Modelling the Impact of Non-Tariff Measures on Supply Chains in the Asia Pacific Region[#]

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Abstract

This paper explores the impact of reducing non-tariff measures (NTMs) in major ASEAN countries. New econometric estimates of the impact of different types of NTMs are used in a global supply chain model to separately model the effects on intermediate products and those sold to final consumers. We also distinguish between whether the NTM cost burden is directed at exporters or importers. This paper makes important advances in modelling the heterogeneity of NTMs, offering much richer policy analysis of the impact of NTMs on supply chains in Asia-Pacific region than has previously been possible. We illustrate the benefits, both to the major ASEAN countries and to their trading partners, from the partial liberalization by ASEAN countries of their most trade distorting types of NTMs. Such liberalization increases the GDP and welfare of all countries, with the effect particularly pronounced for the major ASEAN countries themselves, especially Viet Nam and the Philippines. As trade in plant products and animal products is particularly affected by NTMs, these sectors show the largest expansion of trade.

JEL: F13, F14, F17, F68

Keywords: Non-tariff measures; Supply chains; ASEAN; Gravity model; CGE modelling; International trade.

INTRODUCTION

Since 2000, there has been a dramatic increase in the number of non-tariff measures (NTMs) notified to the WTO; both Sanitary and Phytosanitary (SPS) measures and Technical Barriers to Trade (TBT) measures. This has coincided with growing concern for health, quality and environmental attributes and other externalities (Beghin, Maertens and Swinnen, 2015; and Herghelegiu, 2018). At the same time, there has been a shift in emphasis in trade negotiations from tariff reductions to the removal of NTMs (Berden and Francois, 2015; Orefice, 2017). A key driver for this is that many studies have found NTMs can be much more significant barriers to trade than tariffs (e.g. Egger, Francois, Manchin, & Nelson 2015; Kee, Nicita, & Olarreaga, 2009).

The impact of NTMs on "supply" or "global value" chains is attracting increased attention by researchers (Cadestin, Gourdon, and Kowalski, 2016; Kowalski, Lopez Gonzalez, Ragoussis, and Ugarte, 2015). NTMs affect either the fixed or variable costs of firms and the effects of these costs can compound in a supply chain where semi-finished goods cross international borders multiple times: "the effect of a marginal increase in trade costs everywhere in the supply chain is much larger than would be the case if there were a single international transaction" (Ferrantino, 2012).

While there are now many examples of studies which incorporate econometric estimates of the effect of NTMs into computable general equilibrium (CGE) models, there remains significant scope to refine the methodologies used (see the discussion in Walmsley and Minor, 2015, as well as Berden and Francois, 2015, for a survey of recent CGE work). Some key issues, relevant for a supply chain analysis and addressed in the current study, include differentiating between NTMs on intermediate and final goods, as well as distinguishing between NTMs that impose costs on the importer and those that impose costs on the exporter. Moreover, we estimate the restrictiveness of NTMs for direct application in a CGE framework.

In this paper we use a detailed new NTM database to obtain econometric estimates of the effect of different types of NTMs on imports into six major ASEAN countries. We then use these econometric estimates to identify the types of NTMs that are found to have significant negative effects on both imports of

products sold for intermediate production and those sold to final consumers in these ASEAN countries. Next, we consider whether the NTMs primarily impact importers' or exporters' costs, as well as the extent to which these NTMs can be eliminated or reduced. Finally, we simulate a reduction in these NTMs using the ImpactECON Global Supply Chain Model (IESC), which is based on the well-known Global Trade Analysis Project (GTAP) model, but also accounts for differences in import sourcing by firms, final consumers and the capital goods sector, allowing for analysis of NTMs at different parts of the supply chain.

Our approach is novel because we estimate the effect of different types of NTM, both on intermediate inputs and final consumption. Moreover, we model the effect of the removal of burdensome NTMs differently, depending on whether the effect is predominately on exporter or importer costs. We focus on the six largest ASEAN countries. These major ASEAN economies are well linked into regional and global supply chains and are likely to have a broadly similar regulatory environment; thus we are not combining a disparate group of countries from different regions.[1]

ECONOMETRIC METHODOLOGY AND DATA

The NTM database

The database of NTMs that we use has been compiled in a multi-agency project led by UNCTAD.[2] This database - recently relaunched with expanded and updated country coverage - contains detailed and comprehensive data on NTMs obtained from teams of researchers working systematically through all laws, rules and regulations which may affect merchandise trade in a particular country.[3] These measures are then set within a common classification framework and assigned to tariff lines within the World Customs Organization's Harmonized System (HS). Cadot and Gourdon (2016); Cadot, Asprilla, Gourdon, Knebel and Peters (2015); Strutt et al. (2018); Walmsley et al. (2018); Vanzetti, Peters, and

[1] Updated NTM data have recently been collected and publicly released for these countries. Data for many other major Asian economies, including Japan, Korea, China and India, are not currently available.
[2] http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures.aspx
[3] Two authors of the current paper were responsible for contributing the New Zealand data to this database.

Knebel (2014) and Webb, Strutt, Gibson (2019) provide examples of applications of this database.

The classification, developed by UNCTAD and the Multi-Agency Support Team (MAST), has 16 chapters which underpin the NTM database, as summarized in table 1. Within each chapter, there is a hierarchy of classification, for instance the grouping A5 *Treatment for elimination of plant and animal pests and disease-causing organisms in the final product e.g. post-harvest treatment* includes the subgroupings: A51 *Cold/heat treatment*, A52 *Irradiation*, A53 *Fumigation* and A59 *Treatment for elimination of plant and animal pests and disease-causing organisms in the final product, n.e.s.* (UNCTAD, 2013).

(Table 1 about here)

Estimation methodology and data

Our research examines the effect of NTMs on imports in six major ASEAN markets (Singapore, Malaysia, Indonesia, Thailand, Viet Nam and the Philippines). We use a gravity model framework: such frameworks are frequently used for analysis of NTMs and a discussion of their underpinnings in this context can be found in Beghin, Disdier, and Marette (2015); Carrère and De Melo (2011); and Kee, Nicita, and Olarreaga, (2009).

We apply the most widely recognized gravity model estimator, the Poisson pseudo maximum likelihood estimator (ppml) proposed in the seminal work of Santos Silva and Tenreyro (2006). This estimator, which adapts a count data framework, is widely used in gravity model applications because it is robust to heteroskedasticity and also addresses the issue of zero trade values which arise in disaggregated trade data, given that not all countries export all goods. In contrast to negative binomial regression and zero inflated negative binomial estimators, the ppml estimator is scale invariant (Shepherd, 2013). An alternative approach, based on the Heckman selection approach, including as proposed in Helpman, Melitz, and Rubinstein (2008), has been used to good effect in some studies of NTMs, including Crivelli and Gröschl (2016) and Bratt (2017). Recent papers have, however, emphasized the importance of the distributional assumptions, stressing, in particular, the sensitivity of results to the presence of

heteroskedasticity (Santos Silva and Tenreyro, 2015; Martin and Pham, 2015.) For our purposes, we therefore prefer the ppml estimator.

We adapt the estimator proposed in Santos Silva and Tenreyro (2006) to provide the following gravity equation (equation 1):

$$
\begin{aligned}
& m_{ide} \\
& = \sum_k \beta_{\text{NTM\_}k} D_{NTM\_k_{id}} + \beta_2 \ln(\text{consumption}_{jd}) + \beta_3 \ln(\text{production}_{je}) \\
& + \beta_4 \text{AVE tariff}_{ide} + \beta_5 \text{specific tariff}_{ide} + \beta_6 \ln(\text{distance}_{de}) \\
& + \beta_7 \ln(\text{contiguity}_{de}) + \beta_8 \ln(\text{common legal}_{de}) \\
& + \beta_9 \text{RTA}_{ide} + \sum_e \beta_{\text{exporter\_}e} D_{exporter\_e_{ide}} + \sum_d \beta_{\text{importer\_}d} D_{importer\_d_{ide}} \\
& + \sum_j \beta_{\text{sector\_}j} D_{sector\_j_i} + \beta_{10} \ln(\text{world imports}_{di}) + \varepsilon_{ide}
\end{aligned}
$$

The UNCTAD NTM data are cross-sectional, capturing up to 62 different types of NTMs in force in our ASEAN countries of interest in 2015. Our econometric framework is therefore also cross-sectional. In equation 1, m_{ide} is imports of product *i* (at the HS 6 digit level), by importer *d*, from exporter *e* in 2015.[4] The error term is denoted ε_{ide}, and other variables are described in the section that follows.

