negotiations, including the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the Canada-European Union (EU) FTA (Walmsley, Strutt, Minor and Rae (2018); Francois and Pindyuk, (2013)). Measuring and assessing the impact of these NTMs, however, is fraught with

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difficulties. In addition to the challenging nature of econometrically estimating the impact of NTMs, the techniques used to implement them within a CGE framework generally fail to reflect the diverse and complex nature of NTMs and their impacts. For instance, sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT) regulations may raise costs for exporters and importers, who must comply with the additional regulations, while also raising consumer confidence in the quality and safety of those imports, thereby raising demand.

The traditional mechanisms used in computable general equilibrium (CGE) models to address NTMs have been relatively simple to date, with modelers generally incorporating them as tariff equivalents via export or import taxes; or as import-augmenting technological (or iceberg) change, depending on the modeler's judgment of the extent to which rents and costs matter and how rents are distributed between importers and exporters. Neither of these mechanisms capture the consumers' willingness to pay nor the exporter costs directly, instead they work indirectly through trade costs and rents that could lead to misleading results.

The import-augmenting (iceberg) method was first introduced by Samuelson (1954) in a simple two-by-two theoretical exposition, whereby "value melts away" during transit, causing the quantity arriving in the importing market to be lower than the quantity of goods that left the dock in the exporting country. Hence, the costs of producing the exported commodity are only indirectly reduced when NTMs reduce, with less required to be shipped to meet demand in the importing country. The use of the iceberg approach for applied policy analysis has been widely criticized (see Balistreri and Hillberry, 2001; Ottaviano and Thisse, 2003; McCann, 2005; Fugazza and Maur, 2008; and Walmsley and Minor, 2020), with some researchers questioning the validity of implementing reductions in NTMs as simple, and sometimes large, increases in the value of imports that arrive at the destination port – the benefits of which accrue to the importing country. The import tax method, on the other hand, assumes that NTMs create economic rents which form a price wedge between the CIF and market price of the imported good that accrue to the importing country. The export tax method is similar, although the rents accrue to the exporting country.

Our current study proposes a new modelling mechanism that can more appropriately capture the impacts of NTMs on exporters' production costs, thereby augmenting exports. The results from this mechanism are then compared to those obtained from the traditional mechanisms. The new export cost method is also compared to the willingness to pay method (henceforth WTP method), developed by Walmsley and Minor (2020). The WTP mechanism was originally applied to examine the impact of reduced time delays through trade facilitation, although it could also be used to examine the potential positive impacts of NTMs, such as sanitary and phytosanitary measures, on demand. We augment the Global Trade Analysis Project (GTAP) model to include the new export cost method as well as the willingness to pay method for modelling NTMs. This enables us to illustrate and compare the impact of using alternative modelling mechanisms. We use an application focusing on the impact of reductions in NTMs by members of the Association of Southeast Asian Nations (ASEAN), drawing on new econometric estimates of the effects on trade of different types of NTMs in this region developed by Webb et al. (2020). The data on which these estimates were compiled in a multi-agency project led by UNCTAD.[1] This enables us to explore the impacts of the alternative modelling mechanisms in a specific case, facilitating insights into the implications of each method.

Section 2 of this paper outlines the different modelling mechanisms for NTMs, including the new export cost mechanism. In section 3 we introduce the policy scenarios modelled. We then turn in section 4 to explore the implications of using different modelling mechanisms to capture the changes in NTMs modelled. Finally, we present the conclusions of our findings, including discussing implications for future research.

2. Modelling NTMs

Before examining each of the mechanisms for modelling NTMs, we review the mechanism by which demand for imports is modelled in trade models in general and in the GTAP model, in particular. Demand for imports ($Q_{r,s}$) is modelled using the familiar Armington Constant Elasticity of Substitution (CES) demand function, obtained from maximizing utility ($U_s = \left[\sum_{r=1}^{n}\left(Q_{r,s}\right)^{-\rho}\right]^{-\frac{1}{\rho}}$) subject to a budget constraint ($X_s = \left[\sum_{r=1}^{n} P_{r,s} . Q_{r,s}\right]$) and illustrated in Armington (1969).[2] This gives:

$$\mathrm{Q}_{r,s} = \mathrm{Q}_s . \left[\frac{\mathrm{P}_{r,s}}{P_s}\right]^{-\sigma} \quad (1)^{3}$$

which in GTAP is given by:

$$\mathrm{QXS}_{i,r,s} = QIM_{i,s}\left[\frac{\mathrm{PMS}_{i,r,s}}{PIM_{i,s}}\right]^{-ESUBM_i} \quad (2)^{4}$$

where r is the source country (where there are n countries, $r \in$ 1...n); s is the importing country ($s \in$ 1…n) (and in GTAP equation (2) i represents the

[1] http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures.aspx

[2] ρ is a substitution parameter. It is related to the elasticity of substitution (σ) between goods from different countries r, ($\sigma = \frac{1}{1+\rho}$).

[3] Which is equivalent to: $\mathrm{X}_{r,s} = X_s . \left[\frac{\mathrm{P}_{r,s}}{P_s}\right]^{1-\sigma}$, where X represents imports in value terms.

[4] There are two levels of Armington equations (nests) in the GTAP model – this is the second. The first determines demand for domestic and imported commodities to determine $QIM_{i,s}$.

commodity (where there are m commodities, $i \in 1...m$)); $P_{r,s}$ (or $\text{PMS}_{i,r,s}$ in GTAP) is the price of the good from country r; P_s (or $\text{PIM}_{i,s}$ in GTAP) is the composite price of imports in country s; σ (or $ESUBM_i$ in equation (2)[5]) is the elasticity of substitution between goods from different countries r; $Q_{r,s}$ (or $\text{QXS}_{i,r,s}$ in GTAP) is the demand for goods from country r by country s; and Q_s (or $\text{QIM}_{i,s}$ in GTAP) is the demand for imported goods by country s.

In proportionate changes this demand function for imports is:

$$qxs_{i,r,s} = qim_{i,s} - ESUBM_i\left(pms_{i,r,s} - pim_{i,s}\right) \tag{3}$$

where: lower case (as in the GTAP model) represents the percent change in the variable.

In the following subsections, we outline the five methods used to model NTMs – import-augmenting technological change (or iceberg costs), the two trade taxes, the willingness to pay method, and the export cost method – as modifications to this Armington specification.

2.1. Import-augmenting or iceberg method

The most commonly employed approach for modelling trade facilitation, and other NTMs, in the GTAP model is through the iceberg cost variable, τ_r or $AMS_{i,r,s}$ in GTAP. The iceberg method was first developed by Samuelson (1954) in a simple two-by-two theoretical exposition, whereby "value melts away" during transit. Notably, Samuelson's approach reduced the quantity arriving in the importing market $\left[\frac{Q_{r,s}}{\tau_{r,s}}\right]$, in contrast to that which left the dock in the exporting country. Hence the utility function becomes: $U_s = \left[\sum_{r=1}^{n}\left(\frac{Q_{r,s}}{\tau_{r,s}}\right)^{-\rho}\right]^{-\frac{1}{\rho}}$, and the budget constraint: $X_s = \left[\sum_{r=1}^{n} P_{r,s}.\tau_{r,s}.\frac{Q_{r,s}}{\tau_{r,s}}\right]$, since the price has risen to $P_{r,s}.\tau_{r,s}$ and the quantity is now $\left[\frac{Q_{r,s}}{\tau_{r,s}}\right]$; thereby ensuring that the same amount X_s is paid to the exporter for these goods. Demand for imports is therefore given by:

$$\frac{\text{Q}_{r,s}}{\tau_{r,s}} = \text{Q}_s.\left[\frac{\text{P}_{r.s}.\tau_{r,s}}{P_s}\right]^{-\sigma} \tag{4}$$

where: P_s is the composite price of imports in country s, inclusive of iceberg costs. In GTAP notation equation (4) is given by:

$$\frac{QXS_{i,r,s}}{\text{AMS}_{i,r,s}} = QIM_{i,s}.\left[\frac{PMS_{i,r,s}.AMS_{i,r,s}}{PIM_{i,s}}\right]^{-ESUBM_i} \tag{5}$$

[5] ESUBM in the GTAP model.

or in percent changes as shown in the GTAP model:

$$qxs_{i,r,s} = qim_{i,s} + ams_{i,r,s} - ESUBM_i\left(pms_{i,r,s} - ams_{i,r,s} - pim_{i,s}\right) \quad (6)$$

where $ams_{i,r,s}$ is the percent change in the import augmenting iceberg cost of good i from region r to region s.

Hertel, Walmsley and Itakura (2001) note that AMS has two effects on trade within the Armington structure:

- Expansion effect: $AMS_{i,r,s}$ reduces the amount that needs to be imported to satisfy a given level of demand.
- Substitution effect: $AMS_{i,r,s}$ reduces the importer's price causing substitution towards that good and an increase in quantity demanded.[6]

These two effects work in opposite directions, although, in practice, the second effect is larger than the first because the elasticity is greater than one. Model users, therefore, observe the desired result: the demand for imports rises as a result of lowering the NTM through iceberg cost reductions. An important outcome of the expansion effect, is that the calculated or "algebraic" quantity observed by the importer is changed in direct proportion to the size of the NTM.[7]

Importantly, the expansion effect is a productivity shock applied entirely to the importing agents. Importing firms and final consumers reduce their orders with exporters in foreign markets, but still receive the same amount of imports. The argument put forth to explain this direct change in the quantity imported versus the quantity originally exported is that there is potential for less spoilage, theft, breakage or loss in shipment. From a firm's perspective, the increased quantity of goods imported is equivalent to a technological change to the importing firm, akin to a reduction in the production costs. While this explanation may find some basis in a firm's supply chain, the role of a productivity shock for households and government is difficult to reconcile. It is important to note here that a commonly used explanation for the productivity shock on government and households is that it can be interpreted as a change in quality. However, this explanation is inconsistent with the impacts on real GDP that such a productivity shock creates.

