Economic Effects of Standard-Like Nontariff Measures: Analytical and Methodological Dimensions

John C. Beghin and Bo Xiong

Working Paper 16-WP 569
October 2016

Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa 50011-1070
www.card.iastate.edu

John Beghin is professor of economics, Iowa State University, 383 Heady Hall, Ames, IA 50011. E-mail: beghin@iastate.edu.

Bo Xiong is an economist for the State of California, USA.

This paper was commissioned by UNCTAD. We thank Alessandro Nicita for his comments on previous drafts**.**

For questions or comments about the contents of this paper, please contact John Beghin, beghin@iastate.edu.

Economic Effects of Standard-Like Nontariff Measures:

Analytical and Methodological Dimensions

John C Beghin (Iowa State University) and Bo Xiong (State of California)*

This draft: October 20, 2016

Summary: We provide a selective review of the empirical international trade literature on nontariff measures (NTMs) acting like standards–the so-called technical measures under the MAST classification. This review focuses on analytical and methodological dimensions involved in evaluating these NTMs and their economic effects, and draws from established approaches to measure standard-like NTMs and rigorous models used to quantify their effects on trade and welfare. The quantification of technical measures and the assessment of their effects are often entangled. We present each of these major approaches and methodologies with some formalism and details to help guide future investigations of technical measures select a suitable approach for their empirical strategy. An annex contains a more advanced technical formulation for interested readers. We also identify respective and potential pitfalls of each approach and methodology. Promising research directions are suggested for further work quantifying and assessing the economic effects of standard-like NTMs.

***This paper was commissioned by UNCTAD. We thank Alessandro Nicita for his comments on previous drafts.**

Introduction

We provide a selective review of the literature on the economic effects of nontariff measures (NTMs). Our focus is methodological. We provide a fairly detailed review of selected contributions but with important information for interested readers to undertake their own investigations using one of the approaches reviewed here. For a more comprehensive coverage of the literature on standard-like NTMs we refer readers to Beghin, Maertens, and Swinnen (2015). NTMs have proliferated in world trade as custom duties and quantitative restrictions are progressively reduced or eliminated by numerous bilateral, regional, or multilateral trade agreements (World Trade Report, 2012). Figure 1 shows the classification of NTMs according to the recent MAST classification project of the United Nations Conference on Trade and Development (UNCTAD).

Figure 1. MAST classification.

Technical Measures Affecting Imports	A. SANITARY AND PHYTOSANITARY MEASURES
	B. TECHNICAL BARRIERS TO TRADE
	C. PRE-SHIPMENT INSPECTION AND OTHER FORMALITIES
Non- Technical Measures Affecting Imports	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
Measures Affecting Exports	P. EXPORT-RELATED MEASURES

Source: International classification of non-tariff measures, UNCTAD 2012.

Technical measures (groups A, B, and C in Figure 1) are the focal point of our selective review, although many implications discussed in this review also extend to other NTM categories. In particular, we focus on sanitary and phytosanitary (SPS) measures, technical barriers to trade (TBTs), and other technical measures, which often take the form of standards to be met by imports as well as their domestic counterparts. For example, food commodities, either imported or domestically produced, are subject to the testing of residues of additives, pesticides, or other substances hazardous to human health, animal health, or the environment. Member states of the World Trade Organization (WTO) are required to notify the organization before a SPS measure or a TBT is in force. As shown in Figures 2 and 3, both the SPS and TBT notifications are on the rise since the WTO agreements on SPS and TBTs took effect.

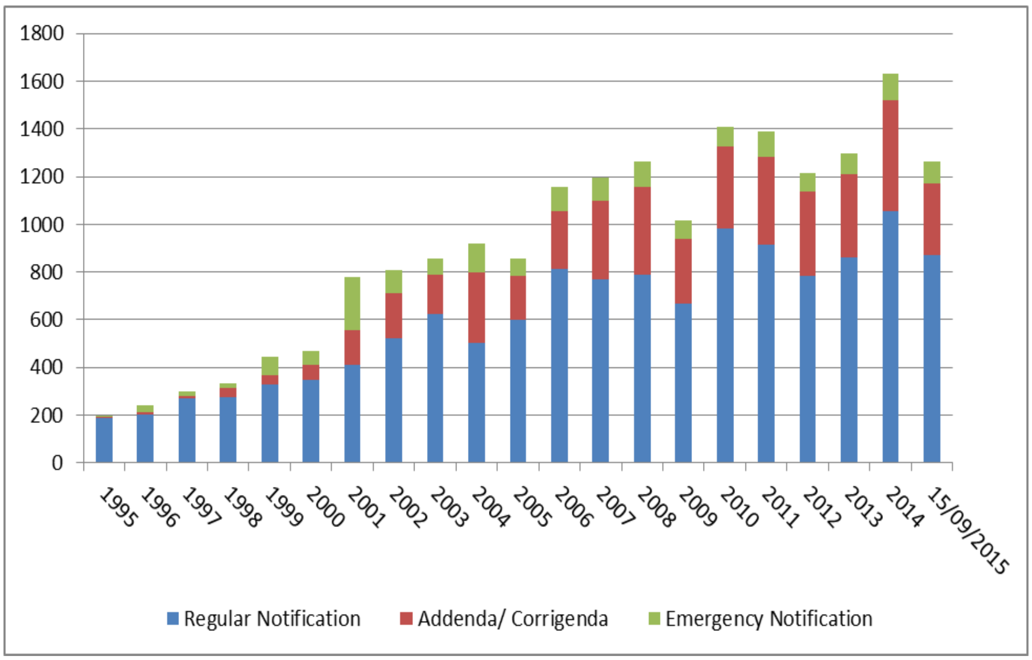

Figure 2. Number of (new and modified) SPS notifications, 2000–2015.

Source: WTO 2015. Committee on Sanitary and Phytosanitary Measures.

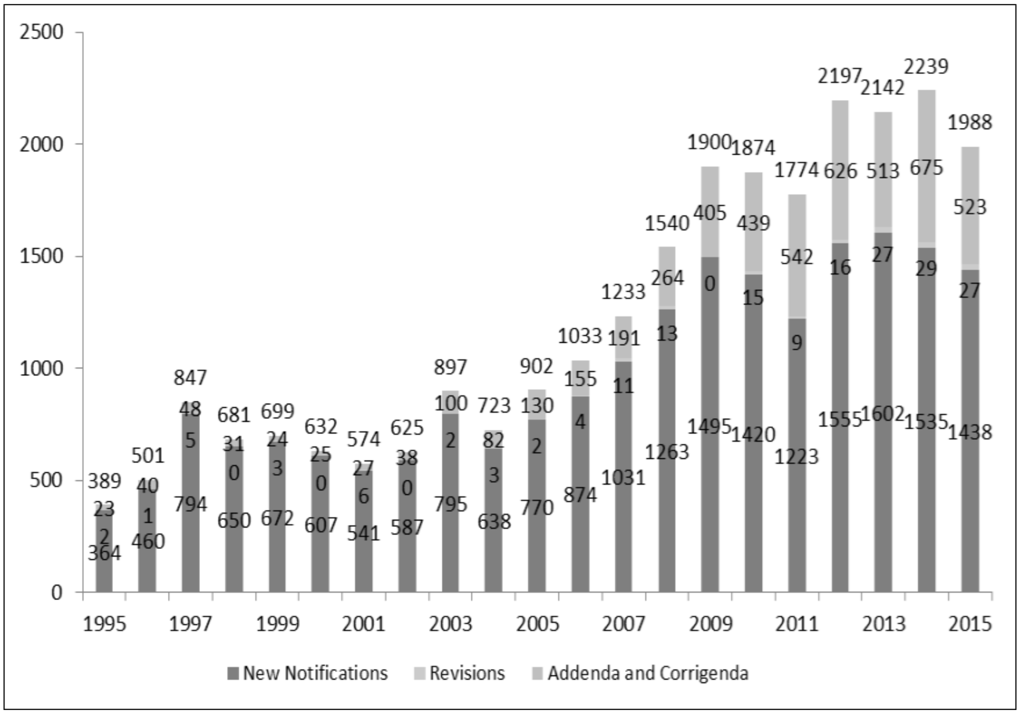

Figure 3. Number of (new and modified) TBT notifications, 1995-2015.
Source: WTO 2016. Committee on Technical Barriers to Trade.

The economic analysis of standard-like NTMs is challenging for two reasons. First, these standard-like NTMs are difficult to characterize and quantify in a systemic way. The specific policies underlying these NTMs are often heterogeneous (e.g., labeling requirement, documentation, inspection, residue standards, all in a single regulation). Hence, they can interfere with various activities in markets or non-market settings. Existing proxies used to measure them can be imprecise or unrepresentative of the overall regulatory regime.

Second, the impacts of standard-like NTMs on trade and welfare are more complex than the effects of tariff schemes or border taxation because some NTMs address informational issues in the marketplace, or generate social benefits that are external to markets, or both. Externalities can arise in consumption or production. Health hazards of consuming unsafe food imports is an example of the former and invasive species decreasing yields in domestic agriculture is an example of the latter. Several NTMs could address a similar market imperfection and each of these NTMs has its own welfare implications. Some may increase welfare and others may decrease welfare because they are poorly targeted or overly stringent. Typically, most NTMs induce higher cost in production for most suppliers, and raise the price at the border for imported goods. These costs and potential benefits, including external ones, have to be combined into a cost-benefit analysis to assess their aggregate impact and to potentially rank the NTMs to sort good and bad policies. In spite of these challenges, economists have made significant progress to quantify these NTMs and assess their impact on markets and society's welfare.

Several approaches have been used to measure and quantify these standard-like NTMs, and assess their impact on trade and welfare. In this review, we provide an established conceptual framework to analyze standard-like NTMs and assess their welfare and trade effects. We also review the major measurements of standard-like NTMs found in the economic literature. We survey a range of established and promising approaches to assess their implications for trade and welfare. For each of these measurements and approaches, we identify the respective strengths, weaknesses, and applicability in various scopes of economic research. Whenever possible, we provide implementation steps to guide users to adopt these tools in their own investigations of NTMs.

1. An intuitive conceptual framework to analyze standard-like NTMs

The economics of technical measures in a market can be graphically explained by the shifts of supply and demand for the product of interest (e.g., Josling, Orden, and Roberts, 2004; Fugazza, 2013; Van Tongeren, Beghin, and Marette, 2009). First, we'll look at supply. A technical measure may increase the costs borne by foreign and domestic suppliers at various stages of the supply chain. In a supply-and-demand diagram, the effects can be captured by upward shifts of supply curves, as shown in figure 4 for an importable good in a small country. Domestic supply is denoted by *y*, domestic demand by *x*, imports by *m*, *NTM* indicates the new policy put in place, and world price is *wp*. The figure first shows the shift upward of the horizontal world supply induced by the added cost of the NTM, *t*(*NTM*), at the border of the small country. The horizontal import supply curve moves from *wp* to *wp+t(NTM)*. The figure also shows the shift of the domestic supply from *y* to *y'* (to the left) for the same reason. The two shifts do not have to be equal, unless the cost structures of domestic and foreign suppliers are identical and their ability to meet the new standard is equal. Hence, the technical measure could have a protective (anti-protective) effect on domestic producers if they meet the new standard more easily (with more difficulties) than foreign producers do. Figure 4 shows the NTM being slightly protective in this illustration. In summary, the magnitudes of the supply shifts depend on individual suppliers' ability to comply with the measure.

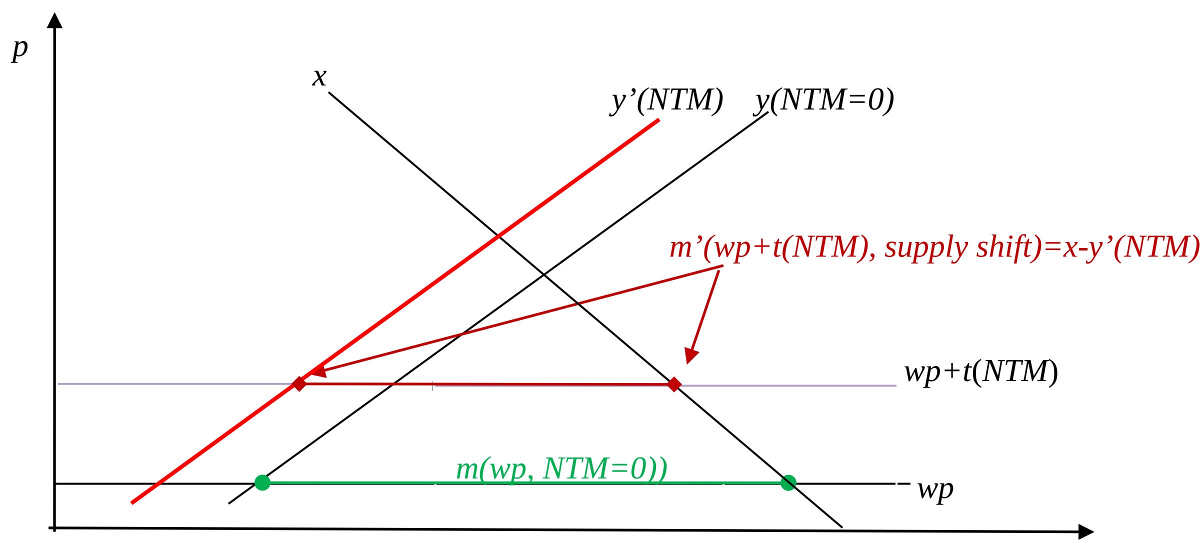

Figure 4. The supply shifts induced by a cost-increasing technical measure *x, y, m***.**

While less frequent, but not implausible, a measure could reduce a detrimental external effect born by domestic suppliers, say, brought about by foreign suppliers (e.g., a measure related to an exotic pest brought by imports prior to the measure). In this case, the impacts on domestic and foreign supply will have opposite directions. The policy will reduce imports by raising the unit cost of imports and expanding domestic supply by reducing the domestic cost (a reduction of the negative externality borne by domestic suppliers). This is shown in figure 5 with the right shift of the domestic supply and the increase in the import unit cost. The two effects contribute to reducing imports. Note that welfare and trade move in opposite directions. Trade decreases and welfare increases by reducing the external effect of the pest assuming that the policy is well targeted and that the gains to suppliers exceed the loss to consumers.