We examine imports that originate from any one of a group of 119 exporting countries. This corresponds to almost all individual countries included in version 9 of the GTAP database, including the 6 major ASEAN countries (Aguiar, Narayanan, and McDougall, 2016).[5] With 6 importing countries, 118 possible partners, and 5,203 HS level 6 "products" in the 2012 version of the HS system that we use, our gravity database includes almost 3.7 million observations, although most of these involve zero trade.[6]

[4] While the UNCTAD data are collected at the more detailed tariff line level, the harmonized system is only consistent at up to the HS 6 digit level, with countries able to adopt their own codes at the more detailed (i.e., HS 8 or HS 10 levels etc.) level. Moreover, the widely used UN COMTRADE database, which we use as the source of import data, is only available at the 6 digit level (https://comtrade.un.org/). We therefore work with data at the HS 6 digit level for consistency across countries.

[5] We exclude the US territory of Puerto Rico as gravity data variables are not available and we also exclude Taiwan which is not included in the UN COMTRADE database.

[6] 88 percent of our observations are zero. It should also be noted that we exclude HS subheadings 27.05.00 and 27.16.00 as these are typically classified as services.

Our NTMs are incorporated through dummy variables ($D_{\text{NTM\_}k,id}$) for each different type of NTM; these are equal to unity if the importing country *d* applies NTM *k* on imports of product *i* from at least one exporting country.

The gravity model framework requires data on "consumption" in the importing country and production in the exporting country for which we make use of sectoral data from the GTAP database for 2011 (Narayanan et al., 2015). In this database, each HS 6 digit product is mapped to one of 43 aggregate sectors (denoted with a subscript *j* in equation 1). For "consumption" data (consumption_{jd}), we use data from the GTAP database on private consumption when estimating the impact of NTMs on imported consumption goods and data on firm purchases when estimating the impact on imported intermediates. We use sectoral output data from the GTAP database for "production" data in the exporting country (production_{je}).[7]

Tariff data are obtained from the World Trade Organization (WTO) and World Bank. [8] Data for Viet Nam, Singapore, Indonesia and the Philippines for 2015 are obtained from the WTO. Data for Malaysia and Thailand are not available directly from the WTO, so we use data from the World Bank WITS database, which has data for Thailand (for 2015) and Malaysia (for 2014). Using these data sources, we incorporate applied ad valorem equivalent (AVE) rates (AVE tariff_{ide}) and include a separate dummy variable where a specific tariff applies ($\text{specific tariff}_{ide}$). As the gravity model works with logarithms and the logarithm of a zero tariff is undefined, some transformation is required; we apply an inverse hyperbolic sine transformation, whereby $ihs(x) = \ln(x + (x^2 + 1)^{0.5})$ gives an identical result to using logarithms for non-zero values while avoiding the need to make ad hoc adjustments to zero values (Gibson, Datt, Murgai, and Ravallion, 2017).

Other gravity data variables typically included as controls - distance (distance_{de}), contiguity (contiguity_{de}), common legal system (common legal_{de}) and the existence of a regional trade agreement (RTA_{de}) - are obtained from the

[7] Given the theoretical underpinnings of the gravity model are based on using nominal GDP, we multiply both our consumption and production data by the ratio of 2015 nominal GDP to 2011 nominal GDP from the World Bank World Development Indicators to generate sectoral data by country that takes account of both the growth of the economy and changes in exchange rate.

[8] http://tariffdata.wto.org and http://wits.worldbank.org/

widely used CEPII database.[9] As data on the existence of RTAs are only available until 2006, we update this by adding new agreements that enter into force from 2006 to 1 January 2015 and which are notified to the WTO.[10] (See, Cheong, Kwak and Tang, 2018, for an in-depth exploration of the effect of RTAs on NTMs.)

We control for importer, exporter and sector fixed effects, through the dummy variables $D_{exporter\_e_{ide}}$, $D_{importer\_i_{ide}}$, $D_{\text{importer\_}d,idedie}$ and $D_{\text{sector},ji}$.[11] Moreover, as some HS subheadings contain many products potentially traded and others contain fewer, we include the natural log of the value of world imports of product i by country d (ln(world imports$_{id}$)).[12] This is an alternative to using product level fixed effects (as used in, for instance, Crivelli and Gröschl, 2016 and Kee and Nicita, 2016). We prefer to control for world imports because it avoids the issues of multicollinearity that we encountered with product fixed effects, where NTMs applied by ASEAN countries on any given product were found to be correlated. Moreover, the use of the world imports as an independent variable is possible in our paper as we only look at a small number of importing countries, whereas the above-mentioned papers, which cover a larger set of countries, are not able to avoid endogeneity through excluding imports from the countries of focus.

We estimate separately the effects of NTMs on two broad sectoral aggregations: Food and Agriculture, and Non-Agriculture products, based on aggregations of the GTAP sectors as set out in appendix 1. NTMs in these two broad sectors tend to be applied for different reasons and can have different effects, hence separation improves the accuracy of estimates.

For these two broad sector aggregations, we further estimate separately the effects of NTMs on imports of consumer goods and intermediate/capital goods. We distinguish between these two categories of products through a conversion table between HS2012 subheadings and the Broad Economic Classification (BEC)

[9] http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp.
[10] http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx.
[11] See Bratt (2017) for a discussion of the challenges in using fixed effects in a gravity model context. In our framework, we had sufficient variation for importer and exporter fixed effects, but not for country-pair fixed effects.
[12] To avoid issues of endogeneity, we exclude imports from our six major ASEAN markets.

available from the UN Statistical Division.[13] Under the BEC framework, products are classified as either intermediate, consumer or investment (capital goods) or are listed as "not classified". This is consistent with the approach taken in compiling the IESC database detailed in Walmsley and Minor (2016). We consequently run four separate regressions.

Estimation results

Our estimation results with the ppml estimator for consumer goods and intermediate/investment goods in both the agriculture and food and non-agriculture product groupings are summarized in tables 2 and 3. As can be seen in table 2, the control variables are generally as would be expected, for instance: trade decreases with distance, particularly for food and agricultural products that are inputs for further processes; and higher ad valorem tariffs decrease trade (although the effect is only statistically significant for food and agricultural products for final consumption and for non-agricultural intermediate inputs).

(Table 2 about here)

Table 3 shows the NTM coefficients, converted to percent changes in imports, that would result from elimination of the NTM.[14] These illustrate the effects of diverse types of NTMs and how these effects vary, including depending on whether they are applied to food and agricultural products or non-agricultural products and whether they are applied on products for final consumption or to intermediate inputs. To illustrate, applying a microbiological (hygiene) requirement (a410) to imports of food and agricultural for final consumption is expected to decrease imports by 63 percent, whereas applying a certification requirement (b830) to a non-agricultural intermediate good is expected to decrease imports by 32 percent. Of the NTMs that have a statistically significant impact, we find their effect is greatest on agricultural intermediates (an average impact of 74 percent on affected products) and smallest for non-agricultural products for final consumption (an average of 49 percent on affected products).

[13] https://unstats.un.org/unsd/trade/conversions/HS%20Correlation%20and%20Conversion%20tables.htm

[14] Given the log-linear nature of the model, coefficients of dummy variables provide percent change through the following formula: $\widetilde{\beta}_i = e^{\beta_i} - 1$ (see WTO, 2012).

