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Regulatory harmonization in the ASEAN region: The effects of applying different types of non-tariff measures

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Abstract

This paper explores the impact of regulatory harmonization on non-tariff measures (NTMs) in six major ASEAN countries (Singapore Malaysia, Indonesia, Thailand, Viet Nam and the Philippines). Our analysis is based on econometric estimates of the impact of different types of NTMs applied by these major ASEAN members, obtained in a gravity model framework. These estimates identify the types of NTMs that have significant negative effects on trade, both on imports of products sold for intermediate production and those sold to final consumers.

We explore the effects of regulatory harmonization by simulating the effects of changing – at the product line (HS 6 digit) level - NTMs in major ASEAN markets so that the NTM regime of each major ASEAN member aligns with that of the major ASEAN member that applies the least trade restricting regulatory regime in a particular sector. The expected overall trade effect of changes in the types of NTMs applied as a result of this regulatory harmonization is calculated using our estimates of the trade effects of different types of NTMs. We implement these estimates of regulatory harmonization in a global supply chain model, which includes general equilibrium interactions, to model the overall impacts of this harmonization on each both major ASEAN countries and their trading partners.

JEL: F13, F14, F17, F68

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

INTRODUCTION

This paper explores the impact of regulatory harmonization on non-tariff measures (NTMs) in six major ASEAN countries (Singapore Malaysia, Indonesia, Thailand, Viet Nam and the Philippines). NTMs are generally defined as policy measures, other than tariffs, which may have an impact on international trade in goods and services (UNCTAD, 2013). They constitute a wide variety of measures imposed for a range of reasons, including legitimate public policy objectives such as environmental policies. Given their effects on trade, NTMs have become a key area of focus for both researchers and policy makers (Beghin, Maertens, and Swinnen 2015).

Our analysis is based on econometric estimates of the impact of different types of NTMs in these major ASEAN members, building on work by Webb, Strutt, Gibson and Walmsley (2017). These estimates identify the types of NTMs that have significant negative effects on trade, both on imports of products sold for intermediate production and those sold to final consumers. We use a novel approach to explore the effects of regulatory harmonization by changing the trade-affecting NTMs in major ASEAN markets to align with the ASEAN market applying the least trade restricting regulatory regime. This means that a country may cease to apply types of NTMs that are not used on the same product in another ASEAN member, but may substitute NTMs which are applied to the product in this other ASEAN member (i.e. the member with the least trade restricting regime). Using these estimates of the trade effects of different types of NTMs, we calculate the expected overall trade effect of changes in the types of NTMs applied as a result of regulatory harmonization.

The potential for a reduction in trade costs through regulatory harmonization is well known, see for instance Egger, Francois, Manchin and Nelson (2015), Reyes (2011) and Strutt et al. (2018). However, our innovative current approach is made possible due to the combination of our new estimates of the specific effects of different types of NTMs, along with the detailed information on the types of NTMs applied to individual products that is available in the UNCTAD database.

To enable general equilibrium interactions and provide estimates of welfare effects, we incorporate our estimates of the effect of regulatory

harmonization into a global supply chain model. 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). Moreover, there is considerable scope for exploring different ways of reflecting "improvements" in NTMs.

We offer a new methodology for modelling regulatory harmonization in a CGE framework that captures many nuances of NTMs that has not previously nee possible. In particular we incorporating our econometric estimates of NTMs into the ImpactECON Supply Chain (IESC) model (Walmsley and Minor, 2016), which is a modified version of the GTAP model which uses a more detailed database, alongside 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.[1] We model 15 regions[2] and conduct our simulations of the effect of regulatory alignment among 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.

ECONOMETRIC METHODOLOGY AND DATA[3]

The NTM database

The database of NTMs that we use has been compiled in a multi-agency project led by UNCTAD.[4] 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

[1] Recent papers have extended the framework underpinning the GTAP model in other ways. For instance Jafari and Britz (2018) introduce firm productivity heterogeneity into a modular CGE to analyse the Transatlantic Trade and Investment Partnership (TTIP) proposal, including reductions in the effect of NTMs.
[2] Singapore, Thailand, Malaysia, Viet Nam, Philippines, Indonesia, Other ASEAN, New Zealand, Australia, Japan, Korea, China, India, United States and the Rest of the World.
[3] This section draws extensively on Webb, Strutt, Gibson and Walmsley (2017)
[4] http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures.aspx

and regulations which may affect merchandise trade in a particular country.[5] 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 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).

[5] Two authors of the current paper were responsible for contributing the New Zealand data to this database.

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
Export measures	P	Export-Related Measures

Source: UNCTAD (2013)

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 of the type that is frequently used for analysis of NTMs (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.[6] 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).[7] 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.[8]

[6] 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.

[7] 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.