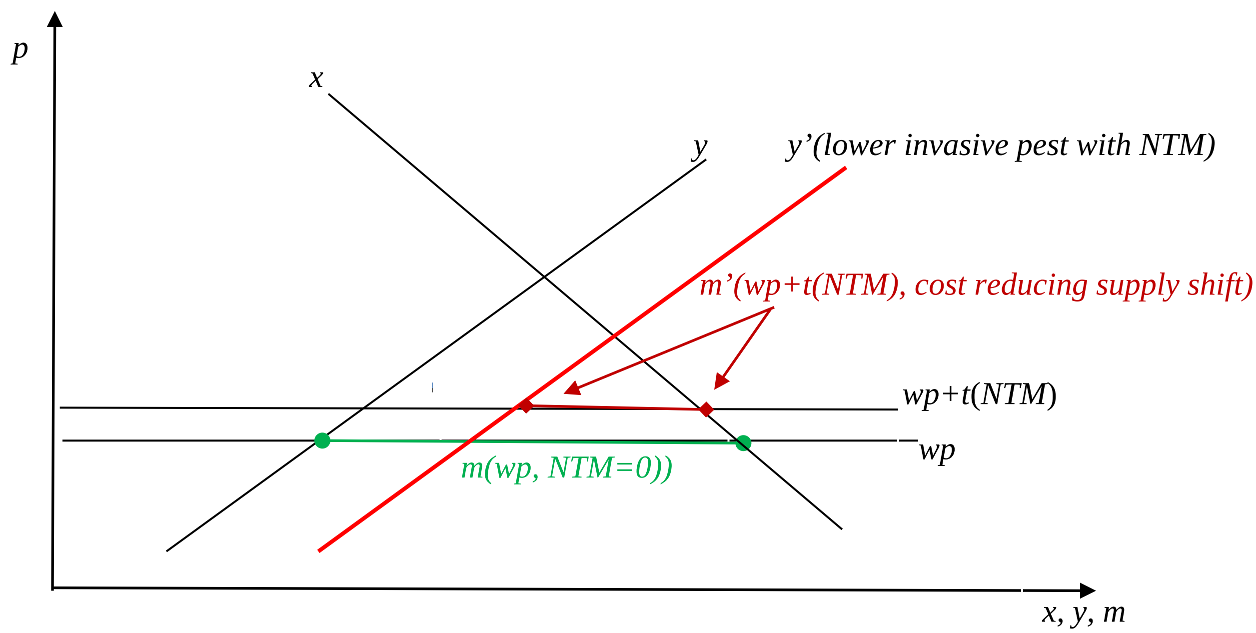

Figure 5. Supply shifts with NTM targeting invasive pest linked to imports.

Now we'll look at demand. When a consumer-based market imperfection is present, standard-like NTMs may affect consumption by signaling higher quality (corresponding to an outward shift of demand from safer or more nutritious food), or disclosing potential risks (corresponding to an inward shift of demand, say from a health warning label). These two opposite shifts are shown in figures 6 and 7, along with their trade effects and holding domestic supply constant for expository purposes. Imports expand under the former case and contract under the latter. Figure 7 also suggests that trade and welfare could move in opposite directions. Hence, the seemingly intuitive conjecture that trade and welfare move in tandem may not hold.

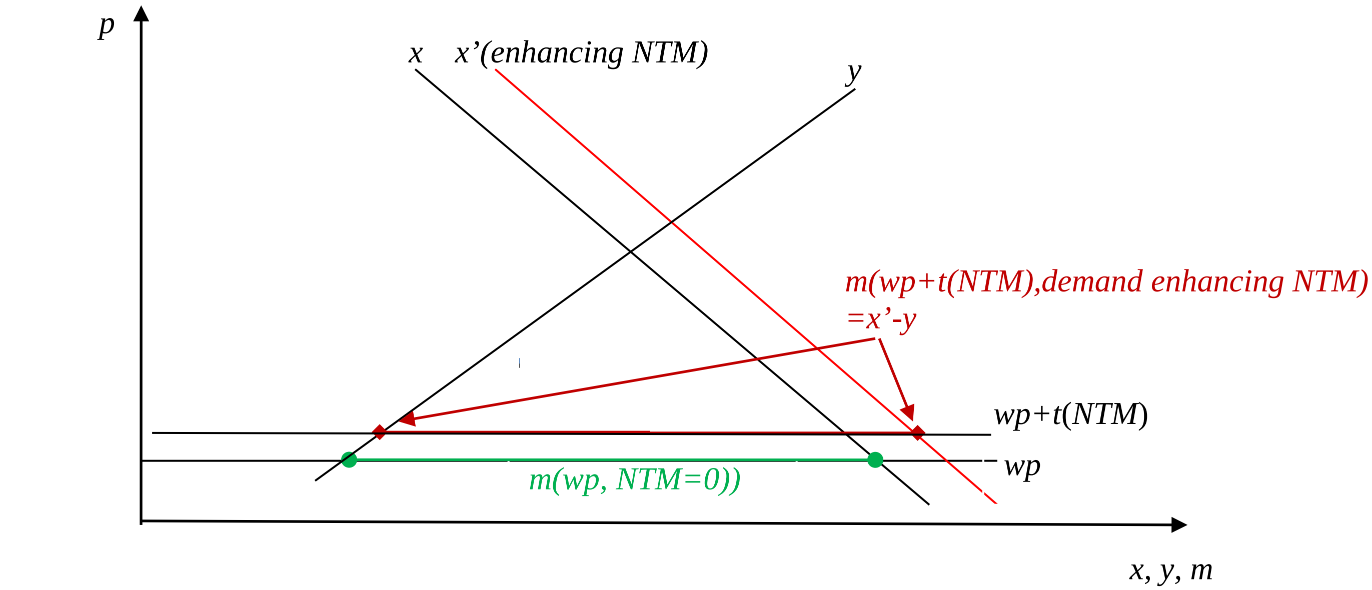

Figure 6. The impact of NTMs on demand (enhancing case with safer product).

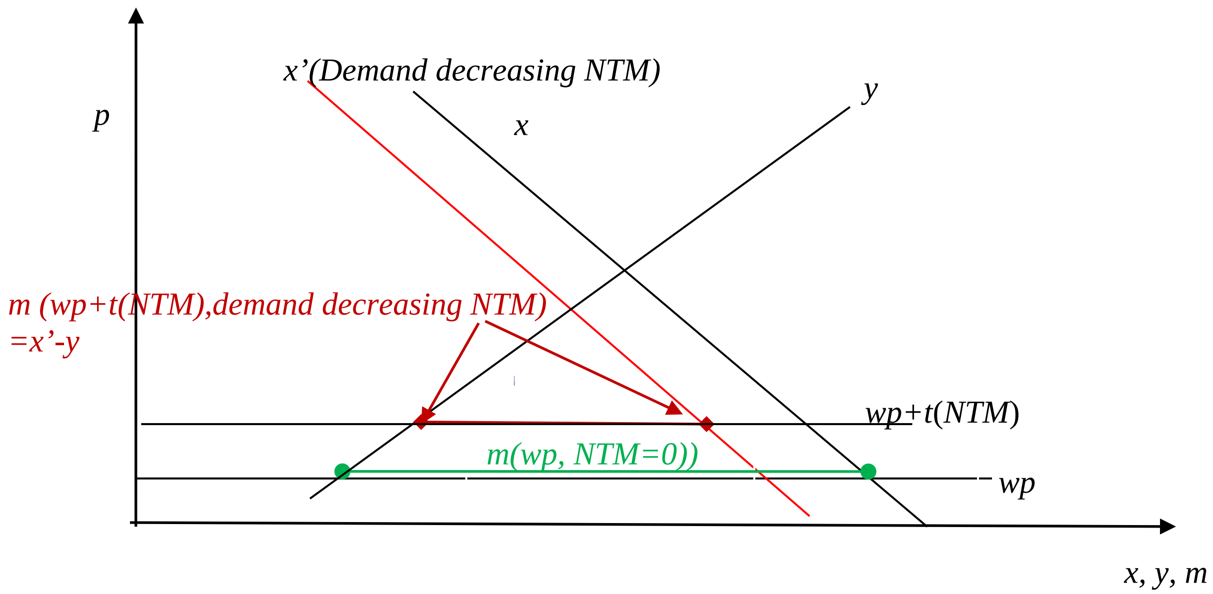

Figure 7. The impact of NTMs on demand (decreasing case with health warning).

When put together, the shift in supply, demand, and unit import cost lead to ambiguous trade and welfare effects requiring some quantification. This ambiguity is shown in figure 8 for a demand enhancing effect and an increase in supply cost (shift to the left). Imports could increase or decrease when the NTM is implemented. If the increase in import unit cost is small relative to the outward shift in demand and left shift of supply, imports are likely to increase. Else they might decrease. Welfare effects depend on the decrease in producer surplus, and change in consumer surplus (demand enhancing effect net of the price increase). In addition, in some cases, the externality addressed by the NTM may not be directly affecting demand, although society's welfare is at stake. In this case the cost of the externality has to be quantified and the impact of the NTM on the external cost has to be assessed and accounted for in the welfare analysis. See Van Tongeren, Beghin, and Marette (2009) for such cases.

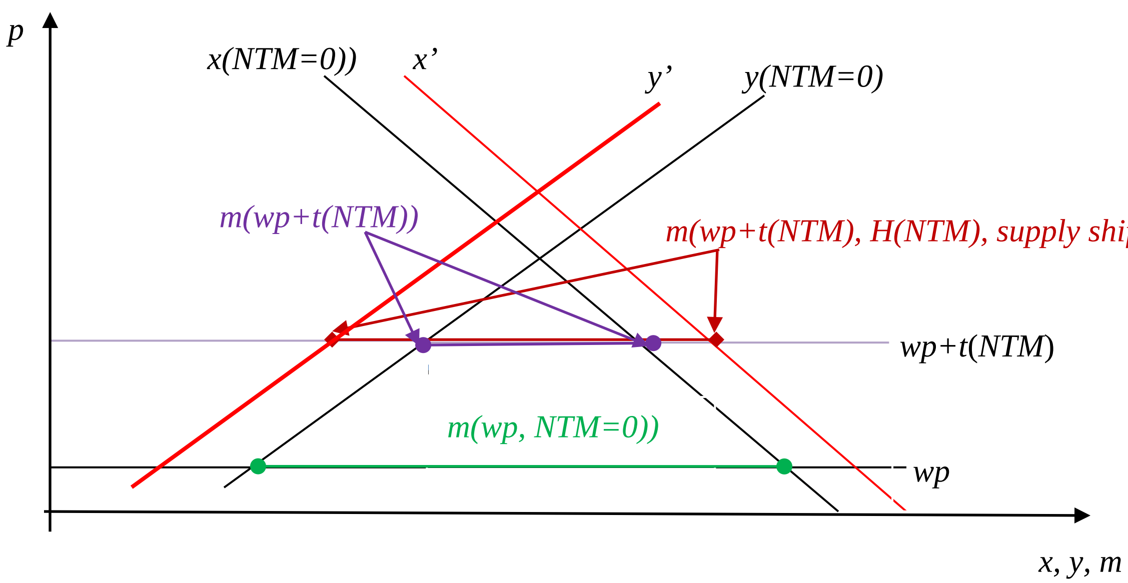

Figure 8. The ambiguous impact of NTMs on demand, supply, and imports.