(Table 3 about here)

Approximately 20 percent of NTMs are found to have a statistically significant negative effect on trade at the 10 percent level. This is less than we would expect and likely reflects the somewhat limited statistical power of our estimations, given that comprehensive NTM data are only available for a single year. If panel data become available in future, more precise estimates would be possible and we would expect to find more NTMs having a statistically significant negative impact on trade.

On the other hand, the relatively large number of NTM variables does introduce the statistical implication that a number of statistically insignificant coefficients could be treated as significant. With a 10 percent significance level we would expect to fail to reject the null hypothesis of no effect for one in every 10 variables that did not in fact affect the dependent variable. However, controlling for these "family wise" errors, such as through a Holm sequential Bonferroni regressive procedure is often seen as too conservative and not appropriate in all circumstances (Roback and Askins, 2005; Fiedler, Kutzner, and Krueger, 2012).

From the discussion above, we are also conscious that the statistical power of our tests is somewhat limited given we only have cross-sectional NTM data. (This is illustrated by the low proportion of coefficients that are statistically significant at the 5 or 1 percent level.) Moreover, as discussed earlier, there is a clear theoretical rationale to expect negative effects given that NTMs frequently raise costs. This contrasts with many applications of multiple hypothesis testing which are based on analysis of scientific experiments for which there may not be an underlying theoretical explanation for the effect of each coefficient. We therefore choose not to utilize family-wise error corrections as we do not consider the inherent tradeoff between reducing the number of coefficients found (incorrectly) to be statistically significant at the expense of discounting too many potential NTMs, to be appropriate for our application.[15] Instead, we address the

[15] The Holm sequential Bonferroni correction divides the α value for the most significant coefficient in each family by the number of variables in the family e.g. for a family of 3 variables the α for a 10 percent significant level is reduced from .1 to 0.033, so a variable significant at the 5

issue through our actionability assumption – as discussed in the following section we only assume that 20 percent of the gains from NTM elimination are realizable. Multiple testing issues could be addressed more fully in the future if panel data on NTMs become available, which would significantly increase the power of our tests.

CGE MODELLING OF NTM LIBERALIZATION

The next stage in the analysis incorporates the economic estimates of the effect of NTMs into the IESC model (Walmsley and Minor, 2016), which is a modified version of the GTAP model, using a more detailed database to augment the GTAP version 9 database (Aguiar, Narayanan and McDougall, 2016). The standard GTAP model specifies trade bilaterally, with imperfect ("Armington") substitution between foreign and domestic goods and between imports from different sources. The IESC model follows this framework but takes account of differences in import sourcing by firms, final consumers and the capital goods sector. We conduct our simulations of the effect of NTM liberalization by the ASEAN countries on all trading partners in a specification with seven sectors; two from the Food and Agriculture grouping and four from the Non-Agriculture grouping, as well as a services sector – see appendix 1. Our model specification includes 15 regions.[16]

Channels to incorporate NTMs: Importer and exporter effects

In the current study we include a novel mechanism to capture the impact of NTMs directly on exporters, following Walmsley and Strutt (2018). This channel is the counterpart of the import augmenting technological change, extensively used in the past and described below, as it reduces the amount of

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percent level may no longer be significant. As can be seen in table 3, many of our coefficients are significant at the 5 or 10 percent level, so would no longer be statistically significant following this correction. When applying this procedure we did, however, find some coefficients to still be significant depending on how we defined a "family". For instance, when we treat certification requirements within each of the UNCTAD chapters as a "family" for the purposes of the Holm sequential correction, we still obtain some statistically significant estimates (at the 10 percent level). Similarly, treating the four NTMs within the UNCTAD classification chapter C (Pre-shipment inspection and formalities) as a family and applying a Holm sequential Bonferroni correction retains some coefficients as statistically significant.

[16] Singapore, Thailand, Malaysia, Viet Nam, Philippines, Indonesia, Other ASEAN, New Zealand, Australia, Japan, Korea, China, India, United States and the Rest of the World.

exports needed to meet a given level of import demand. When modelling reductions in NTMs through this export mechanism, the principal benefits accrue to exporting countries. This is appropriate for the liberalization of many NTMs which directly affect the cost of exporting.

In other cases, however, the obligation of meeting NTM requirements falls on the importer. For these types of NTMs, we use an approach to incorporating NTM reductions which is widely used in the literature: import-augmenting technological shocks (see, for instance, Hertel, Walmsley, and Itakura, 2001, and Francois, Van Meijl, and Van Tongeren, 2005). [17] As discussed in Walmsley and Minor (2015) this has two main effects: (1) it reduces the importer's price, causing a substitution towards that good and an increase in quantity demanded and (2) it reduces the amount that needs to be imported to satisfy a given demand. As a result of the second effect, firms in the importing country require less imported intermediates for a given production level and households and governments can satisfy an initial demand with less imports (from the perspective of the exporter); this increases GDP in the importing countries. These effects of this modelling mechanism mean that the principal benefits accrue to the importing countries.

By modelling benefits accruing to both exporters and importers, our approach is a significant advance on previous approaches where benefits of NTM liberalization principally accrue to importers, even when inconsistent with economic theory or empirical evidence. Other methods of enabling exporters to be affected include incorporating NTMs as import tariffs or export taxes (see Fugazza and Maur, 2008 for discussion and Arita, Beckman, and Mitchell, 2017, Kawasaki, 2015, and Andriamananjara, Ferrantino, and Tsigas, 2003, for three illustrative examples of how this separation is made in practice). The challenge with this approach is that NTMs are generally not associated with an additional tax or fee collected by government. In contrast, our approach captures these as inefficiencies affecting the cost of exporting or importing in a manner that is consistent with the conventional GTAP framework.

[17] An alternative approach is the "willingness to pay" framework proposed in Walmsley and Minor (2015). We, however, focus on the technological shock variables to enable a direct comparison between these approaches. See Walmsley and Strutt (2018) for detailed exploration of the impact of alternative CGE modelling mechanisms.

NTM shocks

The importer and exporter effects that we model are calibrated from our econometric estimates. In particular, we need four sets of shocks: (i) import-augmenting technological shocks to imports of intermediate goods (ii) import-augmenting technological shocks to imports of consumption goods; (iii) import-augmenting technological shocks to imports of goods for government consumption; (iv) exporting efficiency shocks to exports of all goods.[18] These shocks differ across importing and exporting regions, reflecting the different NTMs applied by different importers, as well as differences in the products imported from different regions.

The three import-augmenting shocks reflect the three different agents who use imported goods in our model. However, for exports there is only one agent involved in exporting and therefore only one type of export-augmenting technological shock is needed. The division between the first three sets of import-augmenting shocks and the exporting efficiency shock depends on our analysis of whether the cost of meeting an NTM is directed at the exporter or importer, or is split between both (in which case a weighting of between 25 and 75 percent is applied). As an example, production requirements impose costs on exporters, whereas the cost of meeting importer registration requirements is expected to fall on the importer. In some instances, for example testing requirements, we split the cost of NTM compliance between importers and exporters.[19] Our separation between importer and exporter effects is shown in appendix 2.

Weighting by imports

As each of the identified NTMs only apply to some products within a sector, we need to weight the shock by the proportion of imports from each exporting region that are covered by a particular NTM. These are then aggregated to obtain the effect of the removal of all trade reducing NTMs on a particular

[18] Unlike with imports, where there are different purchasers of intermediates and consumption goods, there is only one agent involved in exporting in the IESC model (firms). Therefore, while the IESC model provides for different import-augmenting technological shocks for imports of intermediates and consumption goods, there is only one type of export-augmenting technological shock.