This stylized shock has implications the modeler must consider. First, it breaks the equivalence of quantities in the model. For example, assuming a positive AMS shock, the quantity imported will be higher than the quantity exported.[8] This

[6] Note that the exporter's price is not directly impacted by AMS, but rather through CGE effects such as resource costs. For this reason, the importers adjusted price is sometimes referred to as the "perceived or effective price".

[7] The term "algebraic quantity" was first referenced by Samuelson (1954).

[8] When aggregated appropriately using the same shares.

raises a problem for the model user when deciding which variable to enumerate when reporting results of "real trade" volumes. Second, it has the effect of raising real GDP in the importing country, since there is the equivalent of a technological change shock that allows all agents (firms, households and government) to satisfy an initial demand with less imports (as seen from the exporter's perspective).[9]

2.2. Trade taxes

NTMs are also often modelled as tariff equivalents via import ($T_{r,s}^{M}$) or export taxes.[10] Import and export taxes are modelled as a wedge between the world and market prices in the importing and exporting countries. Demand for imports with import taxes is therefore given by:

$$\mathrm{Q}_{r,s} = \mathrm{Q}_{s}.\left[\frac{\mathrm{P}_{r.s}.(1+T_{r,s}^{M})}{P_s}\right]^{-\sigma} \tag{7}$$

where: P_s is the composite price of imports in country s, inclusive of import taxes.

In GTAP notation, $\mathrm{TMS}_{i,r,s}$ is defined as the power of the tariff or one plus the tariff rate. Hence (7) in GTAP notation is:

$$QXS_{i,r,s} = QIM_{i,s}.\left[PCIF_{i,r,s}.\frac{TMS_{i,r,s}}{PIM_{i,s}}\right]^{-ESUBM_i} \tag{8}$$

These import and export taxes enter the model as linking the free on board (FOB) and cost, insurance and freight (CIF) prices to the price of imports in the importing country ($PMS_{i,r,s}$).

In percent changes as shown in the GTAP model:

$$pms_{i,r,s} = pcif_{i,r,s} + \mathrm{tms}_{i,r,s} \tag{9}$$

$$pfob_{i,r,s} = pm_{i,r} - \mathrm{txs}_{i,r,s} \tag{10}$$

where $pcif_{i,r,s}$ is the CIF price of commodity i, imported from region r by region s; $tms_{i,r,s}$ is one plus the tariff rate applied on commodity i, imported from region r by region s; $pfob_{i,r,s}$ is the FOB price of commodity i, imported from region r by region s; $pm_{i,r}$ is the price of commodity i from region r (cost plus any output

[9] One might argue that this break in the equivalence of quantities between imports and exports could also be viewed as a productivity shock on exporting firms—reducing the exporter's production costs. While this may be a very reasonable explanation of how some NTMs affect an economy, the productivity gains from the AMS shock are allocated to the importer, not the exporter. The allocation of these productivity gains to the exporter or the importer is likely to significantly affect the allocation of the gains from the reductions in NTM across countries (see Mundell (1968) for further discussion of how the allocation of the iceberg cost between importer and exporter can impact the results).

[10] $T_{r,s}^{M}$ represents 1 plus the tariff rate.

taxes); and $txs_{i,r,s}$ is one minus the export tax rate applied on commodity i, imported from region r by region s. [11,12]

Note the difference between this and the iceberg cost is that tariffs do not reduce the quantity and hence the expansion effect, noted by Hertel, Walmsley and Itakura (2001), is not present. Moreover, revenue from these trade taxes accrues to the regional household of the importing or exporting country depending on whether the import or export tax is used, respectively. These 'tax' variables often serve a dual purpose to reflect the existence of economic rents that accrue to either the exporter or importer, perhaps due to imperfect competition. The choice of whether to use export or import taxes therefore depends on whether these rents are believed to accrue to the importing or exporting region.

2.3. Willingness-to-pay method

The willingness to pay method, developed in Walmsley and Minor (2020), represents that case where consumers derive more utility from a good and are thus willing to pay more for them because they meet certain quality or health and safety standards. In Walmsley and Minor (2020), this technique was used to implement greater willingness to pay for faster delivery of goods due to the World Trade Organization's (WTO) Trade Facilitation Agreement (TFA). However, it is likely that there are numerous NTMs that when applied or harmonized would raise consumers' willingness to pay. For instance, the imposition of rules that ensure the health and safety of consumers, or the acceptance by one country's government of the health and safety regulations imposed by another country's government, thereby indicating that these regulations are equivalent or adequate, are also likely to raise consumers' willingness to pay for those goods. Other examples of NTMs which can increase the value that consumers place on products include restricted use of potentially harmful substances, labelling requirements, packaging requirements, hygiene requirements, and traceability requirements.

Changes in willingness to pay are achieved though the inclusion of preferences ($B_{r,s}$) in the utility function: $U_{r,s} = \left[\sum_{r=1}^{n} B_{r,s} \cdot \left(Q_{r,s}\right)^{-\rho}\right]^{-\frac{1}{\rho}}$,giving the following demand function:

[11] The difference between the CIF and FOB prices is the cost of transportation of the good from the exporting country to the importing country. Hence $pms_{i,r,s} = \left(1 - S_{i,r,s}^{T}\right)\left(pm_{i,r} - \text{txs}_{i,r,s}\right) + \text{tms}_{i,r,s} + S_{i,r,s}^{T}\left(ptrans_{i,r,s}\right)$, where $S_{i,r,s}^{T}$ is the share of transport costs in the CIF price and $ptrans_{i,r,s}$ is the price of the transportation. Hence taxes on exports also directly impact the price of the imported good ($pms_{i,r,s}$), although the impact is diluted, depending on the importance of transportation costs.

[12] We have defined the export tax rate the same way as that used in the GTAP model. In the GTAP model, the export tax is defined relative to the FOB price, such that $PM_{i,r,s} = PFOB_{i,r} \times \left[1 - TXSR_{i,r,s}\right]$.

$$Q_{r,s} = B_i{}^{\sigma}.\left[\frac{P_{r,s}}{P_s}\right]^{-\sigma}.Q_s \tag{11}$$

which in percentage change in GTAP is given by:

$$qxs_{i,r,s} = qim_{i,s} - \sigma_i^M\left(pms_{i,r,s} - pim_{i,s}\right) + \sigma_i^M\left(\hat{\beta}_{i,r,s}^M - \hat{\beta}_{i,s}^M\right) \tag{12}$$

where $\hat{\beta}_{i,r,s}^M$ is the import preference for good i from region r to region s; and$\hat{\beta}_{i,s}^M$ is the composite import preference for good i to region s.[13]

The impact of this new distribution parameter on demand is very similar to the impact of a change in relative prices, but with the opposite sign: a rise in an agent's willingness to pay has the same impact on demand as a decline in the actual price. Their inclusion therefore provides another avenue through which a shock can impact demand, without directly changing the price (or rents) received by the supplier of the good. The underlying revenue flows are not changed except where a change in demand affects purchasing patterns and hence government revenue and firm sales—this stands in contrast to the use of tax variables to represent NTMs. A new equilibrium price will then be determined where supply equals demand, at the new higher level of demand with increased willingness to pay.

2.4. Export cost method

The final method, introduced here, is a new method for implementing NTMs that explicitly recognizes that many NTMs raise the costs of production of the exporting firm. For example, restricted use of substances or production process requirements.[14]

In order to model the impact of the NTM directly on exporter costs we introduce a new variable into the model, $AXS_{i,r,s}$, that represents the productivity of sector i firms located in region r that export to region s. Since the GTAP Data Base does not distinguish between firms that export goods and those that supply to the domestic market, there are two options. First, we could separate the production of goods for domestic sales and for exports into their component parts, as in Akgul, Villoria and Hertel (2016) and Lakatos and Fukui (2014); or second, the change in exporter costs can be appropriately weighted and applied to the productivity of all firms in sector i and region r. The second method is adopted for simplicity, although the two methods are equivalent when the cost structure (i.e., the input-output (IO) cost shares) of firms that export and those that sell goods

[13] Further details on the derivation of this are provided in Walmsley and Minor (2020).
[14] See Webb et al. (2020) for careful analysis that separates NTMs into those that are most likely to impact importers and those which are most likely to impact exporters.

domestically are identical, and they face the same input prices and production taxes.[15]

Note however, that although the data are not separated, exports and domestic goods no longer have the same (final) market price so we can no longer simply sum the quantities using market shares as in GTAP.[16] In this case (for a non-margin commodity):

$$VOM_{i,r} = \sum_{s} VXMD_{i,r,s} + VDM_{i,r} \tag{13}$$

which is equivalent to:

$$PM_{i,r}.QO_{i,r} = \sum_{s} PMX_{i,r,s}.QXS_{i,r,s} + PMD_{i,r}.QDS_{i,r} \tag{14}$$

where: $VOM_{i,r}$ is the value of output at market prices of commodity i in region r; $VXMD_{i,r,s}$ is the value of exports of commodity i from region r to regions s, at market prices; $VDM_{i,r}$ is the value of domestic sales of commodity i in region r at market prices; $PMX_{i,r,s}$ is the price of exported commodity i from region r to region s; $QXS_{i,r,s}$ is the quantity of exported commodity i from region r to region s (as in GTAP); $PMD_{i,r}$ is the price of commodity i sold on the domestic market in region r; $QDS_{i,r}$ is the quantity of commodity i sold on the domestic market in region r; $PM_{i,r}$ is an average market price of commodity i in region r; and $QO_{i,r}$ is the quantity of commodity i produced in region r (as in GTAP).