So far we have abstracted from protectionism. NTM policies are purely protectionist if they do not really address any market imperfection (e.g., risk of external effect on demand or supply, asymmetric information). Purely protectionist NTMs do not affect consumers in their consumption or their health (or any other external effect for that matter). Hence, the demand curve will not be influenced by a purely protectionist NTM. Protectionist policies are motivated by other motives such as creating rent-seeking opportunities or protecting domestic suppliers.

The latter benefit if the policy induces only a small increase (or none) in their cost at the margin, and if it raises the cost of competing imports significantly. The purely protectionist policy is shown in figure 9 below, which depicts a large increase in the unit cost of imports induced by the protectionist NTM and no cost increase for domestic producers. Producer surplus (the area under the supply and below the market price) increases for domestic producers. Domestic consumers lose.

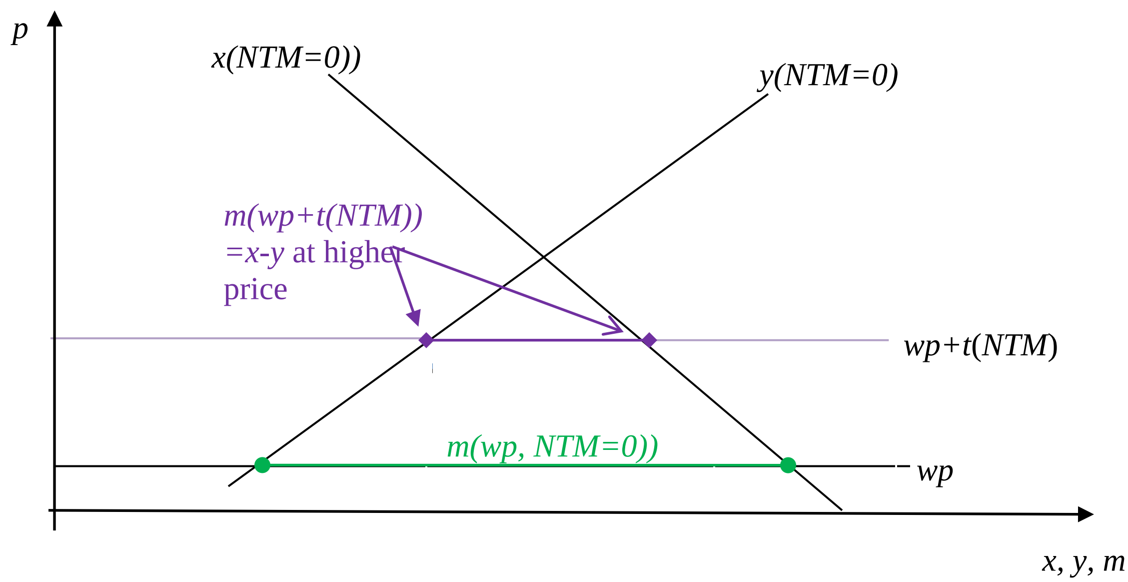

Figure 9. The impact of a purely protectionist NTM on imports

Consumer surplus falls under the new price inclusive of the taxing effect of the protectionist NTM, *wp+t(NTM)*. Since there is no externality being addressed here, consumer surplus reflects the net welfare of the consumer. Consumer surplus decreases since price increases from *wp* to *wp+t*(*NTM*). Welfare losses to society are represented by the trapezoid between the free trade (in green on the world price line) and distorted imports (in purple on the distorted unit cost of imports). In this "pure" case, welfare and imports move in tandem.

Formally, the above intuition can be characterized by a simple partial equilibrium framework (e.g., Disdier and Marette, 2010; Van Tongeren, Beghin, and Marette, 2009) which provides a foundation for quantitative analysis if the economic and policy parameters are appropriately calibrated (see Section 3.2). For NTMs affecting products beyond the targeted good, the potential spillover effects into related markets can be captured in a general equilibrium framework (Beghin, Disdier, and Marette 2015). The associated welfare and trade effects can be inferred using the trade restrictive indices (TRIs) and mercantile trade restrictive indices (MTRIs) (see Sections 1.1, 1.2, and 3.3).[1] We provide such a derivation in the annex for technically inclined readers.

So far, the surveyed methodologies are based on observed changes in trade flows. However, some NTMs can be prohibitive: the associated compliance costs are so high that the trade partnership is terminated altogether. These prohibitive NTMs are addressed in the empirical analyses of absence of trade, which explicitly account for countries' or industries' self-selection to trade (see Section 3.1).[2]

The common message drawn from the above-mentioned approaches (graphical, partial equilibrium models, and general equilibrium approaches) is that trade and welfare effects of standard-like NTMs are ambiguous. Unlike tariffs and border taxes that are shown to constrain trade and lower welfare, the implications of NTMs on trade and welfare cannot be determined a priori. Complex effects on consumption, production, and non-market values when these NTMs are implemented can increase or decrease welfare and trade can expand or contract with no direct mapping between welfare and trade changes. A reduction in trade could be welfare improving by reducing an externality linked to trade (Disdier and Marette, 2010). Effects on prices are less ambiguous. The preponderance of positive price effects from introducing technical measures is

[1] A multimarket partial equilibrium approach can also be used and the TRI is then applied to a subset of sectors rather than the full economy (Anderson, Bannister, and Neary, 1995; Beghin, Bureau, and Park, 2003).
[2] There are also dynamic issues recently analyzed by Swinnen et al. (2015) where hysteresis can occur following shocks in markets. Paths of effects can diverge between two countries because of specific shocks that interact with the political economy of the standards in these countries. This is the frontier of knowledge regarding the analysis of technical measures and is beyond this review.

obvious because they typically raise costs for domestic and foreign suppliers. The price at the border goes up (Cadot and Gourdon, 2016), however, when goods are imperfect substitutes, reductions of external costs for a domestic industry could lead to lower equilibrium price differences between domestic and imported goods as explained later in section 3 under imperfect substitution.

1.1. Formalizing the conceptual framework

To formally derive the economics of technical measures and their impact on market equilibrium, trade, and welfare, we follow a parallel approach to that of van Tongeren, Beghin, and Marette (2009) in partial equilibrium. The framework provides an intuitive and simple characterization that extends to an economy-wide approach. See the annex for a formal derivation of an economy-wide approach to analyzing NTMs.

Let's assume a simple market with the domestic supply y and demand x for a traded good. Imports m are equal to the residual demand ($m = x\text{-}y$) as in the previous figures. Let's assume that there is an externality in consumption H which can be influenced by NTM policies, denoted *NTM*. In this framework, a technical measure has several effects—it can influence the externality (a shift in demand) and potentially raises the cost of production at home (a shift of the marginal cost of production) and abroad (an increase in the price at the border). The pathways of the welfare effects are through the externality, the impact on prices, and the impact on general-equilibrium income.

These welfare effects of technical measures can be assessed by using conventional Marshallian surplus measures based on underlying supply and demand. They indicate the welfare cost and benefits associated with the policy interventions on producers and consumers and the policy impact on the market imperfection. The impact of the NTM on the externality has to be included in this welfare analysis.

Consumer prices *p* comprise the world price *wp* assumed parametric for a small country, a tariff τ, and the price equivalent *t* of the domestic *NTM* imposed at the border on foreign suppliers allowing them to sell in the domestic market, or $p = wp + \tau + t(NTM)$. The impact of technical measures on demand ($\partial x / \partial NTM$) is ambiguous as explained before.

On the production side, domestic supply *y* responds to producer prices, which include production subsidies, *s*, such as farm subsidies, not seen by consumers, $p^p = wp + \tau + t(NTM) + s$. Technical measures *NTM* affect the feasible set and the resource used to produce goods optimally ($\partial y / \partial NTM$). The latter derivative captures the shift in supply brought by the technical measure(s). If the technical measure reduces the feasible set, then supply will shift to the left.

Imports *m* are the residual excess demand or, $m = x(p, H(NTM)) - y(p^p, NTM)$.

The latter equation captures the three effects of *NTM* on imports via price *p* with *t(NTM)*, externality *H*, and supply *y*. Oone can differentiate imports *m* with respect to all the arguments. This step provides a basic trade impact induced by changes in the determinants of imports, including technical measures and other policy interventions in the economy. Not all these determinants have to change at once of course. For a particular good n determined by its own price, we obtain

$$(1)\quad \begin{aligned} dm^n &= (\partial m^n / dp^n) d\tau^n - (\partial y^n / \partial p^n) ds^n + \\ &[(\partial m^n / dp^n)(\partial t^n / \partial NTM^n) + (\partial x^n / \partial H)(\partial H / \partial NTM^n) - \partial y^n / \partial NTM] dNTM^n \end{aligned}.$$

Equation (1) suggests that an empirical strategy will be necessary to separate the impact of technical measures in a given sector n, NTM^n, on supply y^n and demand x^n to identify demand enhancing effects form supply shifts induced by higher cost of production under the technical measures. The annex provides a formal derivation of the welfare measure induced by the NTM. We return to this empirical issue in section 3.

2. **Measurements of standard-like NTMs**

In this section, we look at the most common ways used to measure standard-like NTMs to implement empirical investigation of NTM regimes. As we show, it is difficult to fully disentangle the measurement of the NTMs from the measurement of their impact on trade or welfare.

2.1. Inventory measures based on NTM notifications with the WTO

The WTO tracks all NTMs notified by member states pertaining to international trade in goods and services.[3] Economic literature has suggested several measurements to capture the degree to which NTMs interfere with world trade. In particular, two metrics based on NTM notifications are widely used by economists. Henceforth, we draw from Nicita and Gourdon (2013) to illustrate the two measurements.

The first measure is the *frequency index*, which is the percentage of imports subject to one or more NTM notifications. Formally, the frequency index of an importing country is computed as:

$$(2)\quad FI = \sum_i D_i M_i \Big/ \sum_i M_i \,,$$

where *i* designates a product, D_i equals one if the product is subject to any NTM notifications (and zero otherwise), M_i equals one if trade takes place (and zero otherwise). Intuitively, the frequency index captures the proportion of imported products under any NTMs.

There are several caveats to the frequency index. First, although equation (2) defines the index at the national level, it can be disaggregated by country and by sector. For example, one can calculate the frequency indices on a country-and-chapter basis, with the product index

[3] See the Integrated Trade Intelligence Portal of the WTO at https://www.wto.org/english/res_e/statis_e/itip_e.htm. Specifically, the database register NTMs notified by member states, with specific information about products and partners affected, effective date, and relevant NTM classification.

denoting either four- or six-digit product in the Harmonized System. Second, the frequency index provides a binary assessment as to whether a product is subject to NTMs, but not how many NTM notifications cover that product. In other words, a product under one NTM has the same effect as a product under a dozen NTMs. Third, the frequency index is irrelevant to trade volumes. That is, an NTM targeting a highly traded commodity contributes to the measurement in the same way as an NTM affecting a marginally traded product.

The second measurement based on the NTM notifications is the *coverage ratio*, which is the percentage of trade values subject to NTMs. Formally, the coverage ratio is calculated as

(3) $CR = \sum_i D_i V_i \Big/ \sum_i V_i$,

where V_i is the import value of product *i* in the country of interest. The coverage ratio improves upon the frequency index in that it gives more weight to NTMs that regulate products traded in large volumes.[4] If NTMs are strongly impeding trade, welfare weights would be opposite to trade weights. Therefore, CR may not be the best measure in deriving welfare consequences of the policies. Comparing *CR* and *FI* values for the same sectors, and if CR is larger than FI, this may suggest that the policy motive may go beyond protectionism since regulated goods are traded. Policymakers may be addressing health concerns or other market imperfections.

Figure 10 shows the two measures by specific categories of NTMs in 2010.[5] In general, high-income nations implement more SPS measures and TBTs (or technical measures in general). Beyond technical measures, conventional protectionist measures such as quantity control remain widely adopted in Asia and South America. In addition, the two measurements deliver comparable results in most cases. The two indices are obviously useful to provide stylized facts

[4] One shortcoming of the coverage ratio is that the weights are endogenous as trade flows are affected by NTMs. One way to mitigate the issue is to use trade records before the implementation of NTMs as the alternative weights.
[5] One can further extend the two measures by aggregating all types of NTMs.

across country groups and policy types as shown.