[19] A more precise separation of division of these costs could be obtained from surveys of exporters and importers, thus is an area for future research.

sector. As firms are the only agent who export, the exporting efficiency shock is calculated in the following way:

$$\Delta M_{jde} = \frac{\sum_{i \in j}\left(\sum_k -\tilde{\beta}_{NTM\_k} \cdot D_{NTM\_k_{id}}\right) \cdot m_{ide}}{\sum_{i \in j} m_{ide}} \qquad (2)$$

Where: m_i is imports of product *i* by importer *d* from exporting region *e* (using COMTRADE import data at the HS 6 digit level); ΔM_{jed} is the change in imports of all products mapped to the aggregate sector *j* (43 aggregate commodities in GTAP) by importer *d* from exporting region *e*; $\tilde{\beta}_{NTM\_k}$ is the elasticity calculated from the coefficient for NTM *k* that has been found to have a statistically significant effect on trade (as discussed above); and $D_{NTM\_k,id}$ is a dummy variable equal to one if importer *d* applies NTM *k* on product *i* and – as discussed below – not all major ASEAN countries apply this NTM. For each aggregate sector j, we therefore have separate values of ΔM_{jde} for the change in imports by each of the 6 major ASEAN importing countries (*d*) from each of the 15 exporting regions (*e*).

The calculation of the three import-augmenting technological shocks is more complex because the calculation is done separately for goods classified as intermediate goods (including capital goods) and private consumption goods:

$$\Delta M_{intermediate,jde} = \frac{\sum_{i \in j}\left(\sum_k -\tilde{\beta}_{NTM\_k} \cdot D_{NTM\_k_{id}}\right) \cdot m_{intermediate,ide}}{\sum_{i \in j} m_{intermediate,ide}} \qquad (3)$$

$$\Delta M_{consumption,dej} = \frac{\sum_{i \in j}\left(\sum_k -\tilde{\beta}_{NTM\_k} \cdot D_{NTM\_k_{id}}\right) \cdot m_{consumption,ide}}{\sum_{i \in j} m_{consumption,ide}} \qquad (4)$$

Restrictions on the effect of NTMs and actionability assumptions

We make three relatively conservative assumptions on modelling reductions in NTMs. First, we only consider NTMs that have a statistically significant negative effect on the level of imports at the 90 percent level.[20] Second, we do not simulate the removal of an NTM from a product when all six major ASEAN countries apply this NTM to that product. This reflects the fact that

[20] This is a conservative approach that could be missing the effect of some NTMs which could have a negative effect (including those for which we might find a statistically significant effect if we had access to panel data on NTMs i.e. with a time dimension).

the NTM – despite being found to negatively affect trade – might be the only feasible way to address a legitimate public policy concern.[21]

Third, we assume that only a portion of the set of NTMs identified as trade reducing through our econometric estimation can be removed. There is an emerging body of literature on the extent to which NTMs are actionable, given that they frequently target public policy objectives, for instance, Berden and Francois (2015) suggest that approximately 50 percent of NTMs are actionable. In our simulations, we assume that 20 percent of the potential increases in imports from full NTM liberalization are realizable through targeted efforts, such as economic integration initiatives. This is comparable with similar studies, for instance, Fontagné et al. (2013) use a 25 percent reduction for their reference scenario. Our NTM liberalization scenario can be interpreted as a combination of the following: removing some regulations; applying existing rules to fewer products; or applying regulations in a less onerous way, e.g. inspecting a smaller proportion of total shipments or harmonizing requirements to make it easier for traders to comply.[22]

Calculated shocks

Our approach takes econometric estimates of the effect of different types of NTMs and allocates them to different channels in the CGE model, depending on the type of good affected (consumption, intermediate or government purchases) and whether the NTM burden falls on importers or exporters. As these are weighted by the value of imports affected, these import quantity shocks vary by importer and also across the regions exporting to each major ASEAN county to reflect their different export profiles. Appendix 3 shows, for each ASEAN country, the trade weighted average shocks to quantities of imports from the other 14 regions that are allocated to each of the four transmission channels modelled.[23] In other words, these tables show the estimated percentage change in imports that

[21] This may be viewed as a relatively conservative assumption, since in some cases all 6 countries might apply an NTM for which there is a non, or less, trade restricting alternative.

[22] While the UNCTAD database does not summarize information on the stringency of requirements or other procedural details, a liberalization scenario can assume that less burdensome application of some types of existing NTMs will reduce the trade effects of these NTMs.

[23] While the appendix shows a trade weighted average, we calculate and use separate shocks for imports from each exporting region.

would result from implementing each of these shocks. The overall effect on imports is the combined effect from each of these channels.

Table 4 shows the relative contribution of the three main shocks and summarizes the contribution of the three main types of shocks (exports, consumer imports and firm imports) to the overall estimated change in imports in the modelling described subsequently.[24] While we have allocated NTMs depending on our assessment of whether exporters and importers are targeted, and their effect is calculated depending on the value of trade in products affected, our detailed analysis provides a useful rule of thumb for future work: approximately half of NTM shocks can be allocated to the exporter channel with the other half allocated to an importer channel.

(Table 4 about here)

Model simulation

The approach outlined in the previous section provides an estimate of the change in imports which is exogenous. We then utilize the IESC model to take account of the general equilibrium interactions by endogenizing the change in imports. To do this, we implement the shocks summarized in appendix 3 to calibrate, for each exporting region, the necessary import-augmenting technological change required to achieve each of the required changes in consumption, firm use and government purchases i.e. those that correspond to 20 percent of the change in imports implied by the econometric results for full elimination of all trade reducing NTMs whose cost is directed at importers.[25] Likewise, in separate simulations, we calibrate, for each exporting region, the necessary exporting efficiency change required to achieve each of the required changes in exports i.e. those that correspond to 20 percent of the change in bilateral imports implied by the econometric results for full elimination of all

[24] Government purchases are excluded from this table due to their small value (see table 5).

[25] We consider separately the estimated increases in imports of consumption goods, intermediate inputs and government purchases. As government purchases are a mixture of products classified as consumption and intermediate goods in the BEC framework, we weight these shocks based on each countries' imports within each aggregated sector. In our simulations, the calibration exogenizes exports to all six ASEAN countries by one exporting region at a time to determine the necessary technological change variables.

trade reducing NTMs whose cost falls on exporters.[26] This provides the import augmenting technological shocks and exporting efficiency changes. This approach to calibrating import augmenting technological shocks is discussed in further detail in Webb et al. (2017).

RESULTS: EXAMINING THE IMPACT OF REDUCING NTMS

To obtain the overall effect of NTM liberalization by major ASEAN countries, we apply the import augmenting technological shocks and exporting efficiency change, calibrated in the manner described in the previous section, into our CGE model. These are implemented simultaneously to enable general equilibrium interactions between sectors and regions. While imports from all regions are stimulated through the reduction in ASEAN NTMs, there is considerable variation in the simulated changes in each region's exports to the six major ASEAN countries. With the inclusion of general equilibrium interactions in our modelling, some regions export less of particular products to ASEAN countries.

The effects on GDP, welfare, output and exports of our simulated NTM liberalization are shown in tables 5-7.

(Table 5 about here)

We find that real GDP increases in all countries as a result of NTM liberalization in ASEAN (see table 5). As expected, the greatest gains are to the ASEAN 6 countries who liberalize NTMs, particularly Viet Nam and the Philippines. For our scenario of a 20 percent decrease in trade reducing NTMs we find an increase in Viet Nam's GDP of 1.3 percent and a 0.4 percent increase for the Philippines. For ASEAN 6 countries, the majority of this increase in GDP occurs through the import augmenting technological shocks channels which reflects that importing countries themselves benefit directly from NTM liberalization. (This ranges from 59 percent for Thailand to 90 percent for the Philippines.) While the percentage of overall GDP and welfare gains that our

[26] Given the direct link between exports and imports, we have to conduct the calibration separately for import-augmenting and exporting efficiency shocks as otherwise we would effectively be trying to identify two unknowns in a single equation.

modelling attributes to import augmenting technological shocks aligns with their contribution to total shocks (49 percent, as shown in table 4), these import augmenting shocks account for a much higher contribution to welfare and GDP gains in the ASEAN 6 since their effect is concentrated on the ASEAN 6 countries who liberalize NTMs and therefore benefit from import augmenting technological shocks.