$PMX_{i,r,s}$ and $PMD_{i,r}$ are both derived from the zero profits equation ($PZ_{i,r}$) for the production of the good and the productivity pertaining to exported ($AXS_{i,r,s}$) and domestically supplied ($ADS_{i,r}$) goods and the power of the production tax (one plus the tax rate $(1 + \mathrm{rT0})$ or $TO_{i,r}$ in GTAP): [17]

[15] Note that this does not mean firms that supply the domestic and export market must have the same productivity. As recent evidence suggests, exporting firms tend to have higher productivity (or lower costs) than firms that produce for the domestic market. This can be reflected in differences in the initial values of the productivities of firms that supply the domestic and foreign markets. What is assumed is that they combine their intermediate inputs and value added in the same proportions. To properly account for this heterogeneity of firms and the impact of NTMs on the markups obtained by exporting firms, our methodology would need to be incorporated into a model where exporting firms were disaggregated and markups included, such as the GTAP-HET model developed by Akgul et al. (2016). This might also allow the user to consider an additional mechanism for implementing NTMs as a decline in the fixed cost of exporting.

[16] In GTAP: $VOM_{i,r} = \sum_s VXMD_{i,r,s} + VDM_{i,r}$, hence: $PM_{i,r}.QO_{i,r} = \sum_s PM_{i,r}.QXS_{i,r,s} + PM_{i,r}.QDS_{i,r}$

[17] $ADS_{i,r}$ is the equivalent productivity shock on production of the domestically supplied good. A rise in this reduces the demand for inputs for the good produced for the domestic market. Altering $ADS_{i,r}$ and $AXS_{i,r,s}$ together is equivalent to a shock to $AO_{i,r}$ in the original GTAP model.

$$PMX_{i,r,s} = \frac{PZ_{i,r}}{AXS_{i,r,s}}.(1 + \mathrm{rTO}) = \frac{PZ_{i,r}}{AXS_{i,r,s}}.TO_{i,r} \tag{15}$$

$$PMD_{i,r} = \frac{PZ_{i,r}}{ADS_{i,r}}.TO_{i,r} \tag{16}$$

Substituting equations (15) and (16) into (14), we can derive the relationship between production ($QO_{i,r}$), exports ($QXS_{i,r,s}$) and domestically supplied ($QDS_{i,r}$) goods:

$$\begin{aligned} \frac{PZ_{i,r}}{AS_{i,r}}.(1 + \mathrm{rTO}).QO_{i,r} \\ &= \sum_s \left(\frac{PZ_{i,r}}{AS_{i,r}}.AS_{i,r}.(1 + \mathrm{rTO}).\frac{QXS_{i,r,s}}{AXS_{i,r,s}}\right) \\ &+ \frac{PZ_{i,r}}{AS_{i,r}}.AS_{i,r}.(1 + \mathrm{rTO}).\frac{QDS_{i,r}}{ADS_{i,r}} \end{aligned} \tag{17}$$

where $AS_{i,r}$ is an average of the productivities on domestic and exported goods applied to total production.

In proportionate changes:

$$\begin{aligned} pz_{i,r} - as_{i,r} + to_{i,r} + qo_{i,r} \\ &= \sum_s \frac{VXMD_{i,r,s}}{VOM_{i,r}}.\big(pz_{i,r} - as_{i,r} + to_{i,r} + as_{i,r} \\ &+ qxs_{i,r,s} - axs_{i,r,s}\big) \\ &+ \frac{VDM_{i,r}}{VOM_{i,r}}.\big(pz_{i,r} - as_{i,r} + to_{i,r} + as_{i,r} + qds_{i,r} \\ &- ads_{i,r}\big) \end{aligned}$$

Or

$$\begin{aligned} qo_{i,r} - as_{i,r} &= \sum_s \frac{VXMD_{i,r,s}}{VOM_{i,r}}.\big(qxs_{i,r,s} - axs_{i,r,s}\big) \\ &+ \frac{VDM_{i,r}}{VOM_{i,r}}.\big(qds_{i,r} - ads_{i,r}\big) \end{aligned} \tag{18}$$

Since there is no way of separately identifying $qo_{i,r}$ and $as_{i,r}$, we define a new variable $qoas_{i,r}$ in GTAP to be inclusive of the average productivity $as_{i,r}$. That is:

$$qoas_{i,r} = qo_{i,r} - as_{i,r} \tag{19}$$

Similarly, $ps_{i,r}$ in GTAP is also redefined as* the zero profits price $pz_{i,r}$ for the industry.

$$ps_{j,r} = \sum_e \frac{VFA_{e,j,r}}{VOA_{j,r}}(pfe_{e,j,r}) + \sum_i \frac{VFA_{i,j,r}}{VOA_{j,r}}(pf_{i,j,r}) \quad (20)$$

where $ps_{i,r}$ is the price of producing the average good *i* by sector *i* in region *r*. Note that it differs from the price in GTAP because it now includes the average productivity of domestic and exported goods ($as_{i,r}$). $VFA_{e,j,r}$ is the value of factor endowment *e* used in production of commodity *j* in region *r*; $VFA_{i,j,r}$ is the value of intermediate input *i* used in production of commodity *j* in region *r*; $VOA_{j,r}$ is the value of output of commodity *i* produced in region *r*; $pfe_{e,j,r}$ is the value of price of factor endowment *e* used in production of commodity *j* in region *r*; and $pf_{i,j,r}$ is the price of intermediate input *i* used in production of commodity *j* in region *r*.

Firms' demand for intermediates $qf_{j,i,s}$ and value added $qva_{i,s}$ in the production of the good i then change by $qoas_{i,r}$ (inclusive of the average productivity), since a Leontief production function is assumed at this level.

$$qva_{i,s} = qoas_{i,s} \quad (21)$$

$$qf_{j,i,s} = qoas_{i,s} \quad (22)$$

We remind the reader that because $as_{i,r}$, the average of the productivities on domestic and exported goods applied to total production, is subsumed in $qoas_{i,s}$, the demand for value added ($qva_{i,s}$) and intermediate inputs ($qf_{j,i,s}$) falls with a rise in the productivity of sector *i* firms located in region *r* that export to region *s* ($axs_{i,r,s}$).

In proportionate changes, the market price of the exported good is given by (derived from equation (15)):

$$pmx_{i,r,s} = ps_{i,r} - axs_{i,r,s} - to_{i,r} \quad (23)$$

and the market price of domestically sold good (equation (16)):

$$pmd_{i,r,s} = ps_{i,r} - \text{ads}_{i,r} - to_{i,r} \quad (24)$$[18]

[18] We have retained the perfect transformation assumption between domestic and exports sales in the GTAP model. The alternative is the constant elasticity of transformation (CET) (with finite elasticities), where differences in prices obtained on the domestic and foreign markets would result in changes in relative supply of goods for export and the domestic market. Users might also think of this in terms of a MAKE matrix (with no CET) where each activity produces multiple commodities for the domestic and export markets. A negative shock to $axs_{i,r,s}$ (or $ads_{i,r}$) requires that more or all the inputs (intermediate and value added) required to make the export (or domestic) good, and also raises the price of the exported (domestic) commodity.

For purposes of reporting changes in sectoral production, we define a sectoral quantity index, $qo\_index_{i,r}$ which is the weighted sum of the percent changes in the amounts produced for export ($qxs_{i,r,s}$) and the domestic market ($qds_{i,r}$): [19]

$$qo\_index_{i,r} = \sum_{s} \frac{VXMD_{i,r,s}}{VOM_{i,r}} \left(qxs_{i,r,s}\right) + \frac{VDM_{i,r}}{VOM_{i,r}} \left(qds_{i,r}\right) \quad (25)^{20}$$

The exporter price $PMX_{i,r,s}$ is then linked to the FOB price through the export subsidies and to the market price in the importing region $PMS_{i,r,s}$ through the same mechanisms described in section 2.2 (replacing equation 10):

$$pfob_{i,r,s} = pmx_{i,r,s} - txs_{i,r,s} \quad (26)$$

The export cost method is most closely related to the import-augmenting iceberg method. Both the import-augmenting ($AMS_{i,r,s}$) and the export-cost ($AXS_{i,s}$) method have expansion/contraction effects and substitution effects. The import-augmenting ($AMS_{i,r,s}$) technological change directly reduces demand for imports (expansion/contraction effect), while also lowering the price, causing substitution towards exports (substitution effect). The export-cost ($AXS_{i,s}$) change, on the other hand, directly reduces demand for inputs into production (expansion/ contraction effect), while also lowering the price, causing substitution towards exports (substitution effect). Essentially, Samuelson's iceberg has been moved inside the exporting region, such that fewer inputs (intermediates and value added, equations 18 and 19) are needed to produce the desired exports, rather than the exports melting as they are transported from the exporting to the importing country. The main impact of this change is that the productivity gains are now captured by the exporting country, rather than by the importing country. This is an important distinction which addresses some of the issues raised about the import-augmenting (iceberg cost) method in applied policy analysis.