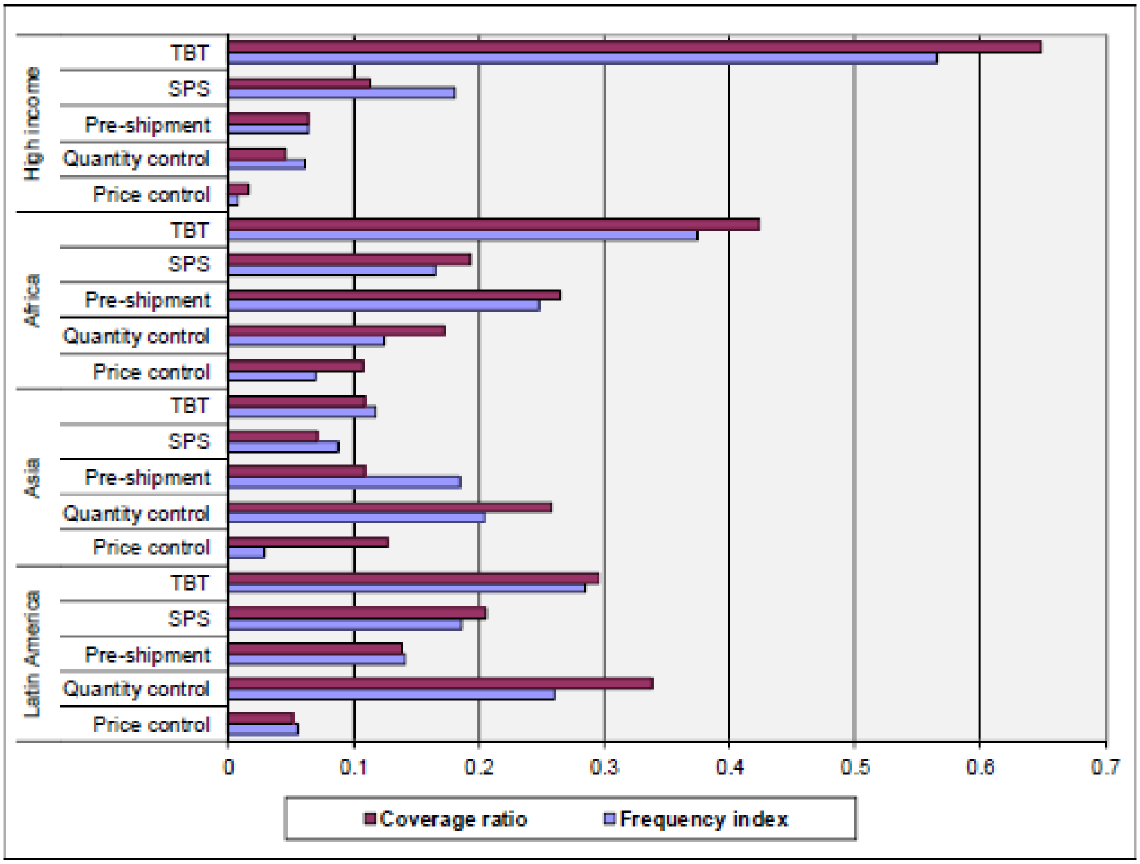

Figure 10. Frequency indices and coverage ratios by type of NTMs, 2010.
Source: Nicita and Gourdon (2013).

In summary, the two measurements based on NTM notifications with the WTO provide an overview of the pervasiveness and frequency of standard-like NTMs in importing countries. However, both metrics are subject to four major issues. The first issue is inherent to the nature of the WTO notifications. Member states of the WTO enforce NTMs differently after the notification with the WTO. It is generally believed that more developed nations have better technical and institutional capacities to rigorously implement the NTMs. In contrast, the notification might not translate into actions at customs in less developed countries. Second, both measures treat all types of NTMs equally, even within each subgroup. Since NTM types cover a wide range of policy instruments, the simple aggregation of all notifications risks downplaying the most restrictive measures and overstressing trivial ones. For instance, it could be the case that one NTM requires minimal modification to the packaging of imports, while another inflicts substantial compliance costs to foreign suppliers. Or, one NTM only affects producers and processors, while another informs consumers at the same time. Third, both measures capture the NTMs affecting positive trade flows. In other words, neither measure accounts for NTMs that prohibit trade from taking place altogether. Fourth, as discussed earlier, neither measure provides a count of all notifications at the product level.[6]

2.2. The ad valorem equivalent of NTMs

Economists have also developed approaches to translate NTMs into a tax equivalent, often at the border, in tariff ad valorem equivalents (AVEs). These AVEs of NTMs allow researchers to compare the trade restrictiveness of NTMs with that of custom duties. Furthermore, the magnitude of these AVEs of NTMs relative to tariffs affecting the same sectors may suggest whether policymakers treat NTMs and tariffs as substitutes to provide protection to domestic industries. We review two widely used methods to derive the ad valorem equivalence of NTMs. The first one is the price wedge method, which focuses on the effect of NTMs in raising prices of imported products. The second method is proposed by Kee, Nicita, and Olarreaga (2009), which identifies the alternative tariff rate leading to the same level of trade in the absence of NTMs. The two approaches are connected in the sense that both use a tax equivalent to the NTMs, although the basis of the equivalence may not be identical.

2.2.1. <u>The price wedge method</u>

The presence of NTMs generally drives up the price of imported goods in the destination markets, either via inflicting additional costs to foreign suppliers or informing domestic

[6] Future research can improve upon the two measurements by replacing the binary indicators with a count variable of all notifications at the product level.

consumers, or both. Therefore, one can identify the contribution of NTMs to the price in the importing market by subtracting the price in the exporting country, tariffs, transportation costs, and other international business costs. That is, the residual price difference is attributed to the presence of NTMs. With the price effects of NTMs, one can compute the AVEs accordingly.

The implementation of the price wedge method critically hinges on the availability of prices of the trade products in both the exporting and the importing countries. In a case study of U.S. apple exports to Japan, Yue, Beghin, and Jensen (2006) show that, in the absence of comparable prices, one can leverage the substitution between domestic and imported products to derive the counterfactual prices.

There are several limitations to the price wedge method. First, it requires an exhaustive accounting of all costs of trade. The price effect of NTMs is overestimated if certain costs of trade are omitted. Second, the price wedge method does not address the root cause of the price effect of NTMs. That is, the price effect is likely to encompass both compliance costs implied by NTMs and higher willingness to pay of consumers as they are better informed. Quality issues are also important.

Cadot and Gourdon (2016) leverage two recent established datasets to estimate the impact of NTMs on observed bilateral price gaps for the same product across countries using the NTM variation across countries and sectors. For trade unit values (CIF), they rely on CEPII's TUV dataset which contains unit values for over 173 reporters, 255 partners, and over 5000 six-digit HS product categories and for the period 2000–08. The bilateral CIF unit values include all trade costs before being taxed by the importing country. The data is based on UN Comtrade unit values. For NTMs they rely on the recently updated TRAINS database mentioned previously, which covers the range of NTMs shown in figure 1 for 65 countries. The dataset has been put into a user-friendly format by the CEPII including frequency and coverage indices per HS 6 sector (see NTM-MAP).

These authors develop a simple model based on the trade model of Melitz (2003), with exporting firms in country *o* for product *k* each having a FOB "milling" price, which then gets turned into a bilateral CIF price by destination *k* by adding trade costs for the product and destination denoted by τ_{dk}. The individual prices get aggregated over all exporting firms to yield an average CIF price which is the trade unit value, P_{odk}^{CIF} function of the average FOB price, the CIF/FOB bilateral trade cost and an aggregator term *V* reflecting the distribution of exporting firms from *o* to *d*:

(4) $P_{odk}^{CIF} = P_{ok}^{FOB} \tau_{odk} V_{odk}$.

Based on equation (4), one can use the variation in prices P_{odk}^{CIF} over destinations to approximate the variation of bilateral trade costs τ_{odk}. Using single OLS regressions for each product, the logarithm of CIF price is explained by the usual trade cost determinants (presence of three NTM types, tariff factor and exogenous bilateral determinants such as distance common border, common language, etc.). The authors further look at the impact of preferential trade agreements on the price gaps including so-called deep integration clauses relying on mutual recognition and/or harmonization of standards and conformity assessments and transparency requirements. The authors find that the estimated impact of NTMs on price gap is smaller than previously estimated using other approaches, and with median AVEs in the single digits (5% for TBTs, 3% for SPS measures). They also report that RTAs and their deep integration clauses decrease the price-raising effect of NTMs by a quarter (via lower NTM AVEs), an intuitive finding. Their estimates are shown in table 1. However, they find that mutual recognition of technical measures has the least impact among the various types of clauses analyzed.

Table 1. Estimates of NTMs by HS chapter

							AVE change					
	AVE without RTA			AVE with RTA			Absolute (percent points)		Proportional (percent of baseline)			
HS Section	SPS (A)	TBT(B)	Total	SPS (A)	TBT(B)	Total	SPS (A)	TBT (B)	SPS (A)	TBT (B)	Total
Animals	11.6	9.2	20.8	8.5	7.8	16.4	-3.1	-1.3	-26.7	-14.5	*-21.3*
Vegetables	9.9	10.3	20.3	9.3	6.6	15.8	-0.7	-3.8	-6.7	-36.4	*-21.9*
Fats & oils	8.9	8.4	17.3	4.9	7.8	12.6	-4	-0.6	-45.4	-7.6	*-27*
Beverages	8.1	8.4	16.5	6.6	5.3	11.9	-1.5	-3.1	-18.4	-37.3	*-28.1*
Minerals	1.6	7.8	9.4	1.6	5.2	6.8	0	-2.6	0.2	-33.4	*-27.6*
Chemicals	1	7	7.9	0.8	4.6	5.4	-0.1	-2.4	-13.6	-34.2	*-31.7*
Plastics	1.2	5.8	7	1.1	3.9	5	-0.1	-1.9	-9.1	-33.1	*-29*
Leather	2.7	3.7	6.5	1.6	2.5	4.2	-1.1	-1.2	-40.7	-31.9	*-35.7*
Wood prod	4.5	2.1	6.5	4.1	1.5	5.7	-0.4	-0.5	-8	-24.7	*-13.3*
Paper	0.7	2.5	3.3	0.5	1.6	2.1	-0.2	-0.9	-24.3	-37.3	*-34.5*
Textile and	0.9	4.8	5.6	0.7	3.6	4.3	-0.2	-1.2	-18	-24.5	*-23.5*
Footwear	0.7	4.3	5	0.6	2.6	3.2	0	-1.7	-6.7	-40.4	*-35.9*
Stone & gla	1.5	4.9	6.4	1.4	3.7	5.1	-0.1	-1.2	-8.2	-23.9	*-20.2*
Pearls	1	4.3	5.3	0.8	4.2	5	-0.2	-0.1	-21.3	-2.1	*-5.6*
Metals	1.2	4.6	5.8	1	2.9	3.9	-0.2	-1.6	-18.5	-35.8	*-32.2*
Machinery	1.5	5.2	6.7	1.2	3.6	4.8	-0.3	-1.6	-19.2	-30.6	*-28*
Vehicles	0.4	8.9	9.3	0.4	7.5	7.9	-0.1	-1.4	-15.5	-15.4	*-15.4*
Optical & n	0.8	7.5	8.3	0.7	6	6.6	-0.1	-1.6	-10.6	-20.8	*-19.9*
Arms	0	0.5	0.6	0	0.5	0.6	0	0	0	0	*0*
Miscellane	0.6	4.9	5.5	0.5	3.4	3.9	-0.1	-1.5	-17.7	-30.6	*-29.2*
Work of Ar	0	2.7	2.7	0	1.7	1.7	0	-1	0	-37.8	*-37.8*
Average	2.8	5.6	8.4	2.2	4.1	6.3	-0.6	-1.5	-21.2	-26.5	***-24.8***

Table 1. Estimates of NTMs by HS Chapter
Source: Cadot and Gourdon (2016).

One issue with the approach in Cadot and Gourdon (2016) is that CIF/FOB price variation should not depend on tariffs since they are measured before taxation at the border. In addition, they are only observed when bilateral trade already exists. Several selection biases could be at work with respect to firms, as in Melitz (2003), and also to explain when trade is observed or not. One could use the two-step Heckman procedure to first predict the probability to observe a trading pair (and a reported price) and then the observed price could be explained in a second step.

2.2.2. AVEs of Kee, Nicita, and Olarreaga (2009)

Kee, Nicita, and Olarreaga (2009) propose a method to estimate the tariff rate ad valorem equivalent that would result in the same level of trade in the absence of nontariff barriers (NTBs).

The method features a regression equation that explains imports as determined by tariffs, domestic support programs, core NTBs (measured by frequency indices), and other characteristics of the importing markets. The NTB frequency variables are based on the older TRAINS UNCTAD database on NTBs. Core NTBs used in Kee, Nicita, and Olarreaga are somewhat different from the so-called core NTBs defined originally by UNCTAD (see Bora, Kuwahara, and Laird, 2002). Kee, Nicita, and Olarreaga include Price control measures (TRAINS codes 6100, 6200, and 6300), Quantity restrictions (TRAINS codes 3100, 3200, and 3300), Monopolistic measures (TRAINS code 7000), and Technical regulations (TRAINS code 8100). Interestingly, although technical measures are not fully included in these “core” NTBs (codes 8200 to 8900 are omitted), these AVEs of core NTBs have been used in many investigations of technical measures. The authors derive the AVEs of NTBs from the estimated coefficients of NTBs and given elasticities of import demand from Kee, Nicita, and Olarreaga (2008). Table 2 displays their empirical results. As shown in the table, the aggregate AVEs of NTBs vary between 30% and 50% in most countries. The authors have made their sectoral estimates available through the World Bank’s research department webpage on AVEs of NTBs.