The GDP gains to countries other than the ASEAN 6 are relatively modest, with the largest percentage increases accruing to New Zealand (0.043%) and the "Other ASEAN grouping" (0.037%).[27] The modest effects on countries other than the ASEAN 6 can be understood by noting that there are two effects: on one hand they benefit from increased export efficiency (with the exporting efficiency change) when ASEAN countries reduce NTM barriers to all trading partners. However, this impact is dampened since ASEAN competitors become more competitive as a result of using imported intermediates more efficiently. In contrast, ASEAN countries liberalizing their NTMs benefit from both increased export and import efficiency.

(Table 6 about here)

Almost all countries see an increase in welfare (as measured by an equivalent variation in income (EV) (see table 6). Consistent with our GDP results, the largest gains are to the ASEAN 6 countries who liberalize NTMs, particularly Viet Nam and the Philippines. In general, the greatest contribution is from "improved trade efficiency" which incorporates the efficiency gains to both exporters and importers from NTM liberalization. Some countries, particularly Viet Nam, Thailand and Indonesia also see significant changes in allocative efficiency as NTM elimination leads to improved allocation of resources. The contribution to welfare of changes in the terms of trade, due to changes in the relative prices of imports and exports, can also be sizable. In some cases, particularly Singapore, Viet Nam and the Philippines, changes in the terms of trade make relatively strong contributions to welfare. Negative terms of trade effects can dampen the positive efficiency gains, even leading to small decreases

[27] The other ASEAN grouping comprises Brunei, Myanmar, Laos and Cambodia, which have distinctly different economies to the major ASEAN countries.

in total welfare for some regions, including Australia, Japan, Korea and the United States.

(Table 7 about here)

Overall, regions typically increase their exports of most products to the ASEAN 6 region as a result in the reduction in NTMs. The largest effects are in the plant and animal products sectors, which are the sectors most affected by NTMs. For instance, Japan, China and India all increase their exports of plant products to ASEAN 6 countries by between 6 and 8 percent while Australia, New Zealand and India increase their exports of animal products to ASEAN 6 countries by between 7 and 18 percent (see left-hand columns of table 7). For countries already closely linked to the ASEAN 6 countries (New Zealand, Australia, India and other ASEAN countries), we see a modest substitution away from exporting to other markets as the reduction in NTMs makes ASEAN 6 countries more attractive markets (see center columns of table 7).

Looking at changes in sectoral output – right-hand columns of table 7 – we typically see a modest decrease in real output in ASEAN 6 countries in sectors most affected by NTMs as imports become relatively cheaper. Resources are shifted to other sectors in the economy which expand and which are a much larger part of the economy.

CONCLUSIONS

This paper illustrates the effects, both on the major ASEAN countries themselves and their trading partners, from partial liberalization by the major ASEAN countries of their most trade distorting types of NTMs. Such liberalization increases the GDP of all countries, and is particularly pronounced for the major ASEAN countries, especially Viet Nam and the Philippines. As trade in plant products and animal products is particularly affected by NTMs, these sectors show the largest expansion of trade. We find a modest decrease in output in major ASEAN countries in these sectors as imports become relatively cheaper, with resources shifted to other sectors in the economy.

The paper takes a novel approach of allowing different types of NTM to have different effects, including for these effects to differ depending on whether they are applied to intermediate production or final consumption or to food and agriculture or other goods sectors. This is an important advance in recognizing and accounting for the heterogeneity of NTMs: there is no such thing as a typical NTM.

By modelling the impact of different types of NTMs separately we are able to consider whether their cost is directed at exporters or importers. This consideration has generally been overlooked in the literature, but can have significant effects, as shown in our results. From detailed assessment of the extent to which exporters and importers are targeted by different types of NTMs, and calculating their effect depending on the value of trade in products affected, our analysis provides a useful rule of thumb for future work with this model – approximately half of NTM shocks can be allocated to the exporter channel and half to the importer channel.

Reductions in NTMs that affect importers in major ASEAN countries have only a minimal effect on the GDP of countries other than the six major ASEAN countries examined in this paper. In contrast, we find much larger effects for other regions from reductions in NTMs that affect exporters when ASEAN countries reduce NTM barriers to all countries. The fact that importers are the principal beneficiaries of shocks modelled through the import augmenting channel is often obscured by the fact that many applications involve bilateral liberalization. By focusing solely on NTM reduction by ASEAN countries, we can see how modest the gains to exporting countries are from liberalization incorporated through the import augmenting channel.

Our paper has significant policy relevance, demonstrating the channels through which both importing countries and their trading partners can benefit from reducing the burden of NTMs on trade. In particular, we show that it is the ASEAN importing countries themselves who can expect to see the largest increases in GDP and welfare. This helps demonstrate that improvements in regulatory regimes - including finding less trade distorting ways of achieving the same regulatory objectives - should not be seen as a concession to trading partners, including in free trade agreements, but rather a tool for encouraging economic growth.

Our approach also lays the groundwork for future studies that can examine more closely which types of NTMs are harmonized or liberalized as a result of economic integration objectives, including ASEAN's efforts working towards a common market as well as its active network of FTAs, such as the ongoing negotiations for the Regional Comprehensive Market. Approaches such as ours, which recognize different types of NTMs, are well positioned to incorporate research on which NTMs are candidates for liberalization or harmonization.

REFERENCES

Andriamananjara, S., Ferrantino, M. J., & Tsigas, M. E. (2003). *Alternative Approaches in Estimating the Economic Effects of Non-Tariff Measures: Results from Newly Quantified Measures* (United States International Trade Commission Office of Economics Working Papers No. 15872.) Retrieved from https://ideas.repec.org/p/ags/uitcoe/15872.html

Arita, S., Beckman, J., & Mitchell, L. (2017). Reducing transatlantic barriers on U.S.-EU agri-food trade: What are the possible gains? *Food Policy, 68*, 233–247. https://doi.org/10.1016/j.foodpol.2016.12.006

Beghin, J. C., Disdier, A.-C., & Marette, S. (2015). Trade restrictiveness indices in the presence of externalities: An application to non-tariff measures. *Canadian Journal of Economics/Revue Canadienne D'économique, 48*(4), 1513–1536. https://doi.org/10.1111/caje.12157

Beghin, J., Maertens, M., & Swinnen, J. F. (2015). Non-tariff measures and standards in trade and global value chains. *Annual Review of Resource Economics, 7*. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2572937

Berden, K., & Francois, J. (2015). *Quantifying Non-Tariff Measures for TTIP*. (Paper No. 12 in the CEPS-CTR project 'TTIP in the Balance' and CEPS Special Report No. 116). Retrieved from http://www.ceps.eu/publications/quantifying-non-tariff-measures-ttip

Bratt, M. (2017). Estimating the bilateral impact of nontariff measures on trade. *Review of International Economics*, *25*(5), 1105-1129.

Cadestin, C., Gourdon, J., & Kowalski, P. (2016). Participation in Global Value Chains in Latin America. *OECD Trade Policy Papers*. Retrieved from http://www.oecd-ilibrary.org/content/workingpaper/5jlpq80ts8f2-en

Cadot, O., Asprilla, A., Gourdon, J., Knebel, C., & Peters, R. (2015). *Deep Regional Integration and Non-Tariff Measures: A Methodology for Data Analysis*. (UNCTAD Policy Issues in International Trade and Commodities Research Study Series 69). Retrieved from http://www.researchgate.net/profile/Julien_Gourdon/publication/272086370_Deep_Regional_Integration_and_Non-Tariff_Measures_A_Methodology_for_Data_Analysis/links/54da01100cf25013d0439fd6.pdf

Cadot, O., & Gourdon, J. (2016). Non-tariff measures, preferential trade agreements, and prices: new evidence. *Review of World Economics, 152*(2), 227–249. https://doi.org/10.1007/s10290-015-0242-9

Carrère, C., & De Melo, J. (2011). Notes on detecting the effects of non tariff measures. *Journal of Economic Integration, 26(*1) 136–168.