This method is somewhat similar to the method discussed in Dee (2003). Dee and Hanslow (2001) developed the FTAP model to examine the impact of NTMs on foreign direct investment (FDI) and services. In that model, NTMs on FDI were applied as output tax or productivity shocks to the sector receiving FDI. They included detailed data on the ownership of firms that allowed them to target the firms receiving the FDI. For instance, a reduction in Korean NTMs on US FDI would benefit US owned firms located in Korea by raising their ability to receive

[19] We also set the original GTAP variable $qo_{i,r}$ equal to $qo\_index_{i,r}$. This assumes that the variable $as_{i,r}$ is defined as the simple weighted sum of $axs_{i,r,s}$ and $ads_{i,r}$: $as_{i,r} = \sum_s \frac{VXMD_{i,r,s}}{VOM_{i,r}}.\left(axs_{i,r,s}\right) + \frac{VDM_{i,r}}{VOM_{i,r}}.\left(ads_{i,r}\right)$. Hence if $axs_{i,r,s}$ (or $ads_{i,r}$) is not shocked $qo_{i,r}$, $qoas_{i,r}$ and $qo\_index_{i,r}$ will be identical. When $axs_{i,r,s}$ (or $ads_{i,r}$) is shocked, this impacts the variable, $as_{i,r}$, and hence $qo_{i,r} = qo\_index_{i,r} \neq qoas_{i,r}$.

[20] Note this is the equation for non-margin commodities.

FDI and hence their productivity. Dee (2003) emphasizes the potential importance of NTMs for firm productivity, as is done in the export method discussed in this paper. The difference is that in the case of NTMs on FDI, the productivity gain is obtained by the firms receiving the FDI regardless of who buys the good; while in this paper we examine the impact of removing NTMs on the exports of firms, regardless of the ownership of those firms. While Dee and Hanslow (2001) went to great lengths to build a new database and model to capture foreign ownership of firms, our method represents an attempt to implement the NTM on export sales without having to separate firms into those that produce for the domestic market and those that export. There are certainly benefits to separating this data, given the significant differences between firms, however, our aim was to incorporate this method into the standard GTAP model without having to adapt the database.

3. Methodology

In order to compare and contrast the different methods for capturing the impact of NTMs in trade models, outlined above, we examine the impact of a reduction in NTMs within the 6 major ASEAN countries under focus. Since our aim is to compare the methods for implementing NTMs, we focus only on changes to merchandise trade NTMs; we do not model any other policy reform in the region.

The widely used standard GTAP model (Hertel, 1997), long considered the benchmark for analysis of trade agreements, is used for this analysis.[21] We adapt the model to incorporate the new method for examining NTMs through a change in exporter costs. The traditional mechanisms of trade taxes and iceberg costs are already incorporated into the GTAP model. The five mechanisms examined are:

- Mechanism 1: AMS: iceberg costs
- Mechanism 2: AXS: exporter costs
- Mechanism 3: TMS: import taxes
- Mechanism 4: TXS: export taxes
- Mechanism 5: WTP: willingness to pay

Mechanisms 1 and 2 are referred to as productivity methods, since they involve adjusting a productivity variable in the model; while Mechanisms 3 and 4 are referred to as trade tax methods, given the use of trade taxes to represent rents. The mechanisms can also be divided according to whether they impact importers (import orientated) or exporters (export orientated): Mechanisms 1 and 3 are similar to the extent that they both impact importers directly; while Mechanisms 2 and 4 impact exporters. The willingness to pay method is likely to be more similar to the trade tax methods, since there is no productivity gain; although the

[21] The model is solved using GEMPACK (Harrison, Horridge, Jerie and Pearson, 2014).

gains between importer and exporter are allocated by market mechanisms, since there are no rents being collected by the importer or exporter.

The database used for the analysis is based on the GTAP 9.2 Data Base (Aguiar, Narayanan and McDougall, 2016), with production, trade and protection calibrated for all regions to the base year of 2011. The full GTAP Data Base of 141 regions and 57 sectors is aggregated to 15 regions and 7 sectors, as shown in Appendix I.

CGE modellers typically rely on econometric estimates of the impact of NTMs to generate scenarios of changes in NTMs. These econometric estimates may be price-based approaches that compare the price in the importing market with comparable prices in free markets, or quantity-based approaches that use the value of trade quantity flows to estimate how much an NTM reduces trade flows (see Berden and Francois, 2015, for discussion of these different approaches). In the current study, we use quantity-based estimates from gravity modelling undertaken to estimate changes in trade due to NTMs (Webb et al., 2020). Often these changes in trade quantities are converted, using elasticity estimates, to obtain the ad valorem equivalent (AVE) of the NTMs (Bekkers and Rojas-Romagosa, 2019). These AVEs would have the same effect as the NTM protection, on the assumption that NTMs can be represented as trade costs. However, since we are comparing several mechanisms that do not all apply the shock directly to trade costs, we have chosen not to use the ad valorem equivalents of trade costs obtained from econometric studies. Instead, we follow Webb et al. (2017) and Webb et al. (2020) in using the econometric estimates of the changes in the quantity of trade flows as our shocks, allowing the model to calibrate the relevant ad valorem equivalent of the mechanism used to model the NTM.[22] For our purposes, this calibration approach takes into account the fact that an ad valorem equivalent of trade costs applied on production costs is unlikely to impact trade in the same way as if the same ad valorem equivalent was applied directly to trade costs. This is due to the additional taxes and transportation margins that are imposed on the good between the price received by the exporter and the price paid by the importer. Ensuring that the change in trade estimated by the gravity model is met under all five mechanisms will improve the direct comparison of the impacts of the mechanisms. We calibrate the iceberg costs to the exported quantities, rather than the imported quantities, after taking account of the melting of the iceberg. This is consistent with the way in which the gravity model estimates the iceberg cost. The willingness to pay estimates are calibrated assuming that market prices

[22] This has a benefit of avoiding any potential inconsistency between the elasticities used in generating AVEs and the elasticities in the GTAP Data Base.

are fixed, since changes in actual prices will offset any change in willingness to pay, leaving demand unchanged.[23]

The implementation of the trade taxes methodology also requires that the NTM ad valorem equivalents be incorporated into the tariff and export taxes in the underlying data using Altertax (see Malcom, 1998) before being removed in the NTM liberalization simulation. Altertax is known to alter the data,[24] which is likely to impact our comparison, however the taxes must be incorporated in order to obtain accurate estimates of welfare. The need to include the estimates of the NTMs in the import and export taxes, and the consequent impact on these flows, is a weakness of the trade taxes approach.

To calibrate the shocks, we run pre-simulation calibrations for each of the mechanisms modelled. In particular, we endogenize the mechanisms (AMS, AXS, TMS, TXS and WTP), implementing a closure swap that exogenizes export quantity flows, following Webb et al. (2017 and 2020). This enables us to simulate the changes in export quantities based on the econometric estimates in order to back out the calibrated shocks for each of the mechanisms modelled. The calibration is undertaken at the commodity and importer level. That means that for each of the five mechanisms, a separate calibration simulation is undertaken for each of the six ASEAN importing countries and five commodities to obtain the econometrically estimated change in quantity – i.e., 6 (goods commodities, Table A1, Appendix I) x 6 (regions, Table A2, Appendix I) x 5 (mechanisms) simulations. For the trade tax simulations, an additional step is required after the calibration simulations to incorporate the NTMs in tariffs or export taxes through Altertax. Once the updated database is created, which incorporates NTMs in either export or import taxes, reductions in the calibrated trade tax equivalents can be simulated.

Once calibrated, we undertake a single simulation for each mechanism to remove the calibrated NTMs on all commodities in all six ASEAN countries simultaneously (i.e., 5 simulations). We also use subtotals to examine separately the impact of Vietnam's liberalization of NTMs on imports from other ASEAN member countries, to see how each of the mechanisms allocates the gains to the importer or exporters. By focusing on one importing country, the differences

[23] We follow Webb et al. (2020) in taking a relatively conservative approach: we only consider NTMs that have a statistically significant negative effect on the level of imports at the 90% level and we assume that only 20 percent of NTMs can be removed, given the various legitimate public policy objectives that they target. See Webb et al. (2020) for further details and discussion of the NTM measures used.

[24] We use the Altertax facility as outlined in Malcom (1998). The Altertax facility allows the tax rates in the GTAP Data Base to be altered with minimal changes to the IO shares. However, while Altertax minimizes the changes in the IO shares, the trade data may adjust significantly when the required change in tax rates is large. Caution is therefore recommended.

between the mechanisms and how they allocate the gains from NTMs across importers and exporters become more apparent. We choose Vietnam because it has high NTMs on goods relative to the other ASEAN countries.

4. Results and analysis

4.1. Calibration results

Table 1 shows the calibrated changes in each of the five mechanisms required to obtain the gravity estimates of the change in quantity of imports due to NTMs imposed by importers on each commodity. The calibrated changes in all five mechanisms are relatively close in absolute terms, particularly in the case of AMS and TMS. Some differences in absolute terms are to be expected, given that the mechanisms enter the equations in slightly different places and would therefore be impacted by slightly different share weights. Moreover, the export mechanisms, and in particular the AXS or exporter cost method, impact the model further away from the importer's sourcing decision (i.e., the Armington equation) and hence the shocks required to achieve the same change in quantity imported are slightly larger.[25] The signs are also as expected given how each mechanism is incorporated into the model; for instance, the negative on TMS represents the removal of an import tariff or importer rent and the positive values of the TXS shocks represents the removal of an export tax or exporter rent. Table 1 also shows that the largest NTMs are on plant and animal products; although Vietnam and the Philippines also have relatively large NTMs on wood products and other manufactures. The NTMs on plant products by Singapore and the Philippines stand out as being significantly larger than the other importing countries (Table 1), although when aggregated across commodities (Table 2), the average for Singapore is relatively low due to the fact that these commodities represent a small share of their imports. The Philippines and Vietnam have the largest aggregate shocks.