Specifically, Kee, Nicita, and Olarreaga (2009) deploy the following regression equation:

$$\begin{aligned} \ln m_{n,c} - \varepsilon_{n,c}\ln(1+t_{n,c}) &= \alpha_n + \sum_k \alpha_{n,k} C_c^k - \exp(\beta_n^{core} + \sum_k \beta_{n,k}^{core} C_c^k) Core_{n,c} - \\ &\exp(\beta_n^{DS} + \sum_k \beta_{n,k}^{DS} C_c^k)\ln DS_{n,c} + \kappa_{n,c}, \end{aligned} \tag{5}$$

where $m_{n,c}$ denotes the value of import of product *n* in country *c*, $\varepsilon_{n,c}$ is the elasticity of import demand, $t_{n,c}$ is the ad valorem tariff rate, α_n is the product fixed effect, C_c^k captures national characteristics, $Core_{n,c}$ is the NTM variable as measured by frequency index, and $DS_{n,c}$ controls for the degree of domestic support. The estimation of equation (5) is subject to potential endogeneity of NTMs and domestic supports because surging imports tend to induce more protectionist policies (Trefler, 1993). Kee, Nicita, and Olarreaga (2009) use instrumental variables to address the problem. In particular, the authors use GDP-weighted average of NTM (and domestic support) measurements in neighboring countries as the instrument for the NTM (and domestic support) variable in the country of interest.

With the estimated parameters in equation (5), one can derive the AVE of NTMs as:

(6) $ave_{n,c}^{core} = [\exp(\beta_{n,c}^{core}) - 1] / \varepsilon_{n,c}$.

According to equation (6), the AVE of NTMs is higher if the underlying policies impair trade more, or if the import demand is less price elastic.

Table 2. Aggregate AVEs of NTBs by Country

				AVE of	
Country Code	**Country name**	**exp(beta core)-1**	**Beta Domestic Subsidy**	**Core NTBs all lines**	**Core NTB if core NTB=1**
ALB	Albania	-0.008	0	0.007	0.326
ARC	Argentina	-0.112	-0.001	0.1	0.389
AUS	Australia	-0.105	-0.001	0.089	0.416
BFA	Burkina Faso	-0.01	0	0.01	0.448
BCD	Bangladesh	-0.041	0	0.036	0.339
BLR	Belarus	-0.094	0	0.089	0.389
BOL	Bolivia	-0.093	0	0.084	0.458
BRA	Brazil	-0.206	-0.002	0.188	0.428
BRN	Brunei	-0.059	0	0.053	0.399
CAN	Canada	-0.06	-0.002	0.045	0.325
CHE	Switzerland	-0.049	-0.001	0.041	0.29
CHL	Chile	-0.09	0	0.083	0.325
CHN	China	-0.076	0	0.063	0.35
CIV	Cote d'Ivoire	-0.462	0	0.423	0.423
CMR	Cameroon	-0.021	0	0.014	0.299
COL	Colombia	-0.19	-0.003	0.174	0.354
CRI	Costa Rica	-0.007	0	0.006	0.363
CZE	Czech R.	-0.013	-0.001	0.011	0.191
DZA	Algeria	-0.477	0	0.441	0.441
EGY	Egypt	-0.447	0	0.395	0.395
EST	Estonia	-0.009	0	0.007	0.288

ETH	Ethiopia	-0.004	0	0.003	0.482
EUN	European Union	-0.154	-0.008	0.134	0.45
GAB	Gabon	-0.003	0	0.003	0.283
CHA	Ghana	-0.042	0	0.037	0.401
GTM	Guatemala	-0.141	0	0.131	0.375
HKG	Hong Kong	-0.031	0	0.028	0.292
HND	Honduras	-0.001	0	0.001	0.543
HUN	Hungary	-0.069	-0.001	0.059	0.309
IDN	Indonesia	-0.065	0	0.052	0.414
IND	India	-0.185	0	0.147	0.357
ISL	Iceland	-0.033	0	0.026	0.361
]OR	Jordan	-0.214	0	0.202	0.413
JPN	Japan	-0.139	0	0.111	0.346
KAZ	Kazakhstan	-0.117	0	0.107	0.425
KEN	Kenya	-0.011	0	0.009	0.376
LBN	Lebanon	-0.122	0	0.12	0.4
LKA	Sri Lanka	-0.003	0	0.003	0.444
LTU	Lithuania	-0.064	0	0.062	0.373
LVA	Latvia	-0.079	0	0.068	0.398
MAR	Morocco	-0.423	0	0.394	0.394
MDA	Moldova	-0.021	0	0.018	0.359
MDC	Madagascar	-0.005	0	0.005	0.442
MEX	Mexico	-0.219	0	0.193	0.336
MLI	Mali	-0.036	0	0.033	0.458
MUS	Mauritius	-0.079	0	0.075	0.421
MWI	Malawi	-0.026	0	0.023	0.429
MYS	Malaysia	-0.355	0	0.319	0.319
NGA	Nigeria	-0.5	0	0.453	0.453
NIC	Nicaragua	-0.08	0	0.074	0.49
NOR	Norway	-0.068	0	0.059	0.399
NZL	New Zealand	-0.155	0	0.143	0.383
OMN	Oman	-0.066	0	0.058	0.431
PER	Peru	-0.102	-0.008	0.089	0.367
PHL	Philippines	-0.431	0	0.382	0.382
PNG	Papua N. Guinea	-0.049	0	0.042	0.367
POL	Poland	-0.054	-0.001	0.046	0.351
PRY	Paraguay	-0.169	0	0.162	0.482
ROM	Romania	-0.066	0	0.06	0.317
RUS	Russia	-0.183	0	0.155	0.417
RWA	Rwanda	-0.006	0	0.006	0.478
SAU	Saudi Arabia	-0.05	0	0.052	0.337

SON	Sudan	-0.528	0	0.481	0.481
SEN	Senegal	-0.5	0	0.465	0.465
SLV	El Salvador	-0.158	0	0.163	0.443
SVN	Slovenia	-0.161	-0.001	0.148	0.374
THA	Thailand	-0.074	0	0.061	0.386
TTO	Trinidad and T.	-0.036	0	0.032	0.36
TUN	Tunisia	-0.145	-0.001	0.132	0.39
TUR	Turkey	-0.068	0	0.06	0.347
TZA	Tanzania	-0.568	0	0.514	0.514
UGA	Uganda	-0.004	0	0.004	0.482
UKR	Ukraine	-0.075	0	0.069	0.421
URY	Uruguay	-0.226	0	0.206	0.42
USA	United States	-0.108	-0.002	0.095	0.374
VEN	Venezuela	-0.123	-0.001	0.111	0.332
ZAF	South Africa	-0.04	-0.002	0.032	0.33
ZMB	Zambia	-0.021	0	0.019	0.443

Source: Kee, Nicita, and Olarreaga (2009).

The ambitious approach proposed by Kee, Nicita, and Olarreaga (2009) exhibits some drawbacks. Their measurement of NTMs is highly aggregated (see Section 2.1 for more discussions of the frequency indices) and amalgamates technical measures with other measures. Second, the regression equation in Kee, Nicita, and Olarreaga (2009) constrains the role of NTMs to be trade-impeding. Beghin, Disdier, and Marette (2015) have extended the TRI approach of Kee, Nicita, and Olarreaga (2009), as explained in section 1, to allow NTMs to be either trade-facilitating or trade-impeding. They develop AVEs for frequency indices of technical measures. Their results suggest that 39% of product lines affected by these technical measures exhibit negative AVEs, meaning that they facilitate trade.

2.3. Heterogeneity, stringency indices and numeric measurements of NTMs

The comparison or aggregation of different NTMs is a challenging task. NTMs encompass a wide range of policy instruments, ranging from Maximum Residue Limits (MRLs) for chemicals, to hygiene standards in the production process, to labeling and border inspections in the stage of distribution. In spite of the challenge, the economic literature has developed approaches to quantify NTMs according to their policy content. In particular, Winchester et al. (2012) have developed ways to characterize NTMs based on their measurability as shown in table 3. They used data collected for a database on NTMs in the EU, USA, Canada, Japan, China, India, Brazil, Argentina, Australia, Russia, and New Zealand by an EU-funded project, the NTM Impact project.

Table 3. Measurability of NTMs

	Binary	Ordered	Quantitative
Type of measure	Rule based calculation	Rank based qualitative or quantitative information	Numerical elements
Example	EU regulates (1) and Australia does not regulate (0)	(1) Argentina bans a product, (2) EU has a regulation of 2 ppm, and (3) China has no regulation.	Maximum residue levels of a specific substance for a specific product

Source: Winchester et al. (2012).

As shown in table 3, an NTM without detailed description can be captured by a binary variable, which takes the value of one if an NTM exists and zero otherwise. An ordered variable can be deployed to measure an NTM with qualitative information on its restrictiveness. A numeric measure is appropriate to capture an NTM containing parameter information such as allowable pesticide residues.

As an attempt to compare NTMs across regions, Winchester et al. (2012) propose a heterogeneity index to capture the divergence of NTMs between trading partners. Specifically, the index is a simple aggregation of regulatory difference at the product level, which is measured by the distance between the NTM variable in the importing country and that in the exporting country. Distance is normalized by the range of the NTM variable so that different types of NTMs can be compared on the same scale. Formally, the index is defined as the (dis)similarity of requirements *i* between importing country *d* and exporting country *o* aggregated over all policies being considered, and computed for the exporting country. This can be calculated as:

$$(7)\ \ HIT_{do} = \sum_{i=1}^{n} DS_{ido}^{HIT} ,$$

with DS_{ido}^{HIT} being a (dis)similarity measure for each policy being considered and defined as:

$$(8)\ \ DS_{ido}^{HIT} = \frac{\left| x_{id} - x_{io} \right|}{\max\left(x_i\right) - \min\left(x_i\right)} .$$

Variable x_i is the observation on requirement *i* (which may be binary, ordered, or quantitative information),[7] and max(x_i) and min(x_i) are, respectively, the maximum and minimum value for requirement *i* across all countries considered. The dissimilarity measure scales the difference for requirement *i* between the exporting and the importing countries by the range of differences over all countries examined. A variation on this index is an asymmetric version accounting for the sign of the numerator. More stringency in the destination market may potentially hurt trade from a less stringent origin, whereas the opposite does not.

The heterogeneity index is particularly appealing when analyzing the potential harmonization of NTMs between trading partners, because the index reduces to zero if trading partners endorse the same set of NTMs. The maximum value of the index is one. The index can then be used as a determinant in econometric investigations of bilateral trade flows.

Next, we review an international case study of MRLs governing pesticides and veterinary drugs in agriculture (Li and Beghin, 2014). The MRLs in agriculture are of great interest for two reasons. First, excessive pesticide residue is a major issue constraining agricultural exports in the developing world. For instance, Xiong and Beghin (2014) show that MRLs adopted by high-income countries tend to marginalize plant product exporters in developing countries.[8] Second,

[7] Dissimilarity based on ordinal ranks is calculated using a Podani modification of the Gower index (Podani, 1999).
[8] In a case study of tea trade, Xiong (forthcoming) further documents that pesticide residues exceeding MRLs is the top reason for tea imports to be rejected at U.S. customs.

the numeric information contained in MRLs can be readily used to evaluate the stringency of the regulatory regime.

In particular, Li and Beghin (2014) compile MRLs affecting 273 products across 77 nations in 2012.[9] To assess the regulatory restrictiveness at the product level in each country, the authors define the following stringency index:

$$S_{ij} = \sum_{k=1}^{K} \exp((MRL_{jk}^{c} - MRL_{ijk}) / MRL_{jk}^{c}) / K \, , \quad (9)$$

where *i* refers to a nation, *j* designates a product, *k* denotes a substance (pesticide or veterinary drug) applicable to the product, MRL_{ijk} is the prescribed MRL for substance *k* in product *j* in country i , and MRL_{jk}^{c} is the MRL set by Codex for substance *k* in product *j*. The exponential transformation in equation (9) expresses convex cost of meeting increasing stringency. Other weighing schemes are possible. Intuitively, the MRL stringency index defined by equation (9) measures the percentage deviation of national MRLs from international counterparts, averaged across all hazardous substances. In particular, the index takes the value of one if a nation is fully aligned with Codex. A higher index corresponds to a more restrictive regime. Furthermore, one can construct the MRL stringency index at the country level by averaging the indices across all products (with import shares as the weights). Figure 11 shows the MRL stringency indices across nations. Stringency indices can also be developed in absence of international standards using a variation of the asymmetric HIT index of Winchester et al. (see Ferro, Otsuki, and Wilson, 2015). Aggregate stringency indices at the country level are useful to characterize a county's regulatory regime. At the commodity level they can be used as a determinant of bilateral trade flows in econometric investigations (de Faria and Wieck, 2015; Xiong, forthcoming; Xiong and Beghin, 2014; Ferro, Otsuki, and Wilson, 2015).