Cheong, J., Kwak, D. W., & Tang, K. K. (2018). The trade effects of tariffs and non-tariff changes of preferential trade agreements. *Economic Modelling, 70*, 370-382. https://doi.org/10.1016/j.econmod.2017.08.011

Crivelli, P., & Gröschl, J. (2016). The impact of sanitary and phytosanitary measures on market entry and trade flows. *The World Economy*, *39*(3), 444–473.

Egger, P., Francois, J., Manchin, M., & Nelson, D. (2015). Non-tariff barriers, integration and the transatlantic economy. *Economic Policy*, *30*(83), 539–584.

Fiedler, K., Kutzner, F., & Krueger, J. I. (2012). The Long Way From α-Error Control to Validity Proper: Problems With a Short-Sighted False-Positive Debate. *Perspectives on Psychological Science*, *7*(6), 661–669. https://doi.org/10.1177/1745691612462587

Ferrantino, M. J. (2012). *Using supply chain analysis to examine the costs of non-tariff measures (NTMs) and the benefits of trade facilitation*. (WTO Staff Working Paper). Retrieved from http://hdl.handle.net/10419/57603

Fontagné, L., Gourdon, J., Jean, S. (2013). *Transatlantic trade: whither partnership, which economic consequences?* (CEPII Policy Brief). Retrieved from http://www.ifoinstitut.net/dms/ifodoc/docs/Akad_Conf/CFP_CONF_VSI/VSI_2014/vsi14-rmd-Felbermayr/Papers/vsi14-rmd-Gourdon.pdf

Francois, J., Van Meijl, H., & Van Tongeren, F. (2005). Trade liberalization in the Doha Development Round. *Economic Policy*, *20*(42), 350–391. https://doi.org/10.1111/j.1468-0327.2005.00141.x

Fugazza, M., & Maur, J.-C. (2008). Non-tariff barriers in CGE models: How useful for policy? *Journal of Policy Modeling*, *30*(3), 475–490.

Gibson, J., Datt, G., Murgai, R., & Ravallion, M. (2017). *For India's rural poor, growing towns matter more than growing cities.* (World Bank Policy Research Working Paper Series No. 7994.) Retrieved from https://ideas.repec.org/p/wbk/wbrwps/7994.html

Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating Trade Flows: Trading Partners and Trading Volumes. *The Quarterly Journal of Economics*, *123*(2), 441–487.

Herghelegiu, C. (2018). The political economy of non-tariff measures. *The World Economy*, *41*(1), 262-286.

Hertel, T. W., Walmsley, T., & Itakura, K. (2001). Dynamic Effects of the "New Age" Free Trade Agreement between Japan and Singapore. *Journal of Economic Integration*, *16*(4), 446–484.

Kawasaki, K. (2015). The relative significance of EPAs in Asia-Pacific. *Journal of Asian Economics*, *39*, 19–30. https://doi.org/10.1016/j.asieco.2015.05.001

Kee, H. L., Nicita, A., & Olarreaga, M. (2009). Estimating Trade Restrictiveness Indices. *The Economic Journal, 119*(534), 172–199. https://doi.org/10.1111/j.1468-0297.2008.02209.x

Kowalski, P., Lopez Gonzalez, J., Ragoussis, A., & Ugarte, C. (2015). *Participation of Developing Countries in Global Value Chains*. *(OECD Trade Policy Paper.).* Retrieved from http://www.oecd-ilibrary.org/content/workingpaper/5js33lfw0xxn-en

Martin, W. J., & Pham, C. S. (2015). *Estimating the gravity model when zero trade flows are frequent and economically determined.* (World Bank Policy Research Working Paper 7308). Retrieved from https://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-7308

Narayanan, B., Aguiar, A., & McDougall, R. (eds.). (2015). *Global Trade, Assistance, and Production: The GTAP 9 Data Base*. Purdue University: Center for Global Trade Analysis. Retrieved from http://www.gtap.agecon.purdue.edu/databases/v9/v9_doco.asp

Orefice, G. (2017). Non-Tariff Measures, Specific Trade Concerns and Tariff Reduction. *The World Economy*, 40(9), 1807-1835.

Roback, P. J., & Askins, R. A. (2005). Judicious Use of Multiple Hypothesis Tests. *Conservation Biology, 19*(1), 261–267. https://doi.org/10.1111/j.1523-1739.2005.00269.x

Santos Silva, J. M. C., & Tenreyro, S. (2006). The Log of Gravity. *The Review of Economics and Statistics*, *88*(4), 641–658.

Santos Silva, J. M. C., & Tenreyro, S. (2015). Trading Partners and Trading Volumes: Implementing the Helpman–Melitz–Rubinstein Model Empirically. *Oxford Bulletin of Economics and Statistics, 77*(1), 93–105. https://doi.org/10.1111/obes.12055

Shepherd, B. (2013). *The gravity model of international trade: A user guide*. ARTNeT Books and Research Reports. Retrieved from http://www.unescap.org/sites/default/files/full-report-gravity-model-2013.pdf

Strutt, A., Knebel, C., Peters, R., & Walmsley, T. (2018). *Modelling the Harmonizing of Non-Tariff Measures: An application to Goods Trade in the Trans-Pacific Partnership Region*. Paper presented at the 21st Annual Conference on Global Economic Analysis, Cartegena.

UNCTAD. (2013). *Classification of Non-tariff Measures: February 2012 Version*. New York and Geneva.

Vanzetti, D., Peters, R., & Knebel, C. (2014). *Sand in the Wheels: Non-Tariff Measures and Regional Integration in SADC*. (UNCTAD Policy Issues in International Trade and Commodities Research Study Series No 71.) Retrieved from http://unctad.org/en/PublicationsLibrary/itcdtab73_en.pdf

Walmsley, T., & Minor, P. (2015). *Willingness to Pay in CGE Models*. (ImpactECON Working Paper No. 04.)

Walmsley, T., & Minor, P. (2016). *ImpactECON Global Supply Chain Model: Documentation of Model Changes*. ImpactECON Working Paper No. 06.

Walmsley, T., & Strutt, A. (2018). *Improving the Modelling of Non-Tariff Measures in a CGE Framework*. Paper prepared for the 21st Annual Conference on Global Economic Analysis, Cartegena.

Walmsley, T., Strutt, A., Minor, P. J., & Rae, A. N. (2018). *Impacts of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership on the New Zealand Economy*. ImpactEcon Report for the New Zealand Ministry of Foreign Affairs and Trade.

Webb, M., Strutt, A., & Rae, A. N. (2017). Impacts of Geographical Restrictions: New Zealand Fruit and Vegetable Imports. *Journal of International Agricultural Trade and Development*, *10*(2).

Webb, M,, Gibson J, and Strutt, A. (2019) "Market access implications of non-tariff measures: Estimates for four developed country markets." *The World Economy 42(2)*.

WTO, 2012. A Practical Guide to Trade Policy Analysis. Available at www.wto.org/english/res_e/publications_e/practical_guide12_e.htm

Tables

Table 1: Classification of non-tariff measures

Technical measures	**A**	**Sanitary and Phyto-sanitary 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 Reasons
	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 (2013)

Table 2: Econometric estimates (control variables)

VARIABLES	Food and Agriculture		Non-Agriculture	
	Consumption	Intermediates	Consumption	Intermediates
Preferential tariff	-0.131***	0.00817	-0.0763	-0.134***
	(0.0371)	(0.0601)	(0.0494)	(0.0394)
Specific tariff	0.0251	-0.616	-0.0663	0.743**
	(0.326)	(0.686)	(0.677)	(0.289)
Consumption/use	-0.105	-0.0144	0.0466	0.559***
	(0.0987)	(0.0720)	(0.0822)	(0.0747)
Production	1.026***	1.099***	0.672***	0.955***
	(0.122)	(0.137)	(0.0743)	(0.0654)
World imports	0.931***	1.133***	0.810***	0.893***
	(0.0378)	(0.0852)	(0.0337)	(0.0210)
Distance	-0.541***	-1.055***	-0.409***	-0.505***
	(0.180)	(0.386)	(0.144)	(0.166)
Contiguity	0.187	0.428*	0.137	0.227
	(0.228)	(0.248)	(0.154)	(0.203)
Common legal system	-0.173	-0.355***	0.0205	0.150
	(0.132)	(0.127)	(0.115)	(0.105)
RTA	0.0119	0.284	0.269	-0.0535
	(0.173)	(0.191)	(0.179)	(0.162)
R-squared	0.110	0.324	0.131	0.340
Importer/Exporter/Sector FE	YES	YES	YES	YES
N (including zero trade obs.)	422430	200368	527730	2.483e+06