The differences between the mechanisms for the aggregate shocks by importer (columns I to V, Table 2) are fairly similar, although there are considerable differences across importing countries. Malaysia, Vietnam and the Philippines experience the largest reductions in NTMs with average reductions for the Philippines almost twice the size of the next highest country, Vietnam.

[25] This is also the case for the willingness to pay method.

Table 1. Calibrated average changes in NTM mechanisms by commodity and importer, %.[a]

	AMS	AXS	TMS	TXS	WTP
		SINGAPORE			
Plant Products	3.77	4.24	-3.46	4.01	3.93
Animal Products	1.86	1.98	-1.77	1.91	1.85
Wood Products	0.02	0.02	-0.02	0.02	0.02
Textiles, Leather & Wearing Apparel	0.00	0.00	0.00	0.00	0.00
Machinery & Equipment	0.02	0.02	-0.02	0.02	0.02
Other Manufactures	0.03	0.03	-0.03	0.03	0.03
		THAILAND			
Plant Products	0.79	0.86	-0.75	0.83	0.79
Animal Products	0.13	0.14	-0.13	0.14	0.13
Wood Products	0.08	0.09	-0.08	0.09	0.08
Textiles, Leather & Wearing Apparel	0.00	0.00	0.00	0.00	0.00
Machinery & Equipment	0.03	0.04	-0.03	0.04	0.04
Other Manufactures	0.02	0.02	-0.02	0.02	0.02
		MALAYSIA			
Plant Products	1.64	1.86	-1.59	1.83	1.67
Animal Products	0.35	0.38	-0.34	0.37	0.35
Wood Products	0.00	0.01	0.00	0.01	0.00
Textiles, Leather & Wearing Apparel	0.01	0.01	-0.01	0.01	0.01
Machinery & Equipment	0.02	0.02	-0.02	0.02	0.02
Other Manufactures	0.03	0.04	-0.03	0.04	0.03
		VIETNAM			
Plant Products	1.3	1.47	-1.23	1.40	1.31
Animal Products	0.12	0.14	-0.12	0.13	0.12
Wood Products	0.61	0.70	-0.59	0.69	0.61
Textiles, Leather & Wearing Apparel	0.05	0.06	-0.05	0.06	0.05
Machinery & Equipment	0.13	0.13	-0.12	0.13	0.13
Other Manufactures	0.19	0.20	-0.19	0.20	0.19
		PHILIPPINES			
Plant Products	4.34	4.58	-3.94	4.27	4.44
Animal Products	0.15	0.17	-0.15	0.16	0.15
Wood Products	0.38	0.44	-0.37	0.43	0.38
Textiles, Leather & Wearing Apparel	0.01	0.01	-0.01	0.01	0.01
Machinery & Equipment	0.06	0.06	-0.06	0.06	0.06
Other Manufactures	0.24	0.27	-0.24	0.27	0.24
		INDONESIA			
Plant Products	0.60	0.67	-0.59	0.66	0.60
Animal Products	0.15	0.17	-0.15	0.16	0.15
Wood Products	0.03	0.04	-0.03	0.04	0.03
Textiles, Leather & Wearing Apparel	0.01	0.01	-0.01	0.01	0.01
Machinery & Equipment	0.09	0.09	-0.09	0.09	0.09
Other Manufactures	0.01	0.01	-0.01	0.01	0.01

Notes: [a] Trade-weighted average shocks that are applied bilaterally in the model.

Source: Authors' simulations drawing on NTM estimates from Webb et al. (2020).

When aggregated from the export side to give the average NTMs imposed on a country's exports (columns VI to VIII, Table 2), the NTMs for the Philippines as an exporter are considerably lower than those found for the Philippines as an importer (0.06 as opposed to 0.5); while those for Indonesia are higher. This means that the Philippines imposes higher NTMs on imports from ASEAN members than it faces on its exports to ASEAN countries. This is due to the fact that the Philippines does not send a large share of its exports to other ASEAN countries, and those countries and commodities it does export have relatively low NTMs. Indonesia, on the other hand, exports more to ASEAN and in particular to Malaysia, which has relatively high NTMs; while it imposes relatively small NTMs on its imports from ASEAN countries (Table 1). Hence the shock to Indonesia's exports (around 0.18) are larger than those imposed on Indonesian imports (around 0.09).

Table 2. Weighted average of calibrated changes in NTM mechanisms aggregated by importer and by exporter, selected NTM mechanisms (percent).[a]

	Shocks aggregated by importer					Shocks aggregated by exporter		
	I AMS	II AXS	III TMS	IV TXS	V WTP	VI AXS	VII TXS	VIII WTP
Singapore	0.109	0.113	-0.102	0.106	0.112	0.057	0.056	0.059
Thailand	0.062	0.060	-0.060	0.059	0.062	0.161	0.153	0.156
Malaysia	0.154	0.156	-0.149	0.152	0.156	0.185	0.175	0.178
Vietnam	0.256	0.274	-0.248	0.265	0.259	0.244	0.226	0.259
Philippines	0.507	0.512	-0.471	0.473	0.517	0.062	0.06	0.065
Indonesia	0.088	0.092	-0.087	0.091	0.087	0.189	0.181	0.171

Notes: [a] Shocks for AMS and TMS aggregated by exporter show similar differences. They are not included since the gains from these mechanisms go to the importer and hence the differences are not important for the analysis of the results.

Source: Authors' simulations.

These differences between the shocks when the country is considered an importer, as opposed to an exporter, explain most of the differences between the final impacts of the five different mechanisms. It is therefore worthwhile separating the countries into two groups: a) Singapore, Vietnam and the Philippines, which impose higher NTMs on their imports, than their exports face in other ASEAN countries; and b) Thailand, Malaysia and Indonesia whose exports face higher NTMs, than they impose on imports from other ASEAN countries.

4.2. Macroeconomic impacts

An examination of the real GDP results reveals two important differences between the various mechanisms used. First, the methods that entail productivity improvements, AMS and AXS (columns I and II, Table 3), have a larger impact on real GDP than those methods which alter the rents or tax wedges, TMS and TXS (columns III and IV, Table 3), or the willingness to pay, WTP (column V, Table 3), regardless of the country. A productivity improvement directly increases the amount of product that can be produced or consumed with a given amount of resources; while a decrease in taxes merely improves the allocation of resources, thereby increasing the efficiency with which those resources are used. Like trade taxes, willingness to pay also leads to a reallocation of resources; although in that case the reallocation is due to preferences rather than a reduction in taxes or costs, hence the gains are smaller still. Since all five of the methods involve similarly sized shocks (Table 1 and Table 2), it is not surprising that the methods that directly impact productivity, as well as prices, yield a larger increase in total production or real GDP.

Table 3. Impact on real GDP of ASEAN and Vietnam's liberalization of NTMs on goods from ASEAN, five alternative NTM mechanisms (percent).

	ASEAN reduces NTMs on ASEAN					Vietnam reduces NTMs on ASEAN				
	I AMS	II AXS	III TMS	IV TXS	V WTP	VI AMS	VII AXS	VIII TMS	IX TXS	X WTP
Singapore	0.13	0.08	0.02	0.02	0.01	0.00	0.02	0.00	0.00	0.00
Thailand	0.06	0.14	0.02	0.03	0.02	0.00	0.04	0.01	0.01	0.00
Malaysia	0.13	0.18	0.02	0.03	0.01	0.00	0.03	0.00	0.00	0.00
Vietnam	0.29	0.23	0.04	0.06	0.01	0.28	0.03	0.02	0.03	-0.01
Philippines	0.25	0.07	0.07	0.05	0.04	0.00	0.01	0.00	0.00	0.00
Indonesia	0.03	0.05	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Total ASEAN	0.10	0.10	0.02	0.02	0.00	0.02	0.02	0.00	0.00	0.00

Source: Authors' simulations.

If we aggregate the changes in real GDP into an ASEAN total (see row labelled "total ASEAN"), we find little difference between the change in real GDP for ASEAN under the two productivity methods (columns I and II, Table 3). The export tax and import tax methods (columns II and IV, Table 3) also lead to similar changes in overall total ASEAN real GDP. The allocations across countries, however, differ considerably between the import and export variants of the productivity and trade tax methods.

This leads to our second finding: the allocation of the gains across regions differs significantly between the export and import methods (i.e., comparing Column I with II and Columns III with IV, Table 3). Moreover, these differences between the methods reflect the differences seen in the weighted calibrated shocks shown in Table 2. For instance, the Philippines does not gain as much in terms of real GDP when an export orientated method is used (columns II and IV, Table 3), since the average shocks impacting the Philippines as an exporter are relatively small (Table 2); on the other hand, methods that assume the gains go to the importer (Columns I and III, Table 3) show the Philippines as a significant beneficiary of the liberalization of NTMs. Singapore and Vietnam show similar results, for the same reason: they impose higher NTMs on their imports than they face on their exports. Hence, when the gains from reducing NTMs are given to the importer, these countries obtain a larger share of those gains.

The reverse is true for our second group of countries: Malaysia, Thailand and Indonesia. Malaysia, Thailand and Indonesia export a high share of their goods and services to ASEAN countries with higher NTMs, and therefore face higher

NTMs on their exports than they impose on their imports. Hence when export mechanisms are used to model a reduction in NTMs, Malaysia, Thailand and Indonesia obtain more of the gains than under the import methods.