---

[9] The global MRL information is available from the Global MRL Database at https://www.globalmrl.com/.

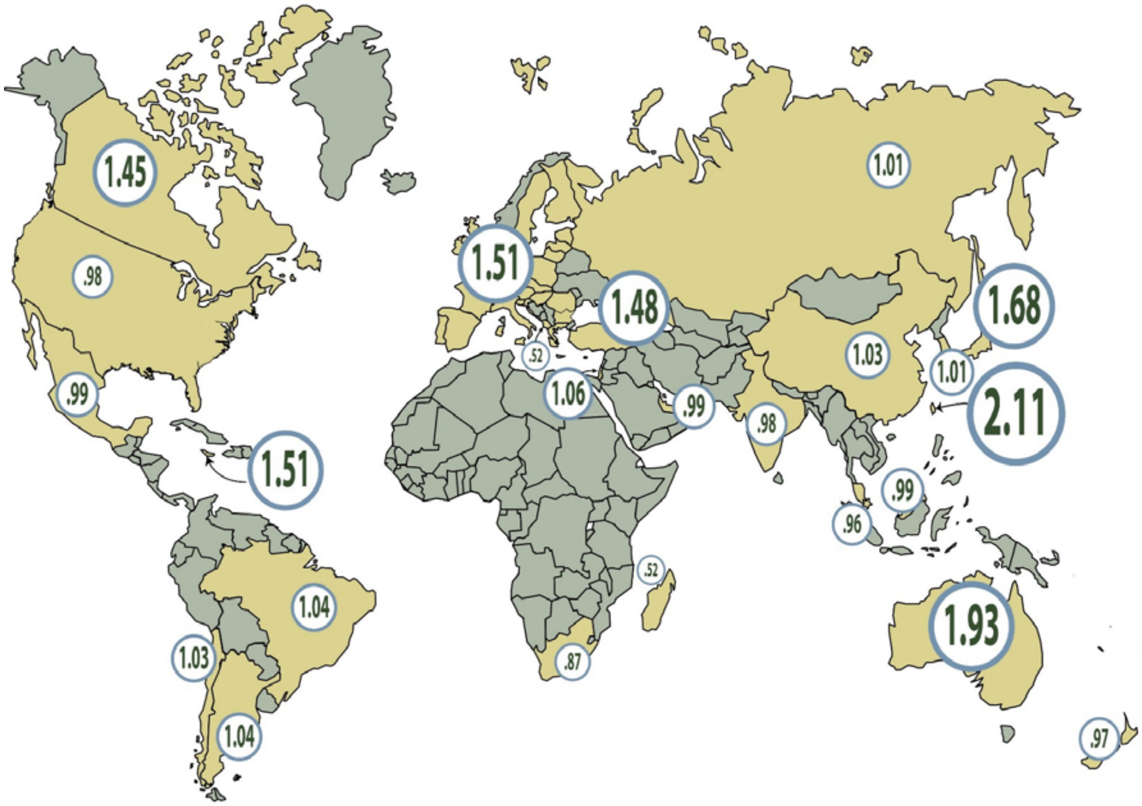

Figure 11. MRL stringency index by country, 2012.

Map source: Beghin (2014); data source: Li and Beghin (2014).

MRL stringency index	
Country	(Equal weight across products) Protectionism Indices All MRLs
Taiwan	2.11 (0.47)
Australia	1.93 (0.57)
Japan	1.68 (0.76)
Jamaica	1.51 (0.57)
European Union	1.51 (0.57)
Turkey	1.48 (0.55)
Canada	1.45 (0.49)
Israel	1.06 (0.21)
Brazil	1.04 (0.12)
Argentina	1.04 (0.11)
Chile	1.03 (0.14)
Russian Federation	1.03 (0.10)
Rep. of Korea	1.01 (0.15)
China	1.01 (0.05)
Malaysia	0.99 (0.04)
Unit. Arab Emirates	0.99 (0.03)
Mexico	0.99 (0.36)
United States	0.98 (0.36)
India	0.98 (0.13)
New Zealand	0.97 (0.06)
Singapore	0.96 (0.13)
South Africa	0.87 (0.14)
Sri Lanka	0.52 (0.20)
Albania	0.52 (0.20)

As shown in Figure 11 and the associated table of stringency indices, developed markets such as the EU, Canada, Japan, and Australia implement MRLs that are more stringent than Codex recommendations. In contrast, developing nations generally adopt MRLs either close to or more lenient than the international standards.

While the stringency index of Li and Beghin provides a useful assessment of the MRL regime relative to Codex, the measurement has several limitations. First, the index only accounts for hazardous substances regulated by both the Codex and individual nations. Certain chemicals can be monitored by individual countries but absent from Codex due to the lack of scientific evidence or consensus. Ferro, Otsuki, and Wilson overcome this problem as noted previously. Second, all these indices, by averaging across all hazardous substances, could be assigning low weights to chemicals intensively applied in certain regions of the world. The weights to be used in the aggregation are an unsettled issue.

2.4. Measures of NTM transparency and harmonization

"Deep integration" has been taking place under a multitude of RTAs in the last quarter of a century. Trade partners in these RTAs have attempted to adopt more transparent and harmonized regulatory regimes. In parallel, measures of NTM deep integration (transparency and harmonization or regulatory reciprocity) have emerged in the applied economic literature (Henry de Frahan and Vancauteren, 2006; Vancauteren, 2013; Vancauteren and Henry de Frahan, 2011; Cadot and Gourdon, 2016; Lejárraga and Shepherd, 2013; Lejárraga, Shepherd, and van Tongeren, 2013). Transparency is surprisingly opaque, but harmonization is much less so. Transparency is multidimensional. It centers on reducing uncertainty, on simplification, and increasing predictability of the regulatory process at the border (rules of origin, conformity certification) in disputes and inspection, among others. Several authors (Lejárraga and Shepherd, 2013; Lejárraga et al., 2013; Cadot and Gourdon, 2016) look at the presence of transparency provisions in RTAs, and their scope in an extensive series of trade agreements. They develop a series of count variables of transparency procedures in trade agreements or in sub-chapters of RTAs like on SPS and TBTs, rules of origin, dispute settlements, and reciprocity of conformity assessment. They also use a series of dummy variables to indicate the presence of transparency chapters in RTAs, reciprocity clauses, or harmonization clauses in RTAs.

Other authors look at “revealed transparency” by using metrics on the ease of doing business, the absence of bribery, and other trade facilitation measures (Turnes and Ernst, 2015). The latter metrics are well known and available from several sources (the World Bank ease of doing business indicators and for the quality of regulatory system and anti-corruption measures under the “Global Governance Indicators”). Other reputable sources exist for corruption indicators, such as Transparency International UK. Among the ease of doing business, the indicators related to trading across borders are the most relevant ones. These trade indicators are available for a panel of countries over time and are expressed as continuous variables for both import and export transactions (time or cost required to complete a trade transaction). Hence, their use appears promising. In addition, in business data, the indicators on “enforcing contracts” are also relevant as they gauge the quality of institution to resolve disputes. The drawback of these economy-wide indicators is that they substitute for country-fixed effects and are not specific to sectors or goods. Hence, they do not provide sectoral variation which would be wanted in a disaggregated econometric investigation.

Harmonization and reciprocity in regulation are first captured by noting which policy or regulations have been harmonized or are under reciprocal recognition within a custom union (Vancauteren, 2013; Vancauteren and Henry de Frahan, 2011) or in RTAs (Cadot and Gourdon 2016; Blind et al., 2013). Other analysts have used “revealed” harmonization measures by looking at a lack of harmonization for specific policies with departures from international or regional standards (Czubala, Shepherd, and Wilson, 2009; Xiong, forthcoming).

Further, some investigations measure the lack of harmonization developing “regulatory” distance metrics by looking at the heterogeneity of policy instruments and within instruments the stringency of the regulation. These distance measures are in a similar spirit of the heterogeneity indices discussed in section 2.3 and the separation between heterogeneity and harmonization is admittedly somewhat arbitrary. They differ by their range of policies considered by the type of normalizations and weights to aggregate them. For example, Cadot et al. (2015) use averages of dichotomic measures of sharing similar policy instruments, or no aggregated policies, and/or goods. They rely on the new Trains database previously mentioned. The advantage of their measure is the flexibility in aggregation. They can generate sector-specific distances that are useful for disaggregated trade analysis.

Disdier, Fontagné, and Cadot (2014) capture the presence or absence of harmonization of NTM regulation in economic integration agreements between North-South and within South or within North. Looking at bilateral trade flows, the latter authors use dummy variables to indicate when any of the two countries is a member of an RTA, and conditioned on that, if the RTA includes TBT integration, harmonization to regional or international standards, and if countries harmonize up to more stringent standards or down to lower standards.

These measures of transparency and harmonization can then be used in investigations of determinants of bilateral trade flows at various aggregation levels (sectoral at different HS levels, aggregate trade). The other application beyond trade flows is that of Cadot and Gourdon (2016), previously mentioned in section 2.2. It looks at the impact that “deep integration” has on AVE estimates of NTMs using price wedge data. Not all these policies matter equally to facilitate trade and reduce price wedges. Hence, sorting out those measures that matter most is a worthwhile task.

3. Approaches to assess the impact of NTMs on trade and welfare

In this section, we review empirical approaches to evaluate the effects of NTMs on international trade and social welfare. In section 3.1, we provide two case studies using the gravity equation approach to determine the trade effects of NTMs. In particular, one study investigates the impact of MRLs on trade in plant products; the other assesses the trade effect of NTMs relative to other domestic and trade policies. In section 3.2, we review a partial equilibrium analysis that accounts for both the market impact of NTM policies and external effects influenced by these NTMs. A general equilibrium analysis of welfare effects of NTMs follows in section 3.3.[10]

3.1. Modeling trade flows with gravity equations featuring NTM variables

The gravity equation model is a prominent tool in empirical studies of international trade. The model posits that bilateral trade flow can be explained by characteristics of the importing country, characteristics of the exporting country, and various trade costs pertaining to the bilateral partnership. In particular, the trade costs include fixed costs such as certification and licensing, transportation costs (usually measured by the distance between the trading partners), tariff schemes, cultural similarity, linguistic difference, historical ties, and NTMs. In particular, we review two papers that econometrically estimate the impact of NTMs on international trade.

3.1.1. <u>MRLs on pesticides and trade in plant products</u>

Xiong and Beghin (2014) deploy an augmented gravity equation model to quantify the effect of MRLs on plant product imports in high-income countries. Specifically, the authors improve upon the standard gravity equation model by explicitly capturing the role of MRLs in enhancing import demand (via addressing informational issues or lowering health risks). In particular, the regression equation is specified as:

$$\begin{aligned}\ln(T_{sijt}) = (1-\varphi)Q_{sit} - \theta\ln(1+tar_{sij}) - \theta b_d \ln(1+dist_{ij}) + \theta b_l Lang_{ij} + \theta b_b Bord_{ij} + \theta b_c Col_{ij} \\ -\theta\gamma\max\{MRL_{sjt} - MRL_{sit}, 0\} + \theta\beta MRL_{sjt} + fe_{jt} + fe_{hit} + \varepsilon_{sijt},\end{aligned} \tag{10}$$

where T_{sijt} is the trade value of product *s* from the exporting country *i* to the importing country *j* in year *t*, Q_{sit} is the supply of product *s* in country *i* in year *t*, tar_{sij} is the tariff rate, $dist_{ij}$ is the

[10] The economic development literature addresses the implication of NTMs for labor markets, export performance and welfare in developing countries using micro-data based approaches (e.g., Maertens and Swinnen 2009). See Beghin, Maertens and Swinnen (2015) for a review of these effects.

geographical distance, $Lang_{ij}$ is the common language dummy variable, $Bord_{ij}$ is the common border indicator, Col_{ij} is the historical tie dummy variable, fe_{jt} is the time-varying fixed effect in the importing market, and fe_{hit} is sectoral fixed effect in the exporting country. Note that the variable $\max\{MRL_{sjt} - MRL_{sit}, 0\}$ captures the cost of trade associated with more stringent MRLs in the importing country relative to those in the exporting country, and the variable MRL_{sjt} captures the potential demand-enhancing effect of MRLs in the importing market brought by stringent MRLs.

Xiong and Beghin use the stringency indices in Li and Beghin (2014) as the measurements of MRL restrictiveness (recall section 2.3). The authors identify 61 exporting countries, 20 high-income importing countries, and the associated bilateral trade records in 2007, 2008, 2011, and 2012 of 109 plant products at either the four-digit or six-digit level of the Harmonized System classification. In terms of the estimation strategy, the authors implement the Heckman two-step procedure to address the absence of trade, due to prohibitive costs implied by NTMs or other barriers, and report the effects of MRLs along both the intensive margin of trade (or the change in the volume of trade) and the extensive margin of trade (or the change in the decision to trade). Table 4 displays the empirical results.