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 3: Estimated effect of NTM reductions (for NTMs found to reduce trade that are statistically significant at the 90 percent level)

		Food and Agriculture		Non-Agriculture	
NTM	Description	Consumption	Intermediates	Consumption	Intermediates
Sanitary and Phytosanitary Measures					
a110	Temporary geographic prohibitions	65%***	59%***	---	---
a140	Authorization requirements (for importers)	62%**	---	---	49%***
a210	Residue tolerance limits	49%*	---	---	---
a220	Restricted use of substances	---	---	36%***	---
a320	Marking requirements	---	---	---	78%**
a330	Packaging requirements	---	43%**	---	---
a410	Hygienic requirements: microbiological requirements	63%***	---	---	---
a490	Hygienic requirements	---	97%***	---	93%**
a590	Treatment requirements nes	---	81%***	---	---
a640	Storage and transport requirements	38%**	---	---	78%**
a690	Other production requirements	---	---	---	98%***
a820	Testing requirements	---	---	---	60%*
a840	Inspection requirements	---	---	---	62%***
a851	Traceability (origin)	65%***	---	---	---
a852	Traceability (processing history)	---	---	---	49%***
a859	Other traceability requirements	49%***	---	---	---
a890	Other conformity requirements	---	82%*	90%*	---
Technical Barriers to Trade					
b110	Prohibitions	---	86%***	---	---
b210	Residue tolerance limits	---	---	---	80%**
b320	Marking requirements	62%*	---	---	---
b330	Packaging requirements	---	---	---	32%**
b410	Production process requirements	---	---	---	48%**
b420	Storage and transport requirements	---	---	43%***	---
b700	Performance standards	---	---	40%**	---
b810	Product registration requirements	---	54%***	---	---
b830	Certification requirements	---	---	---	32%***
b840	Inspection requirements	49%**	---	---	---
b850	General traceability requirements	---	---	30%*	---
b859	Other traceability requirements	---	90%**	54%**	---
b890	Conformity assessments nes	84%***	---	52%**	37%**
b900	Other TBT requirements	93%***	---	---	71%***
c300	Direct consignment requirements	47%***	48%*	---	---
c400	Import monitoring requirements	---	88%***	---	---
c900	Customs formalities	---	87%*	---	---
Number of statistically significant NTMs		11	10	7	14
Number of NTMs in regression		61	62	40	61
Percentage of statistically significant NTMs		20%	18%	18%	23%
Estimated trade weighted effect of a statistically significant NTM		68%	74%	49%	65%

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Percentage of shocks and effects corresponding to NTM channels

	Exporter effect (%)	Consumer imports effect (%)	Firm imports effect (%)
Singaporean imports	57	24	19
Thailand imports	62	19	20
Malaysia imports	39	42	19
Viet Nam imports	53	11	36
Philippines imports	43	17	40
Indonesia imports	51	30	19
Total import shocks	51	20	29

Table 5: Simulated changes in GDP

	Total change in real GDP (2011 US$m)	Total change in real GDP (%)	Due to exporter effect (%)	Due to consumer imports effect (%)	Due to firm imports effect (%)
Singapore	686	0.25	0.05	0.12	0.09
Thailand	721	0.21	0.09	0.06	0.06
Malaysia	824	0.29	0.08	0.14	0.07
Viet Nam	1,739	1.28	0.31	0.26	0.71
Philippines	974	0.43	0.04	0.12	0.27
Indonesia	744	0.09	0.03	0.03	0.021
Other ASEAN	35	0.04	0.04	0	0
New Zealand	70	0.04	0.04	0	0
Australia	165	0.01	0.01	0	0
India	263	0.01	0.01	0	0
Japan	107	0	0	0	0
Korea	93	0.01	0.01	0	0
China	635	0.01	0.01	0	0
US	207	0	0	0	0
ROW	1,304	0	0	0	0

(The percentage effect of government imports is 0.001 or less for all regions.)

Table 6: Simulated changes in welfare (2011 US$m)

	Contribution of different components			Total change
	Allocative efficiency	Improved trade efficiency	Terms of trade*	
Singapore	35	651	504	1,191
Thailand	150	572	261	982
Malaysia	34	790	70	894
Viet Nam	456	1,289	1,281	3,026
Philippines	107	867	628	1,602
Indonesia	116	628	85	829
Other ASEAN	2	33	-15	19
New Zealand	6	64	-21	49
Australia	-1	166	-170	-5
India	28	235	-151	112
Japan	-36	142	-208	-102
Korea	-27	120	-151	-58
China	29	606	-551	84
US	-2	209	-397	-190
ROW	0	1,304	-1,165	139

* Changes in relative prices of exports and imports (including small impacts due to investment and savings prices).

Table 7: Simulated changes in real output and real exports (%)

	Exports to ASEAN 6			Exports to Non-ASEAN 6			Output		
	Plant Products	Animal Products	Other	Plant Products	Animal Products	Other	Plant Products	Animal Products	Other
Singapore	9.9	18.6	0.4	9.1	9.7	0.1	4.2	-1.7	0.1
Thailand	4.0	5.2	0.4	1.0	0.9	0.0	-0.3	-0.4	0.1
Malaysia	6.1	-2.2	0.3	1.9	4.1	-0.1	-0.2	-0.8	0.1
Viet Nam	12.7	-2.3	0.1	1.0	2.9	-0.4	-1.3	-0.9	0.9
Philippines	0.9	1.0	0.4	2.2	2.0	-0.3	-1.7	-0.2	0.4
Indonesia	3.6	10.5	0.6	0.8	1.9	0.3	-0.2	-0.5	0.1
Other ASEAN	2.7	-2.1	1.1	-0.2	0.0	-0.2	0.0	0.0	0.0
New Zealand	3.1	11.2	1.5	-0.4	-0.7	-0.4	-0.1	0.6	0.0
Australia	2.9	6.5	0.0	-0.1	-0.1	0.0	0.1	0.3	0.0
India	8.4	18.1	0.1	-0.3	-0.4	-0.1	0.1	0.1	0.0
Japan	6.7	-2.0	-0.2	0.0	0.1	0.1	0.0	0.0	0.0
Korea	2.9	-1.4	-0.3	-0.1	0.0	0.0	0.0	0.0	0.0
China	5.8	5.1	0.7	-0.1	-0.1	0.0	0.0	0.0	0.0
US	0.2	4.9	0.2	-0.1	0.0	0.0	0.0	0.0	0.0
ROW	3.1	4.0	1.0	-0.1	0.0	0.0	0.0	0.0	0.0

Appendix 1: GTAP sectors and aggregations[a]

Sectors modelled	GTAP Sectors included in aggregated sector modelled
Plant products (Agriculture and Food)	PDR - Paddy rice; WHT - Wheat; GRO - Cereal grains n.e.c.; V_F - Vegetables, fruit, nuts; OSD - Oil seeds; C_B - Sugar cane, sugar beet; OCR - Crops n.e.c.; VOL - Vegetable oils and fats; PCR - Processed rice; SGR – Sugar; OFD - Food products n.e.c.; B_T - Beverages and tobacco products
Animal products (Agriculture and Food)	CTL - Bovine cattle, sheep and goats, horses; OAP - Animal products n.e.c.; RMK - Raw milk; FSH – Fishing; CMT - Bovine meat prods; OMT - Meat products n.e.c.; MIL - Dairy products
Wood products (Non-Agriculture)	FRS - Forestry; LUM - Wood products; PPP - Paper products, publishing
Textiles, apparels, leather etc. (Non-Agriculture)	PFB - Plant-based fibers; WOL - Wool, silk-worm cocoons; TEX - Textiles; WAP - Wearing apparel; LEA - Leather products; FRS - Forestry; LUM - Wood products; PPP - Paper products, publishing
Machinery and equipment (Non-Agriculture)	MVH - Motor vehicles and parts; OTN - Transport equipment n.e.c.; ELE - Electronic equipment; OME - Machinery and equipment n.e.c.
Other manufactures (Non-Agriculture)	COA – Coal; OIL – Oil; GAS – Gas; OMN - Minerals n.e.c.; P_C - Petroleum, coal products; CRP - Chemical, rubber, plastic products; NMM - Mineral products n.e.c.; I_S - Ferrous metals; NFM - Metals n.e.c.; FMP - Metal products; OMF - Manufactures n.e.c.; ELY - Electricity; GDT - Gas manufacture, distribution
Services	GTAP services sectors