This becomes even more apparent when we separate the liberalization of NTMs by Vietnam only (columns V to VIII, Table 3). Here we find that under the AMS method (Column VI), all the increases in real GDP accrue to the importer, in this case Vietnam; while under the AXS method (column VII), the same total gains in real GDP are spread across all the ASEAN exporters of goods to Vietnam, as well as Vietnam.[26] This emphasizes the point made above, that under the AMS method, the gains accrue to the importer (in this case, Vietnam), not the exporters.

Table 4 shows some of the results for other key macroeconomic variables. In general, trade (exports and imports) rises under all methods. This is because a reduction in NTMs generally reduces the price of NTMs, which increases demand for traded goods. The fall in Vietnam's exports, and the lower change in exports for all ASEAN countries, under the AMS method reflects the iceberg effect discussed in section 2.1 – when NTMs are reduced, less goods must be exported for the importer to receive the same amount of imports. Hence, although bilateral imports between two countries may rise, the amount that needs to be exported to fulfill that increase in imports is now lower, and the changes in exports under the AMS method are lower than those obtained under all the other methods. This effect is also captured by examining the difference in imports sent (qiwreg) and imports received by the consumers in the importing country (qimreg), which are provided in brackets.[27] This difference again reflects the fact that fewer goods need to be sent (qiwreg) to meet the consumer demand for imports (qimreg in brackets). The imports received by consumers (qimreg in brackets) under the AMS method closely resemble those received under the other methods. It is this effect on exports which generates much of the concern about use of the iceberg approach.

Investment rises in all ASEAN countries, but most notably in Thailand, Malaysia, Vietnam and the Philippines, under most of the methods (Table 4). The exception is the willingness to pay method, where investment rises by considerably less than the other methods and falls in the case of the Philippines. Unlike the other methods, the willingness to pay method does not lower the costs of production, raising production. This is particularly true of the largest sector, services, which is not directly impacted by the removal of goods' NTMs. In the case of the Philippines, demand for capital falls as consumers switch to imported

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[26] A further reason we choose Vietnam for explanatory purposes is because the shocks as importer and exporter are quite closely matched.

[27] The variable qimreg has been added to the code to demonstrate the effect on imports of the AMS method. The results for qimreg are not provided for the other methods because in the other methods qimreg and qiwreg are very close, differing only to the extent that tariffs alter the import share weights.

plant products. Under the other methods, reduced production costs increase production of services, which in turn raises demand for capital and hence investment.

Table 4. Impact of ASEAN liberalization of NTMs on goods from ASEAN, selected macroeconomic variables, five alternative NTM mechanisms (percent).

	Exports	Imports	Investment	Terms of trade	Trade balance (US$ millions)
			SINGAPORE		
AMS	0.06	0.06 (0.17)[a]	0.07	0.03	135.75
AXS	0.10	0.17	0.07	0.09	137.03
TMS	0.11	0.18	0.07	0.03	-15.44
TXS	0.09	0.19	0.07	0.09	49.98
WTP	0.05	0.15	0.04	0.04	-111.39
			THAILAND		
AMS	0.01	0.16 (0.23)[a]	0.26	0.09	-149.77
AXS	0.17	0.22	0.25	-0.02	-148.81
TMS	0.04	0.23	0.27	0.11	-172.86
TXS	0.15	0.21	0.23	-0.01	-181.01
WTP	0.03	0.19	0.18	0.12	-101.22
			MALAYSIA		
AMS	0.09	0.20 (0.36)[a]	0.27	0.06	-53.25
AXS	0.28	0.35	0.27	0.03	-54.68
TMS	0.19	0.35	0.26	0.08	-106.90
TXS	0.24	0.35	0.24	0.04	-125.33
WTP	0.14	0.29	0.12	0.09	-52.17
			VIETNAM		
AMS	-0.11	0.38 (0.63)[a]	0.92	0.14	-443.54
AXS	0.15	0.65	0.90	0.15	-437.37
TMS	0.23	0.57	0.75	0.13	-353.61
TXS	0.15	0.62	0.82	0.16	-392.62
WTP	0.24	0.36	0.17	0.13	-95.42
			PHILIPPINES		
AMS	0.10	0.36 (0.97)[a]	0.51	0.01	-252.86
AXS	0.16	0.86	0.51	0.45	-252.39
TMS	0.92	0.73	0.29	-0.12	-109.12
TXS	0.18	0.87	0.51	0.45	-247.00
WTP	1.13	0.63	-0.13	-0.16	104.33
			INDONESIA		
AMS	0.13	0.19 (0.28)[a]	0.03	0.07	25.68
AXS	0.32	0.28	0.03	-0.04	21.64
TMS	0.20	0.30	0.03	0.08	18.57
TXS	0.28	0.28	0.02	-0.03	-30.24
WTP	0.20	0.27	0.00	0.09	59.35

Notes: [a] Results in brackets represent imports calculated using qimreg. These are the amounts received by consumers in the importing country, compared to amounts of goods sent (qiwreg).

Source: Authors' simulations.

With the general rise in investment, trade balances also tend to decline as a result of the reduction in NTMs in these countries, with the expansion in investment mostly funded by foreign savings. In general, the tax methods lead to smaller increases in income and hence savings than the productivity methods, which causes the increase in investment to be lower or the trade balance to fall even further under the tax methods, than under the productivity methods. In the case of the TMS method, for instance, global savings falls, causing investment to be lower and the changes in the trade balances to be lower (or more negative) due to less savings across regions.

The terms of trade tend to rise as a result of the reduction in NTMs, with prices received for exports rising relative to imports. Those countries where the NTM shocks are larger when examined from the exporting point of view (Thailand, Malaysia and Indonesia, Table 2), experience a smaller increase in terms of trade when the export methods are used. This is because the export methods tend to reduce the price of exports of the exporting countries (Thailand, Malaysia and Indonesia) further than the import methods, lowering the terms of trade of these countries; which in turn lowers the price of imports of the other countries (Singapore and the Philippines) more, raising their terms of trade.

4.3. Welfare

The welfare results for the five alternative mechanisms are shown below in Table 5. A comparison of the results for the two productivity methods (AMS and AXS) and the willingness to pay method reveals surprisingly similar results across regions, although an analysis of the decomposition (Table 5) suggests that there are important differences in where those welfare gains come from.

For instance, in the case of Singapore, Vietnam and the Philippines, we know from Table 2 that the shocks based on these countries as importers are larger than those where these countries are considered exporters, hence the AXS method has a smaller technological effect, but a larger terms of trade impact, while the AMS method has a larger productivity effect and lower terms of trade effect (Table 5). The reverse is true for Malaysia, Thailand and Indonesia, where the shocks are larger when examined from the exporters' point of view – hence the AXS method shows the larger productivity effect (Table 5). The decomposition of the willingness to pay method looks similar to the AMS method, albeit the gain due to productivity is a gain in preferences, which is obtained by the importing country.

It is also interesting to note that the allocative efficiency effects are larger under the AXS method, than those obtained when using AMS methods. This is because the changes in trade are larger under the AXS method than the AMS method, which has lower trade due to the iceberg effect – less goods need to be exported to meet the importers' demand for goods. Lower imports mean lower allocative efficiency effects on imports.

Table 5. Impact on welfare of ASEAN's liberalization of goods NTMs on imports from ASEAN countries, five alternative NTM mechanisms (US$ millions)

	Allocative efficiency	Technological change	Terms of trade	Capital goods	Preferences	Total
			SINGAPORE			
AMS	39.9	313.9	101.7	-26.2	0	429.3
AXS	39.8	176.0	249.5	-33.5	0	431.9
TMS	64.7	0.0	100.9	-24.4	0	141.2
TXS	42.1	0.0	257.1	-34.1	0	265.1
WTP	40.9	0.0	131.9	-26.9	279.9	425.8
			THAILAND			
AMS	54.4	168.1	225.5	-3.8	0.0	444.1
AXS	78.4	414.3	-54.4	-4.2	0.0	434.1
TMS	85.1	0.0	280.2	-4.1	0.0	360.8
TXS	108.1	0.0	-33.6	-3.9	0.0	70.5
WTP	64.5	0.0	297.7	-4.3	96.0	453.8
			MALAYSIA			
AMS	25.6	355.1	161.3	-12.1	0.0	529.8
AXS	49.2	459.9	25.9	-14.1	0.0	520.8
TMS	67.0	0.0	193.7	-12.0	0.0	248.7
TXS	91.9	0.0	53.4	-13.7	0.0	131.6
WTP	41.3	0.0	227.8	-13.7	224.5	479.9
			VIETNAM			
AMS	48.6	351.2	140.5	39.0	0.0	579.2
AXS	67.1	247.2	215.0	40.0	0.0	569.4
TMS	61.2	0.0	122.0	27.1	0.0	210.1
TXS	79.9	0.0	222.3	35.4	0.0	337.6
WTP	9.6	0.0	123.7	21.3	241.6	396.1
			PHILIPPINES			
AMS	60.3	497.1	2.6	5.1	0.0	565.1
AXS	104.4	43.8	409.8	6.7	0.0	564.7
TMS	160.6	0.0	-90.7	-19.5	0.0	50.3
TXS	108.4	0.0	412.3	6.2	0.0	526.9
WTP	94.7	0.0	-119.4	-26.5	440.1	388.8
			INDONESIA			
AMS	32.1	183.4	140.7	-5.8	0	350.4
AXS	40.4	406.7	-97.4	-6.5	0	343.2
TMS	41.6	0.0	178.0	-5.9	0	213.6
TXS	60.0	0.0	-78.0	-6.2	0	-24.1
WTP	29.5	0.0	183.7	-6.7	129.3	335.8

Source: Authors' simulations.