[8] 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}).[9]

Tariff data are obtained from the World Trade Organization (WTO) and World Bank. [10] 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

[9] 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.

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

widely used CEPII database.[11] 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.[12] (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 $D_{\text{sector},ji}$.[13] 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$_{id}$)).[14] 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)

[11] http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp.
[12] http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx.
[13] 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.
[14] To avoid issues of endogeneity, we exclude imports from our six major ASEAN markets.

available from the UN Statistical Division.[15] 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).

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

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 shows the NTM coefficients, converted to percent changes in imports, that would result from elimination of the NTM.[16] 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).

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

Table 3: Estimated effect of NTM changes (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

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.[17] Instead, we address the

[17] 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 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

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 HARMONIZATION

The next stage in the analysis incorporates the economic estimates of the effect of NTM harmonisation 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 harmonization 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.[18]

In the current study we utilize a new mechanism to capture the impact of NTMs directly on exporters, following Walmsley and Strutt (2019). 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 exports needed to meet a given level of import demand. When modelling reductions in NTM costs as a result of regulatory harmonization through this export mechanism, the principal benefits accrue to exporting countries. This is appropriate for many NTMs which directly affect the cost of exporting.

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.

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

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). [19] 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 reduced NTM costs 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.

Shocks required

As detailed above, we need to implement four sets of shocks: (i) import-augmenting technological shocks to imports of intermediate goods (ii) import-

[19] 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 (2019) for detailed exploration of the impact of alternative CGE modelling mechanisms.

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.[20] 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. [21] However, for exports there is only one agent involved in exporting and therefore only one type of export-augmenting technological shock is needed.[22]

Calculating changes in imports from regulatory harmonization

The first step in calculating our shocks is to determine the benchmark for regulatory harmonization i.e. the regime against which all members harmonize. For each of the 7 goods sectors in our models (set out in annex 1), we calculate which ASEAN 6 country has the regime that would overall have the least effect on trade (when weighted by total exports to the ASEAN 6 members). This is calculated at the detailed HS6 level, following to the formula set out in appendix 3. We calculate these shocks on the basis of those that will affect exporters, since we assess that these trade costs are likely to receive the greatest attention from policy makers.

[20] 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.

[21] This means that we consider separately the estimated increases in imports of consumption goods, intermediate inputs and government purchases, with the definition of these based on the BEC framework. 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.

[22] 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. Our separation between importer and exporter effects is shown in appendix 2.

On this basis, Malaysia is selected as the benchmark for four sectors, with the remaining two sectors using the regime of the Philippines (for animal products), and Singapore (for wood products).

Three important implications of this approach should be noted. First, larger results would be obtained if we used more disaggregated sectors rather than the 7 currently used. Moreover, even larger results could be obtained if we selected the least trade restricting regime for each product i.e. at the HS 6 digit level. It is our view that the conservative results that flow from using aggregated sectors may be a more realistic representation of harmonization than modelling harmonization at a much more detailed level. Product-by-product analysis of the "best" regime would be incredibly resource intensive in practice and we would not expect the "best" regime to be chosen for all products. Second, determination of the "least trade restricting" regime is based on our econometric estimates of the effect of different types of NTM; it does not take into account the stringency of the application of measures to particular products. Third, we focus on "least trade restricting" regimes, calculated purely on trade effects: this does not take into account political considerations, for example where some ASEAN members may push for their regime to be the "benchmark" upon which other regimes converge.

Once we have established the least trade restricting "benchmark" regime, we then compare, for each ASEAN member, the NTMs that it applies on a particular product at the HS 6 digit level with the least trade restricting NTM regime applied in the ASEAN 6 region. This comparison is made for each of the types of NTMs described in the UNCTAD database, using the estimated effects set out in table 3. This means that if an ASEAN 6 country currently applies a NTM of a type found to reduce trade – such as an inspection requirement - but this NTM type is not applied in the benchmark regime then imports of this product would be increased as a result of the removal of this type of NTM. On the other hand, if this ASEAN 6 country does not apply a NTM type that has been found to reduce trade, but this type of NTM is applied in the benchmark regime then imports of this product would be decreased accordingly. The overall trade

effect of regulatory harmonization on a product is the net effect of these changes for all types of NTMs that are found to reduce trade applied to a product.[23]

Moreover, consistent with Vanzetti, Peters and Knebel (2017) we reduce the effects of NTMs which are applied by ASEAN members trading amongst themselves by 25 percent, to reflect the effect of regulatory harmonization (the requirements are now consistent among the ASEAN 6 which reduces compliance costs for firms).

We then aggregate the product level effects to the the sectoral level at which we model (weighted by the value of imports affected). The import quantity shocks implemented vary by importer and also across the regions exporting to each major ASEAN county, reflecting their different export profiles. Finally, consistent with Berden and Francois (2015) an "actionability" assumption is also incorporated with only 50 percent of the potential gains being estimated as realizable.