As shown in Table 4, MRL stringency enhances the demand in the importing market on one hand and imposes additional costs on exporters of plant products on the other. The net effect is positive is this particular case study, suggesting that NTMs are not necessarily barriers to international trade. Table 4 also indicates that, relative to their competitors in the developed nations, plant product exporters from developing nations benefit less from the demand enhancement but suffer more from the implied costs. From a policy perspective, this finding calls for development strategies to further engage agricultural exporters from developing countries as

NTMs proliferate in developed countries.

Table 4. Marginal effects of MRLs on imports of plant products

Table 4. Marginal effects of MRLs on imports of plant products

	South-to-North		North-to-North	
	Intensive Margin	Extensive Margin	Intensive Margin	Extensive Margin
Demand-enhancing Effect	0.745***	0.334	0.928***	0.473
	(0.068)	(0.464)	(0.084)	(0.375)
Trade-cost Effect	-0.421***	-0.020	-0.259***	-0.078
	(0.077)	(0.057)	(0.093)	(0.078)
H_0: zero net effect of importer's MRLs				
P value	0.000	0.000	0.000	0.000

Note: Marginal effects are computed as the averages of marginal effects for individual observations. Standard errors in parenthesis are derived from the Delta method. Notations *, **, and *** denote significance levels at 0.1, 0.05, and 0.01 respectively.
Source: Xiong and Beghin (2014).

3.1.2. <u>The trade effect of NTMs relative to other domestic and trade policies</u>

Hoekman and Nicita (2011) investigate the trade effect of NTMs relative to other policies affecting international trade. In particular, the authors account for conventional trade policies such as tariffs and preferential trade agreements, as well as domestic policies such as administrative burdens faced by businesses and the quality of infrastructure in the importing and exporting markets.

Specifically, Hoekman and Nicita (2011) compile bilateral trade records among 105 countries in 2006. The NTMs are measured by frequency indices as in Kee, Nicita, and Olarreaga (2009). The authors also propose a relative preferential margin (RPM) to characterize the preferential treatments enjoyed by exporters in a given country relative to their competitors elsewhere. In addition, the authors use the Doing Business index to capture the administrative costs pertaining to import or export activities.[11] Finally, the authors deploy the Logistic

[11] The index measures the fees associated with the compliance with procedures to export or import a 20-foot container. Data is available at http://www.doingbusiness.org/.

Performance Index from the World Bank Indicator to represent the behind-the-border costs faced by exporters and importers.

Hoekman and Nicita (2011) estimate the gravity equation model via the Poisson Pseudo Maximum Likelihood (PPML) method proposed by Silva and Tenreyro (2006). The PPML approach allows frequent zero trade records and has been shown to be robust to different patterns of heteroscedasticity. Controlling for other factors such as market sizes, other national characteristics, and geographical and cultural factors pertaining to the bilateral partnership, the reported trade effects of various policies are shown in table 5 across several estimation methods.

Table 5. Impacts of Various Policies and Trade Costs on Trade in Developing Countries

	0LS	PPML	NBREG	ZIP	ZINB
Trade policy tariff (log)	0.315***	0.198**	0.312***	0.197***	0.299***
	0.025	*0.044*	*0.035*	*0.044*	*0.032*
Trade policy NTB (log)	0.03	0.146***	0.053*	0.146***	0.054**
	0.025	*0.046*	*0.028*	*0.046*	*0.026*
Trade policy RPM (index)	0.016*	0.027***	0.023**	0.027***	0.025**
	0.01	*0.008*	*0.01*	*0.008*	*0.01*
DB Import Costs (log)	0.098*	0.324***	0.240***	0.326***	0.245***
	0.057	*0.094*	*0.078*	*0.094*	*0.07*
DB Export Costs (log)	0.394***	0.222**	0.201***	0.224**	0.168***
	0.057	*0.096*	*0.07*	*0.096*	*0.065*
LPI importer (index)	0.357***	0.408***	0.279**	0.403***	0.300***
	0.083	*0.149*	*0.109*	*0.149*	*0.1*
LPI exporter (index)	1.182***	0.701***	0.135	0.695***	0.15
	0.087	*0.15*	*0.108*	*0.15*	*0.101*
Standard errors are in italics					
* Signi?cance level of 10%.					
** Signi?cance level of 5%.					
*** Signi?cance level of 1%.					

Source: Hoekman and Nicita (2011), their table 7.

As shown in Table 5, imports of developing countries are significantly constrained by tariffs, NTB/NTMs, administrative costs (as represented by the Doing Business variable), and internal costs from poor logistics (logistics quality is represented by the Logistic Performance Index, hence the positive sign). The authors look at the impact of economic development on poor countries when they become middle-income countries with the implied reduction in trade costs and improvements in infrastructure and business climate. Reductions in domestic impediments have as much importance as reducing trade barriers at the border. The exports of developing nations are more impeded by tariffs and low quality of infrastructure than by other policies. This provides an interesting context to the impact of NTM/NTBs on trade. The finding suggests that lowering the domestic costs pertaining to trade activities is as important as improving market access worldwide.

These two authors also compute mercantilist TRIs as shown in equation (A6) in the Annex, but simplified as in Feenstra (1995), focusing on own-price effects and zeroing cross-price effects (see Kee Nicita and Olarreaga equation (18) for the empirical formula used). The MTRI provides a scalar measure of the aggregate trade impact of these various NTMs and tariffs in all sectors. They show that developing countries tend to have distortions penalizing trade in agriculture relatively more than trade in manufacturing products. NTMs dominate the trade impact of tariffs in many countries and most sectors.

3.2. Welfare analysis with the partial equilibrium approach

The welfare effects discussed at the beginning of section 1 are often evaluated quantitatively by calibrating relatively simple partial equilibrium models to implement policy scenarios in which policies such as NTMs are removed. The removal of these NTMs induce changes in domestic demand, supply, trade flows, potential external effects and tax revenues which are needed to characterize welfare effects. The benefit of using such a simple framework is that the policy characterization can be richer and more detailed than in a large-scale model. That is the tradeoff often faced by policy analysts.

Peterson and Orden (2008) provide a well-executed welfare analysis of changes in various phytosanitary trade policies within NAFTA affecting avocado trade between Mexico and the

United States. They characterize the consumer in the importing country with CES preferences for avocados from different sources. The welfare of the consumer is characterized by the equivalent variation metric. Production of avocados is characterized by a CET frontier that can shift inward if a pest infestation from weevils and fruit flies arises. That is the potential externality which could be brought by imported avocados. The expected frequency of pest outbreaks is represented by a product of probabilities of various failures in the system (presence of pest in imports, non detection at packing, survival of the pest in transport, non detection at the border, etc.) scaled by the volume of imports. Domestic producers can control the various pests at a cost. The producers' welfare is estimated by using producer surplus inclusive of pest control and loss of productivity with pest outbreaks. Mexican exporters can comply with the SPS measures imposed by the United States at some cost of compliance. Chilean avocados are also imported but are not potential vector of pest infestation.

Once fully specified, the model is calibrated using price and quantity data from 2005–06 and consensus price elasticities and technical parameters. The model replicates the base year data. Typically in these modeling exercises, there are enough undetermined "free" parameters to replicate actual baseline data. The model is then used to simulate alternative states of the world with policy changes. Import restrictions parametrized in the model are removed and the model traces the impact of the policy removal on all endogenous variables (prices, quantities, trade, expected pest outbreaks, and associated compliance cost, control cost, and welfare).

Results from the simulation are shown in table 6. The table shows what happens to avocado producers in California, Chile, and Mexico and to consumers under three scenarios, which show increasingly lax SPS regulatory systems in the United States, and hence, lower compliance cost for Mexican suppliers and lower consumer prices from these cheaper imports. However, higher pest outbreaks and associated costs are also implied by these more lax regimes. Domestic producer prices and welfare are affected negatively by the competition from increased Mexican imports. Net welfare increases in all scenarios and risk environments. However under “high risk” of pest case, the laxest regime is far from being the welfare maximizing one.

Table 6. Welfare impacts of SPS policy changes under average and high pest risk

	Scenario 1		Scenario 2		Scenario 3	
scenario	Average Risk	High Risk	Average Risk	High Risk	Average Risk	High Risk
Welfare effects						
Producer surplus						
California	−76.269	−76.401	−76.763	−76.902	−81.586	−102.127
Chile	−16.848	−16.844	−17.002	−16.998	−17.551	−16.998
Mexico	5.093	5.094	5.302	5.302	6.236	6.351
U.S. equivalent variation	153.721	153.646	156.915	156.836	168.441	156.441
Other fruit fly costs	8.0E−06	7.8E−05	0.002	0.016	0.029	0.244
Net U.S. welfare change	77.452	77.245	80.15	79.918	86.826	54.069

Source: Peterson and Orden (2008), their table 4.

Beyond this investigation by Peterson and Orden, many of these partial equilibrium analyses of NTM regimes share common characteristics. They are simple but can easily incorporate specific and detailed characterizations of NTM policies, trade costs, and institutions. For example, Van Tongeren, Beghin, and Marette (2009) develop a simple calibrated partial equilibrium model to undertake a cost-benefit analysis of mandatory labelling of fish consumption in France. They evaluate the impact of a label providing health information influencing consumer choice between types of fish exhibiting different levels of health risk from heavy metals and also offering some health benefits from omega fats. The policies have some trade consequences when they affect the mix of fish types consumed. They use results from a laboratory choice experiment that elicited consumer valuation, especially from pregnant women for the healthy and risky attributes. Consumers vary by level of concern for health effects. The welfare analysis includes consumer surplus, and profits of two supply chains for sardine and tuna.

These simple PE models can also incorporate quality differences in a more subtle way than larger models. Welfare effects are typically smaller than in large models because one looks at one or a few markets. This can be deceptive at first glance. These partial equilibrium models are also versatile and can be changed and recalibrated easily and many scenarios can be investigated. Larger models tend involve heavier lifting, so to speak.

3.3. Welfare analysis with general equilibrium model approach

The Annex introduces the general equilibrium approach to measuring welfare effects of technical measures and other distortions in a small, open, distorted economy and generalizes the discussion of section 1.1 on welfare analysis using Marshallian surpluses. The TRI is a welfare metric providing a tariff scalar measure equivalent to the distortive effects of various distortions in an economy while holding welfare at the same level. At a basic level, the TRI captures triangles of deadweight losses created by the various distortions impacting trade flows. Kee, Nicita, and Olarreaga (2009) use their ad valorem equivalent estimates of NTBs to compute TRIs for tariffs, domestic policies, and NTBs for a series of countries. We already reviewed these ad valorem equivalents of NTBs in sub-section 2.2.2 and showed the formula in equation (6) above. Their estimates of NTB AVEs abstract from the facts that technical measures could help mitigate some market imperfections and could enhance trade. Hence, all AVEs are positive. To implement their TRI estimates they use Feenstra's (1995) approximation to the TRI. It restricts cross-price effects to zero and focuses instead on own-price effects of tariffs, AVE of NTMs, and AVEs of domestic subsidies on resource allocation. It then aggregates the dead weight losses of these policies over all *n* sectors following the formula:

$$. \quad T_c = \left(\frac{\sum_n (\partial m_{nc} / \partial p_{nc})(\tau_{n,c} + AVE_{n,c}^{NTM} \quad + AVE_{n,c}^{s})^2}{\sum_n (\partial m_{nc} / \partial p_{nc})} \right)^{1/2} \quad (11).$$

In some sense this simplification is partial equilibrium approximation of a full blown general-equilibrium TRI because intermarket effects are not accounted for.[12] The advantage of this approximation is that it reduces the number of required elasticity estimates to the own-price estimates.

The approximation still aggregates the cumulative effect of various policies on resource allocation in each sector and then provides an estimate of the overall welfare effects summing up over all sectors.

The TRI estimates obtained by Kee, Nicita, and Olarreaga are shown in table 7 for a subset of countries. The table also shows mercantilist TRI (denoted OTRI) and market access TRIs faced by exporters to the listed country (denoted MA-TRI). We abstract from these trade effects as we have discussed trade effects in section 3.1.

As the table 8 shows, unsurprisingly, the welfare effect of all distortions is larger than the effects of tariffs. The interesting aspect is the heterogeneity in the magnitudes across countries for both the tariff TRI and for the overall TRI for all distortions.

[12] With a few additional assumptions on preferences and production, it is possible to generate minimum compensated import price responses to account for some cross-price effects in the TRI (see Beghin, Bureau, and Park, 2003).