The welfare impacts of the TMS and TXS methodology are smaller than the productivity methods (Table 5), as was also found in the real GDP results. The results also differ quite a lot depending on whether the tariff or export tax is used. The differences can again be linked back to the relative size of the shocks from the exporter and importer points of view. In general, the allocative efficiency gains are greatest where the NTM shocks are the largest; hence Thailand, Malaysia and Indonesia see larger allocative efficiency gains from the TXS method. However, the terms of trade also falls or is significantly lower when the NTM is implemented as an export tax for these countries and hence the total change in welfare is much lower under the TXS method than under the TMS for these countries. The reverse is true for the Singapore the Philippines, and to some extent Vietnam who have larger NTMs on their imports.

To understand the welfare results further, we separate the impact of Vietnam reducing NTMs on its imports (columns I-V, Table 6) and the impact of NTMs being reduced on Vietnamese exports (columns VI-X, Table 6) on Vietnamese welfare.[28] As we saw in the case of real GDP, the AMS method allocates the productivity gain entirely to the importer, while the AXS method allocates it across exporting regions. This is most clearly seen when looking at the single country results. For Vietnam, under the AMS method there is a large gain in welfare of US$351 million (column I, Table 6) due to technological change, while the AXS method shows zero technological gain here (column II, Table 6). When Vietnam is the exporter of goods on which NTMs are reduced (columns VI to X, Table 6), it receives a welfare gain from technological change under the AXS method (column VII), and nothing under the AMS method.

Notice, however, that the terms of trade effect under the AXS method (column II, Table 6) is almost as large as the technological change effect under the AMS method (column I, Table 6). This is because, although Vietnam does not gain from the iceberg productivity effect under the AXS method, it does gain from the rise in the price received for exports. Hence, rather than receiving a productivity gain, importers receive a terms of trade gain (plus a little extra allocative efficiency) which is roughly equivalent in size to the iceberg productivity gain they would have achieved under the AMS method. Since the changes in the capital goods terms of trade are also similar between the AMS and AXS methods, the total change in welfare is also similar.

When we examine Vietnam as an exporter (Table 6), there is a productivity gain that feeds into a technology effect of US$247 million accruing to Vietnam as the exporter under the AXS method (Table 6). This amount is smaller than the gain obtained as an importer based on the AMS approach (US$351 million), because as

[28] Note the two numbers do not sum to the total change in welfare, since it does not take account of the indirect effects of the other ASEAN countries reducing NTMs on each other; however, this difference is small.

we saw in Table 2, the shock when Vietnam is an exporter is smaller. This US$247 million represents the productivity gain in the production of exports and is offset by a slight decline in the terms of trade. Similar terms of trade effect differences are seen between the TMS and TXS methods.

Table 6. Decomposition of Vietnam's welfare due to liberalization of goods NTMs, five alternative NTM mechanisms (US$ millions)

	Vietnam (only) reduces NTMs on imports from other ASEAN countries					ASEAN reduces NTMs on imports from Vietnam (only)				
	I AMS	II AXS	III TMS	IV TXS	V WTP	VI AMS	VII AXS	VIII TMS	IX TXS	X WTP
Allocative efficiency	24.2	41.6	29.9	42.5	-20.2	26.4	27.6	33.9	45.3	34.3
Technological change	351.2	0.0	0.0	0.0	0.0	0.0	247.2	0.0	0.0	0.0
Terms of trade	-7.6	325.7	-73.7	327.8	-80.3	181.3	-76.2	228.1	-70.8	243.5
Capital goods terms of trade	11.3	11.7	-8.9	11.9	-15.6	32.6	31.7	40.8	27.1	42.7
Preferences	0.0	0.0	0.0	0.0	241.6	0.0	0.0	0.0	0.0	0.0
Total	379.1	379.0	-52.7	382.2	125.4	240.3	230.3	302.9	1.6	320.4

Source: Authors' simulations.

Under the willingness to pay method, most of the gains accrue to Vietnam as an exporter from an improvement in the terms of trade with small improvements in allocative efficiency also contributing (column X, Table 6). However, as an importer, we can see that Vietnam gets most of its welfare gains from the change in preferences, with allocative efficiency and terms of trade declining and contributing negatively to welfare. The gain in welfare through preferences is similar in size to the productivity gain under the AMS method, since like AMS the preferences are related to the reduction of NTMs by the importing country.

4.4. *Sectoral and factor impacts*

Table 7 provides the changes in sectoral production as a result of the reduction in NTMs under the five alternative methods. The changes in sectoral production between the five methods are fairly similar, with larger differences across methods tending to occur in plant and animal product sectors where the non-tariff barriers are largest (Table 1). The changes in production shown in the TMS and TXS methods (Table 7) tend to be smaller, in absolute terms, than those obtained under the productivity methods; and the WTP method results are comparable to those of the TMS and TXS methods. The trade tax method results are consistent with the macroeconomic results, with countries that experience larger barriers on their imports, e.g., Vietnam, the Philippines and Singapore, experiencing greater gains/smaller loses under the TMS method than the TXS method and vice versa for those with larger barriers on exports. The changes in exports follow the same pattern and hence drive the changes in production.

A comparison of the productivity methods shows that the production changes tend to be lower under the AMS method than the AXS method, even for Singapore, Vietnam and the Philippines, where real GDP is lower under the AXS method. This lower production under the AMS method is due to the iceberg effect – fewer goods need to be exported to satisfy the same amount of imports and hence exports increase by significantly less under the AMS method than under the other methods. The higher real GDP results from the addition of the iceberg effect to the smaller increase in production, while the productivity effect under the AXS method is incorporated into the production changes.

Table 7. Impact on sectoral production of ASEAN's liberalization of goods NTMs, five alternative NTM mechanisms, %

	AMS	AXS	TMS	TXS	WTP
		SINGAPORE			
Plant Products	5.23	6.30	6.33	6.36	2.60
Animal Products	1.42	1.70	1.59	1.62	0.59
Wood Products	0.32	0.40	0.41	0.40	0.37
Textiles, Leather & Wearing Apparel	0.82	0.85	0.83	0.83	0.17
Machinery & Equipment	-0.03	0.02	0.03	0.01	0.05
Other Manufactures	0.08	0.11	0.12	0.11	0.07
Services	-0.04	-0.04	-0.06	-0.06	-0.04
		THAILAND			
Plant Products	0.29	0.56	0.45	0.47	0.44
Animal Products	0.10	0.16	0.09	0.08	0.11
Wood Products	0.02	0.08	0.02	0.05	0.03
Textiles, Leather & Wearing Apparel	-0.29	-0.26	-0.35	-0.29	-0.29
Machinery & Equipment	-0.10	-0.06	-0.12	-0.07	-0.16
Other Manufactures	-0.13	-0.09	-0.15	-0.10	-0.14
Services	0.00	0.00	-0.02	-0.05	-0.02
		MALAYSIA			
Plant Products	0.47	0.83	0.74	0.75	0.53
Animal Products	0.58	0.81	0.70	0.69	0.65
Wood Products	-0.02	0.04	0.01	0.02	0.10
Textiles, Leather & Wearing Apparel	-0.34	-0.30	-0.40	-0.38	-0.33
Machinery & Equipment	-0.25	-0.21	-0.25	-0.23	-0.20
Other Manufactures	-0.14	-0.10	-0.13	-0.11	-0.11
Services	0.02	0.03	-0.02	-0.03	-0.01

(Continued)

Table 7. Impact on sectoral production of ASEAN's liberalization of goods NTMs, five alternative NTM mechanisms, % (continued)

	AMS	AXS	TMS	TXS	WTP
VIETNAM					
Plant Products	0.20	0.59	0.43	0.42	0.50
Animal Products	0.14	0.14	0.02	0.05	0.04
Wood Products	-1.12	-1.08	-0.98	-1.08	-0.79
Textiles, Leather & Wearing Apparel	-0.55	-0.52	-0.41	-0.50	-0.43
Machinery & Equipment	-0.19	-0.13	-0.03	-0.12	-0.19
Other Manufactures	-0.59	-0.54	-0.46	-0.54	-0.27
Services	0.29	0.29	0.13	0.18	0.03
PHILIPPINES					
Plant Products	-0.74	-0.71	-0.69	-0.71	-0.77
Animal Products	0.26	0.26	0.16	0.26	0.11
Wood Products	-0.38	-0.37	-0.12	-0.36	0.06
Textiles, Leather & Wearing Apparel	-0.20	-0.20	0.25	-0.19	0.63
Machinery & Equipment	-0.25	-0.23	0.47	-0.22	0.79
Other Manufactures	-0.02	0.00	0.33	0.01	0.40
Services	0.16	0.16	0.05	0.15	0.02
INDONESIA					
Plant Products	0.12	0.24	0.21	0.21	0.22
Animal Products	0.21	0.27	0.24	0.23	0.25
Wood Products	-0.09	-0.07	-0.12	-0.10	-0.13
Textiles, Leather & Wearing Apparel	-0.21	-0.20	-0.26	-0.23	-0.26
Machinery & Equipment	-0.18	-0.15	-0.21	-0.18	-0.23
Other Manufactures	-0.09	-0.06	-0.10	-0.08	-0.09
Services	0.02	0.02	0.00	-0.01	0.00

Source: Authors' simulations.