Implementation in the global supply chain model

The approach outlined above provides an estimate of the change in imports which will result from regulatory harmonization under the assumptions discussed. To model this type of harmonization, we first need to calibrate the shocks before implementing them in the IESC model in a way that takes account of the general equilibrium interactions. We implement the calibration shocks for each exporting region, exogenizing exports to capture the import-augmenting technological change required to achieve each of the required changes in consumption, firm use and government purchases. 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.[24] As a result of these 30 calibration simulations (2 for each region) we have the import augmenting technological shocks and exporting efficiency changes which can then be implemented simultaneously to enable general equilibrium

[23] If the overall effect was negative for a particular product for a particular country, we excluded this product from our harmonization scenario as this would not be a credible outcome from regulatory harmonization.

[24] 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.

interactions between sectors and regions. This approach to first calibrating import augmenting technological shocks is discussed in further detail in Webb et al. (2017).

RESULTS: EXAMINING THE IMPACT OF REGULATORY HARMONIZATION

To obtain the overall effect of regulatory harmonization 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 global supply chain model. These shocks 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 preliminary effects on GDP, welfare, output and exports of our simulated NTM liberalization are presented in the conference slides and are available on request from the authors, and are subject to being revised.

We find that real GDP increases in all countries as a result of NTM harmonization in ASEAN, with the greatest gains to Viet Nam and the Philippines. For most ASEAN 6 countries (Viet Nam, the Philippines, Thailand, and Indonesia) the majority of this increase in GDP occurs through the import augmenting technological shocks channels (particularly as it relates to imported intermediates), which reflects that importing countries themselves benefit directly from reducing the impact of NTMs. In contrast, the contribution of import augmenting technological shocks channels is much smaller for Malaysia, which often served as the benchmark regime and therefore saw less changes to its NTM.

The GDP gains to countries other than the ASEAN 6 are relatively modest, with the largest percentage increases accruing to the "Other ASEAN grouping" and Korea.[25] The modest effects on countries other than the ASEAN 6 can be understood by noting that there are effects working in two directions: on

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

one hand they benefit from increased ASEAN export efficiency when ASEAN countries reduce NTM barriers to all trading partners as a result of harmonizing to more efficient types of NTMs. However, this impact is dampened since ASEAN competitors have an advantage in exporting among themselves due to the reduced regulatory compliance costs and also they become more competitive as a result of using imported intermediates more efficiently. ASEAN countries harmonizing their NTMs benefit from both increased export and import efficiency, including reduced transaction costs when trading amongst themselves.

All ASEAN 6 countries see an increase in welfare (as measured by an equivalent variation in income (EV). Consistent with our GDP results, the largest gains are to Viet Nam and the Philippines. Both "improved trade efficiency" which incorporates the efficiency gains to both exporters and importers from NTM harmonization and changes in the terms of trade, due to changes in the relative prices of imports and exports, explain the vast majority of these changes in the welfare of the ASEAN 6, with the exception of Malaysia which has negative terms of trade effects. Negative terms of trade effects counteract the relatively small positive efficiency gains for all non-ASEAN members, with the exception of New Zealand, leading to a decrease in welfare.

CONCLUSIONS

This paper illustrates the effects, both on the major ASEAN countries themselves and their trading partners, from regulatory harmonization by the major ASEAN countries of their most trade distorting types of NTMs. It builds on earlier work on the effect of NTM liberalization in ASEAN (Webb 2018; Webb, Strutt, Gibson and Walmsley 2017) to develop new estimates of the impact of regulatory harmonization.

Both this paper and Webb, Strutt, Gibson and Walmsley (2017) provide important contributions to the modelling of NTMs. Both sets of research take 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. Moreover, 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 and those in Webb, Strutt, Gibson and Walmsley (2017). Comparing our results with Webb, Strutt, Gibson and Walmsley (2017) also illustrates the potential differences between the liberalization (removal) of NTMs and their harmonization, including the different assumptions necessary to model their likely effects.

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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: Determination of the least trade restrictive regime

In order to determine the least trade restricting regime, we find the country (*d)* that has the smallest estimated change in imports in sector j if its NTMs affecting exporters are eliminated ($\Delta M_{jd)}$. This is calculated according to the following formula:

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

Where: m_i is total ASEAN 6 imports of product *i* (using COMTRADE import data at the HS 6 digit level); $\tilde{\beta}_{NTM\_k}$ is the elasticity calculated from the coefficient for NTM *k* that has been found to have a statistically significant effect on trade, multiplied by the exporter weight set out in appendix; and $D_{NTM\_k,id}$ is a dummy variable equal to one if importer *d* applies NTM *k* on product *i.*