[a] See www.gtap.agecon.purdue.edu/databases/v9/v9_sectors.asp for further details

Appendix 2: Division of NTM obligations

NTM	Description	Exporter weight (proportion of cost directed at exporter)	Importer weight (proportion of cost directed at importer)	Explanation
Sanitary and Phytosanitary Measures				
a100	General prohibitions/restrictions	0	1	Since these do not impose any costs on exporters who are able to export.
a110	Temporary geographic prohibitions	0	1	Since these do not impose any costs on exporters who are able to export.
a120	Geographical restrictions on eligibility	0	1	Since these do not impose any costs on exporters who are able to export.
a130	Systems approach	0.5	0.5	Since involves a combination of measures, which may affect importers or exports
a140	Authorization requirements (for importers)	0	1	Since the importer has to be authorized
a150	Importer registration requirements	0	1	Since the importer has to register
a190	Prohibitions/restrictions nes	0	1	Since these do not impose any costs on exporters who are able to export.
a210	Residue tolerance limits	1	0	Since affect production processes
a220	Restricted use of substances	1	0	Since affect production processes
a310	Labelling requirements	0.75	0.25	As labelling can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer
a320	Marking requirements	1	0	Since would be done prior to shipment i.e. by exporter
a330	Packaging requirements	0.75	0.25	As packaging can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer
a410	Hygienic requirements: microbiological requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a420	Hygienic requirements during production (until final consumption)	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a490	Hygienic requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a500	General treatment requirements	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a510	Cold/heat treatment	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a520	Irradiation requirements	0.5	0.5	Since this treatment can be done

				by either the exporter or the importer
a530	Fumigation requirements	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a590	Treatment requirements nes	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a610	Plant-growth processes	1	0	Since affect production processes
a620	Animal raising/catching requirements	1	0	Since affect production processes
a630	Food and feed processing requirements	1	0	Since affect production processes
a640	Storage and transport requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a690	Other production requirements	1	0	Since affect production processes
a810	Product registration requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a820	Testing requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a830	Certification requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a840	Inspection requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a850	General traceability requirements	0.5	0.5	Both importer and exporters need to keep records
a851	Traceability (origin)	0.5	0.5	Both importer and exporters need to keep records
a852	Traceability (processing history)	0.5	0.5	Both importer and exporters need to keep records
a853	Traceability (distribution and location after delivery)	0	1	Borne by final seller i.e. importer
a859	Other traceability requirements	0.5	0.5	Both importer and exporters need to keep records
a860	Quarantine requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a890	Other conformity requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a900	SPS measures nes	0.5	0.5	As there is no information to identify whether the cost would be borne by the exporter or the importer
Technical Barriers to Trade				
b110	Prohibitions	0	1	Since these do not impose any costs on exporters who are able to export.
b140	Authorization requirements (for importers)	0	1	Since the importer has to be authorized

b150	Importer registration requirements	0	1	Since the importer has to register
b190	Prohibitions/restrictions nes	0	1	Since these do not impose any costs on exporters who are able to export.
b200	Tolerance limits nes	1	0	Since affect production processes
b210	Residue tolerance limits	1	0	Since affect production processes
b220	Restricted use of substances	1	0	Since affect production processes
b310	Labelling requirements	0.75	0.25	As labelling can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer.
b320	Marking requirements	1	0	Since would be done prior to shipment i.e. by exporter
b330	Packaging requirements	0.75	0.25	As packaging can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer.
b400	General production or post-production requirements	0.5	0.5	As there is no information to identify whether the cost would be borne by the exporter or the importer
b410	Production process requirements	1	0	Since affect production processes
b420	Storage and transport requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
b490	Production requirements	1	0	Since affect production processes
b600	Product identity requirement	1	0	As goes to the product itself i.e. how manufactured
b700	Performance standards	1	0	Since affect production processes
b810	Product registration requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b820	Testing requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b830	Certification requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b840	Inspection requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b850	General traceability requirements	0.5	0.5	Both importer and exporters need to keep records
b851	Traceability (origin)	0.5	0.5	Both importer and exporters need to keep records
b852	Traceability (processing history)	0.5	0.5	Both importer and exporters need to keep records
b853	Traceability (distribution and location after delivery)	0	1	Borne by final seller i.e. importer
b859	Other traceability requirements	0.5	0.5	Both importer and exporters need to keep records
b890	Conformity assessments	0.5	0.5	As the cost may be borne by

	nes			either the importer or the exporter
b900	Other TBT requirements	0.5	0.5	As there is no information to identify whether the cost would be borne by the exporter or the importer
c100	Pre-shipment inspection	1	0	Since it is before shipment
c300	Direct consignment requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
c400	Import monitoring requirements	0	1	As the cost is more likely to be borne by the importer.
c900	Customs formalities	0	1	As the cost is more likely to be borne by the importer.

Appendix 3: Changes in ASEAN6 imports due to NTM reductions modelled (trade weighted average increase)[a]

	Singapore	Thailand	Malaysia	Viet Nam	Philippines	Indonesia
Importer Augmented Technological Change (Private Consumption)						
Plant products	17.07	14.43	17.33	14.24	21.20	8.06
Animal products	18.46	20.60	10.22	20.93	17.33	18.71
Wood products	0.01	0.00	0.00	0.32	0.00	0.90
Textiles & apparel	0.05	0.00	0.00	0.00	0.00	2.07
Machinery & equip.	2.76	1.43	0.00	0.29	4.43	2.10
Other manufactures	1.93	1.67	1.36	6.12	1.67	1.43
Importer Augmented Technological Change (Firm Use)						
Plant products	7.61	1.18	3.11	9.41	29.64	1.55
Animal products	10.75	1.72	2.68	3.43	47.39	4.97
Wood products	0.06	0.73	0.08	10.24	4.63	0.02
Textiles & apparel	0.00	0.02	0.73	4.11	1.09	0.00
Machinery & equip.	0.02	0.50	0.18	3.34	0.64	0.67
Other manufactures	0.56	0.33	0.28	4.52	3.05	0.27
Importer Augmented Technological Change (Government Purchases)						
Plant products	15.35	7.73	9.54	11.09	25.87	3.16
Animal products	16.50	10.22	7.73	8.74	27.23	9.44
Wood products	0.05	0.64	0.06	9.82	3.62	0.09
Textiles & apparel	0.05	0.01	0.25	3.75	0.57	0.27
Machinery & equip.	0.13	0.53	0.17	3.17	0.75	0.69
Other manufactures	0.49	0.44	0.30	4.20	2.52	0.26
Exporting Efficiency Change						
Plant products	14.20	7.29	5.64	15.60	8.31	3.74
Animal products	19.78	8.96	9.09	10.39	1.98	10.74
Wood products	0.05	0.75	0.02	6.79	2.94	0.32
Textiles & apparel	0.05	0.01	0.00	3.59	0.45	0.38
Machinery & equip.	0.19	0.73	0.17	3.17	0.81	0.85
Other manufactures	1.13	0.78	0.36	4.63	5.12	0.39

[a] See explanation in text for details of assumptions.