Table 8 provides the real returns to factors of production under the five alternative methods. The table shows to the real returns to mobile factors (labor and capital) generally rise more under the productivity methods than the tax methods, as production rises more, leading to larger increases in the marginal products of those factors of production. On the other hand, land, which is specific to plant products and is greatly affected by the reductions in large NTMs on plant products, experiences a larger rise in marginal product under the tax method, where its productivity remains unchanged. With the exception of land, which is only used in the production of agricultural goods, the changes in the returns to factors of production are significantly smaller (and sometimes negative) under the WTP method. This is primarily due to the very small gains in production of services, the largest sector in the economies and a significant source of demand for the other factors of production.

Table 8. Impact on Vietnam's real wages/returns of ASEAN's liberalization of NTMs on goods from ASEAN using the alternative mechanisms (percent)

	AMS	AXS	TMS	TXS	WTP
Land	0.95	0.88	1.36	1.37	1.17
Office Managers and professionals	0.59	0.59	0.44	0.49	0.03
Technicians and associate professionals	0.55	0.55	0.42	0.47	0.01
Clerks	0.69	0.69	0.49	0.56	0.04
Service and shop workers	0.63	0.63	0.46	0.52	0.03
Agricultural and low skilled workers	0.42	0.41	0.47	0.47	0.15
Capital	0.47	0.48	0.37	0.40	-0.01
Natural resources	0.04	0.05	0.03	0.01	-0.12

Source: Authors' simulations.

5. Conclusions

Overall, we find that the choice of mechanism can have important consequences for estimates of the impact of the reduction in NTMs: careful consideration of the nature of the NTMs being investigated, the estimates being utilized, and the appropriate CGE mechanisms to use, could improve analysis.

We find that, in terms of real GDP, the AMS and AXS productivity methods lead to much larger changes across all countries than do the tax and WTP methods. The allocation of the gains to GDP depends on whether the NTM is applied to the exports or imports. If the shock is applied to exports, then the exporters gain from the reforms; if applied to imports then the gains go to importers. The relative importance of NTMs on imports versus exports for each country determines how much of the global gain is allocated to them under the alternate methods. For example, in Singapore, Vietnam and the Philippines, the NTMs applied to imports are higher than those faced by their exports, thus they gain more from the reduction of NTMs on their imports than from the reduction of NTMs on their exports in the ASEAN liberalization experiment.

Welfare results tend to be much smaller under the import and export tax methods than when using productivity or WTP methods. The welfare impacts for the AXS and AMS methods are very similar, although the two methods allocate the productivity gains differently, the terms of trade effect offsets these differences, leading to similar overall changes in welfare. The terms of trade effects differ across mechanisms, depending on the relative importance of NTMs on a country's imports relative to their exports. Hence for Singapore, Vietnam and the Philippines, terms of trade effects tend to be larger when the export methods are used, because these mechanisms result in lower prices and given that NTMs on imports are more important, the decline in import prices outweighs the decline in exports prices, leading to a rise in the terms of trade.

The surprising impact of the iceberg in the AMS method can be seen in the results for production, trade and the allocative efficiency effects. The iceberg method tends to lead to lower changes in all of these effects, relative to the AXS method, despite getting similar overall changes in welfare.

When modelling changes in NTMs, it is important to keep in mind that many serve legitimate policy purposes and may not be able to be reduced or removed.[29] Since aggregate indexes are typically not able to separate out the NTMs that can be removed or negotiated from those that must remain, modellers need to be cautious in the cuts they assume can be achieved in NTMs. Furthermore, aggregate indexes generally include a wide range of NTMs that will fit more than one modelling mechanism. Therefore, splitting NTMs across more than one mechanism is likely to be more appropriate than applying just one mechanism. The choice of which mechanism to use is ultimately an empirical issue that depends on the specific nature of the NTMs being analyzed. With the ongoing development of highly detailed and internationally comparable NTM data, led by UNCTAD, there remains much scope for further empirical work to try to categorize specific NTMs in ways that align with appropriate modelling mechanisms. This would allow us to determine the method on a case-by-case basis as argued by Andriamananjara et al. (2004) and explored in further detail by Webb et al. (2020).

While it may be possible to make specific recommendations on the most appropriate modelling mechanism to use at the individual NTM level, this will not assist GTAP modellers who generally need to work with highly aggregated data, so it may make sense to use tractable methods that yield reasonable results across the model. Fortunately, progress is being made on this front, for example, Webb et al. (2020) undertook detailed empirical work, finding that the burden of NTMs falls approximately equally between importers and exporters. While this may not be the case in all empirical exercises, in the absence of further evidence, their work offers a useful rule of thumb to support NTMs being applied 50:50 between importers and exporters. The choice between the productivity and tax mechanisms depends on whether the NTM is likely to lead to productivity improvements or rents, with the main difference being the final impact on real GDP and welfare. The tax approaches have the disadvantage of needing to be included in the database using altertax or some other approach. The willingness to pay approach, on the other hand, is quite different from the other approaches, leading to lower changes in production, but larger changes in trade and welfare. Therefore, a useful starting point for GTAP modellers may be to follow Webb et al. (2020) in choosing to split the modelling of NTM cuts evenly between iceberg (AMS) and the new export cost (AXS) mechanism detailed in this paper.

In this paper, we calibrated the NTM shocks for each modelling mechanism to ensure they matched econometric estimates of changes in real trade flows in order

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[29] And some NTMs promote trade flows, for example by strengthening consumer trust that certain standards have been met.

to accurately compare the impacts of the alternative mechanisms. The decision of whether to calibrate the shocks for applied economic analysis or simply apply shocks based on the AVEs of NTMs may depend in part on the extent to which the shocks differ across the different mechanisms to obtain the same change in trade.[30] The typical calculation to convert econometric estimates to AVEs of NTMs assumes that the shock will be implemented in the Armington equation as an import tax (TMS) or import-augmenting technological change (AMS). In this case, the differences between the shocks were quite small, especially when considered against the uncertainty of the econometric estimates and associated elasticities. However, if transportation margins and/or trade taxes are particularly large, the shock imposed on exports will need to be larger in order to achieve the same change in quantity.

We believe the current paper makes an important contribution to improved understanding of the implications of using a range of alternative modelling mechanisms, including the newly developed export cost method introduced here. We provide a range of insights into the implications of the different modelling mechanisms for results. With significantly improved, very detailed NTM databases now becoming available for many countries, we expect future work to focus much more carefully on detailed analysis of specific types of NTMs, with modelling mechanisms used that are appropriate for the NTMs under analysis. Despite substantial advances in recent years, the empirical estimation and modelling of NTMs remains an emerging field of research, with estimates and model results still subject to much uncertainty. This highlights the importance of researchers being explicit about their assumptions, including details of empirical estimates used and how these are incorporated into the model, in addition to using sensitivity analysis, as appropriate.

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[30] Though researchers need to take care to calculate shocks correctly when using AVEs of NTMs (see Bekkers and Rojas-Romagosa, 2019).

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Appendix A. Aggregation

Table A 1. Sectoral aggregation

Sectors modelled	Description	GTAP sectors[a]
Plant Products[b]	Crops and plant products	pdr wht gro v_f osd c_b ocr vol pcr sgr ofd b_t
Animal Products[b]	Livestock and animal products	ctl oap rmk fsh cmt omt mil
Wood Products[b]	Forestry, wood and paper products	frs lum ppp
Textiles, Leather & Wearing Apparel[b]	Textiles, leather and apparel	pfb wol tex wap lea
Machinery and Equipment[b]	Motor vehicles, machinery and equipment	mvh otn ele ome
Other Manufactures[b]	Extractive and other manufactured sectors	coa oil gas omn p_c crp nmm i_s nfm fmp omf
Services	Services	ely gdt wtr cns trd otp wtp atp cmn ofi isr obs ros osg dwe

Notes: [a] See www.gtap.agecon.purdue.edu/databases/contribute/detailedsector.asp for details. [b] Goods commodities impacted by NTMs.

Table A 2. Regional aggregation

Country/region modelled	Original GTAP regions[a]	Aggregated regions for reporting
Singapore	sgp	ASEAN
Thailand	tha	ASEAN
Malaysia	mys	ASEAN
VietNam	vnm	ASEAN
Philippines	phl	ASEAN
Indonesia	idn	ASEAN
OtherASEAN	brn khm lao xse	Rest of Asia[b]
NewZealand	nzl	Australasia
Australia	aus	Australasia
India	ind	Rest of Asia
Japan	jpn	Rest of Asia
Korea	kor	Rest of Asia
China	chn	China
US	usa	United States
ROW	xoc hkg mng twn xea bgd npl pak lka xsa can mex xna arg bol bra chl col ecu pry per ury ven xsm cri gtm hnd nic pan slv xca dom jam pri tto xcb aut bel cyp cze dnk est fin fra deu grc hun irl ita lva ltu lux mlt nld pol prt svk svn esp swe gbr che nor xef alb bgr blr hrv rou rus ukr xee xer kaz kgz xsu arm aze geo bhr irn isr jor kwt omn qat sau tur are xws egy mar tun xnf ben bfa cmr civ gha gin nga sen tgo xwf xcf xac eth ken mdg mwi mus moz rwa tza uga zmb zwe xec bwa nam zaf xsc xtw	Rest of the world

Notes: [a] See http://www.gtap.agecon.purdue.edu/databases/regions.asp?Version=9.211 for details of the GTAP countries and regions. [b]Includes some ASEAN countries not focused on in the analysis.