Table 7. TRIs for Tariffs and NTBs

Trade Restrictiveness Indices							
		Tariffs only			Tariffs & NTBs		
Country code	country name	OTRI	MA-OTRI	TRI	OTRI	MA-OTRI	TRI
ALB	Albania	0.118	0.022	0.134	0.124	0.34	0.15
		-0.002	-0.005	-0.001	-0.004	-0.076	-0.013
ARG	Argentina	0.13	0.064	0.142	0.181	0.275	0.279
		-0.002	-0.004	-0.002	-0.024	-0.029	-0.037
AUS	Australia	0.061	0.095	0.099	0.119	0.147	0.2. 0
		-0.004	-0.023	-0.006	-0.02	-0.037	-0.03
BFA	urkina Fas	0.107	0.029	0.123	0.158	0.121	0.268
		0	-0.009	0	-0.014	-0.024	-0.035
BGD	Bangladesh	0.179	0.028	0.227	0.255	0.346	0.399
		-0.005	0	-0.005	-0.022	-0.036	-0.036
BLR	Belarus	0.086	0.051	0.109	0.168	0.101	0.312
		-0.001	-0.004	-0.001	-0.008	-0.017	-0.016
BOL	Bolivia	0.08	0.011	0.086	0.148	0.122	0.272
		-0.003	-0.005	-0.002	-0.022	-0.03	-0.033
BRA	Brazil	0.106	0.073	0.131	0.27	0.149	0.497
		-0.003	-0.004	-0.004	-0.023	-0.025	-0.03
BRN	Brunei	0.13	0.018	0.551	0.185	0.056	0.596
		-0.008	-0.001	-0.027	-0.016	-0.013	-0.032
CAN	Canada	0.029	0.028	0.076	0.063	0.072	0.191
		-0.001	-0.007	-0.003	-0.009	-0.023	-0.037
CHE	Switzerland	0.04	0.027	0.175	0.067	0.066	0.247
		-0.004	-0.004	-0.018	-0.009	-0.036	-0.016
CHL	Chile	0.069	0.022	0.069	0.11	0.158	0.202
		0	-0.001	0	-0.01	-0.026	-0.02
CHN	China	0.14	0.024	0.211	0.204	0.066	0.343
		-0.005	0	-0.011	-0.02	-0.01	-0.028
CIV	ote d'Ivoir	0.095	0.029	0.119	0.315	0.263	0.495
		-0.005	-0.003	-0.005	-0.046	-0.052	-0.044
CMR	Cameroon	0.14	0.032	0.161	0.164	0.138	0.224
		-0.005	-0.002	-0.006	-0.008	-0.027	-0.026
COL	Colombia	0.114	0.046	0.134	0.249	0.132	0.456
		-0.003	-0.01	-0.004	-0.025	-0.031	-0.049
CRI	Costa Rica	0.048	0.079	0.079	0.05	0.202	0.087
		-0.001	-0.007	-0.004	-0.007	-0.049	-0.024
CZE	Czech Rep.	0.043	0.012	0.064	0.049	0.027	0.094
		-0.001	-0.002	-0.001	-0.002	-0.005	-0.015
DZA	Algeria	0.131	0.002	0.161	0.392	0.002	0.557
		-0.002	0	-0.002	-0.03	-0.001	-0.03
EGY	Egypt	0.129	0.026	0.224	0.411	0.088	0.586
		-0.003	-0.003	-0.006	-0.035	-0.015	-0.032
EST	Estonia	0.009	0.018	0.049	0.024	0.064	0.132
		0	-0.002	-0.001	-0.006	-0.009	0.025)
ETH	Ethiopia	0.139	0.036	0.185	0.151	0.49	0.222
		-0.004	-0.012	-0.005	-0.01	-0.089	-0.025
EUN	ropean Uni	0.017	0.028	0.078	0.079	0.086	0.406
		-0.001	-0.002	-0.006	-0.011	-0.014	-0.036
GAB	Gabon	0.155	0.002	0.178	0.155	0.003	0.178
		-0.001	0	-0.001	-0.009	-0.003	-0.022
GHA	Ghana	0.145	0.017	0.247	0.178	0.321	0.296
		-0.003	-0.007	-0.004	-0.012	-0.062	-0.026
GTM	Guatemala	0.07	0.049	0.098	0.18	0.349	0.356
		-0.001	-0.014	-0.001	-0.021	-0.084	-0.029
HKG	Hong Kong	0	0.054	0	0.017	0.174	0.122
		0	-0.001	0	-0.005	-0.025	-0.017

Source: Kee, Nicita, Olarreaga (2009), their table 4.

Table 8 summarizes the NTM measures and methodologies to assess trade and welfare effects reviewed in sections 2 and 3.

Table 8: Summary of the Literature Reviewed on NTMs and Their Trade and Welfare Effects

Focus and approach	Strengths / weaknesses	Examples
Measures of NTMS		
Index of heterogeneity and stringency of MRLs	Stringency difficult if no international standard; can quantify protectionist countries; limited coverage of NTM types	Winchester et al. (2012); Li and Beghin (2014); de Faria and Wieck; Ferro et al. (2015)
Frequency and coverage ratios of NTMs	All NTMs treated alike; frequency ratios forego variation; exists for a large set of countries, new MAST data set allows to disaggregate by type of measure; good for stylized facts (sectors, measure types)	Nicita and Gourdon (2013); Kee et al. (2009); Beghin et al. (2015)
AVEs of NTMs	Based on frequency measures of core NTMs; use older data; all NTMs within a country have a similar effect; New approach allows for negative AVEs of NTMs	Kee et al. 2009; Beghin et al. 2015
Price wedge measure	Actual price data; uses new MAST dataset and RTA dataset; looks at deep integration	Cadot and Gourdon (2016); Cadot et al. (2015);
Transparency measures ; harmonization		Lejarraga and Shepherd (2013); Lejarraga et al. (2013); Disdier et al. (2014); Czubala et al. (2009); Vancauteren and de Frahan (2011); Vancauteren (2013)
Estimates of NTM impact on bilateral trade across nations and welfare		
Large econometric studies using panel or cross sections of countries, many sectors, using simple proxies of total NTM regimes in gravity-type models	Many abstract from market imperfections; recent investigations allow for trade enhancing effects and separate supply and demand shifts. includes and identifies several sources of trade costs (tariffs, distance, other trade costs) broad brush; Mixed evidence on NTM trade cost; traditionally could explain why estimated NTM could be trade-enhancing, a regular finding Various proxies used for NTM regime Some derive TRI and MTRI measures	Econometric: Hoekman and Nicita (2011); Kee et al. 2009; Li and Beghin (2012); Beghin et al. (forthcoming);

4. Conclusions

In this paper, we reviewed various methodologies developed by economists to quantify NTMs and evaluate their impacts on international trade and social welfare. The economic analyses of NTMs call for advanced approaches because NTMs differ from tariffs in three major aspects. First, NTMs contain a large set of policy instruments, ranging from border control measures, to marketing requirements, to product or process standards. Second, some NTMs affect stakeholders on both sides of the market and therefore bear complex implications for trade and welfare. Third, certain NTMs serve public objectives such as risk mitigation and environmental sustainability that are not fully reflected in market forces.

We first presented a simple economic framework to conceptualize the above-mentioned complexity of NTMs and their effects on demand, supply, prices, trade, and welfare. We then reviewed several empirical approaches that quantify NTMs and their characteristics such as transparency of regulatory regimes and also those that translate NTMs into tariff or subsidy equivalents. We also review prominent econometric and simulation-based methods to assess the trade and welfare effects of NTMs.

We have highlighted the advantages and drawbacks of the various measures and approaches and the progress made to better investigate these technical measures. The recent analysis of deep integration and its interface on technical measures and regulatory regimes is a major development. The increasing recognition is that market imperfections may exist and that some technical measures do improve welfare and allocative efficiency. It is an important milestone. The policy debate has shifted to discussing what NTMs to keep and how to streamline NTM regimes rather than dismissing them as simple trade barriers. Still sorting out good and bad NTMs requires careful analyses and characterization of these regimes. This characterization of technical measures remains difficult and future research perfecting the characterization of NTMs and allowing for more meaningful aggregation of these NTMs will be influential if successful. Most econometric analyses suffer from omitted variable problems because they only use incomplete characterization of NTM regimes or sub-regimes such as some specific SPS or TBT measures. The new database collected for the MAST project appears promising in that regard.

Reference

Anderson, J.E., G.J. Bannister, and J. P. Neary. (1995) "Domestic distortions and international trade." *International Economic Review* (1995): 139-157.

Beghin, J.C., J.C. Bureau, and S.J. Park. (2003). "Food security and agricultural protection in South Korea." *American Journal of Agricultural Economics* 85.3 (2003): 618-632.

Beghin, J.C., A.C. Disdier, and S. Marette. (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.

Beghin, J.C., M. Maertens, and J.F.M. Swinnen. (2015). “Nontariff Measures & Standards in Trade & Global Value Chains." *Annual Review of Resource Economics* 7 (2015): 425-450.

Beghin, J.C. 2014. “The Protectionism of Food Safety Standards in International Agricultural Trade”. *Agricultural Policy Review,* Winter 2014: 7 & 9.

Cadot, O., A. Asprilla, J. Gourdon, C. Knebel, and R.Peters. (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).

Cadot, O., and J. Gourdon. (2016). “Non-tariff measures, preferential trade agreements, and prices: new evidence.” *Review of World Economics* 152: 227-249.

Czubala, W., B. Shepherd, and J.S. Wilson. (2009). Help or Hindrance? The Impact of Harmonised Standards on African Exports. *Journal of African Economies*, 18(5): 711-744.

de Faria, R. N., and C. Wieck. (2015). "Empirical evidence on the trade impact of asynchronous regulatory approval of new GMO events." *Food Policy* 53: 22-32.

Disdier, A.C., L. Fontagné, and O. Cadot. (2014). "North-South standards harmonization and international trade." *The World Bank Economic Review*: 29.2 (2015): 327-352

Disdier, A. C., and S. Marette. (2010). The combination of gravity and welfare approaches for evaluating nontariff measures. *American Journal of Agricultural Economics*, 92(3): 713-726.

Feenstra, R.C., (1995). “Estimating the effects of trade policy,” in G. Grossman and K. Rogoff (eds.), *Handbook of International Economics*, vol. 3, Elsevier, Amsterdam.

Ferro, E., T. Otsuki, and J.S. Wilson. (2015) "The effect of product standards on agricultural exports." *Food Policy* 50: 68-79.

Fugazza, M. (2013). *The Economics Behind Non-Tariff Measures: Theoretical Insights And Empirical Evidence*. No. 57. United Nations Conference on Trade and Development.

Henry de Frahan, B., and M. Vancauteren. (2006). “Harmonization of food regulations and trade in the Single Market: evidence from disaggregated data.” *European Review of Agricultural Economics* 33(3): 337–360.

Hoekman, B. and A. Nicita, (2011). “Trade Policy, Trade Costs, and Developing Country Trade,” *World Development* 39(12): 2069-2079.

Josling, T., D. Roberts, and D. Orden. (2004). *Food Regulation and Trade: Towards a Safe and Open Global System*. Institute for International Economics, Washington DC.

Kee, H.L., A. Nicita, and M. Olarreaga, (2008). “Import Demand Elasticities and Trade Distortions,” *Review of Economics and Statistics* 90(4): 666-682.

Kee, H.L., A. Nicita, and M. Olarreaga, (2009). “Estimating Trade Restrictiveness Indices,” *The Economic Journal* 119: 172-199.

Lejárraga, I., and B. Shepherd. (2013). "Quantitative evidence on transparency in regional trade agreements." OECD trade policy papers No 15.

Lejárraga, I., B. Shepherd, and F. van Tongeren, (2013). “Transparency in Nontariff Measures: Effects on Agricultural Trade,” chapter 4 in J.C. Beghin (ed.) *Non Tariff Measures with Market Imperfections: Trade and Welfare Implications*. Vol. 12. Emerald Group Publishing: 99-125.

Li, Y., and J.C. Beghin. (2014). "Protectionism indices for non-tariff measures: An application to maximum residue levels." *Food Policy* 45: 57-68.

Maertens, M., and J.F.M. Swinnen. (2009). "Trade, standards, and poverty: Evidence from Senegal." *World Development* 37.1: 161-178

Melitz, M. J. (2003). The impact of trade on intra‐industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695-1725.

Nicita, A., and J. Gourdon. 2013. *A preliminary analysis on newly collected data on non-tariff measures*. UNCTAD POLICY ISSUES IN INTERNATIONAL TRADE AND COMMODITIES STUDY SERIES No. 53.

Peterson, E.B., and D. Orden. (2008). "Avocado pests and avocado trade." *American Journal of Agricultural Economics* 90.2: 321-335.

Podani, J. (1999). Extending Gower's general coefficient of similarity to ordinal characters. *Taxon*, 331-340.

Silva, J. S., & Tenreyro, S. (2006). The log of gravity. *The Review of Economics and statistics*, *88*(4), 641-658.

Swinnen, J., K. Deconinck, T. Vandemoortele, and A.Vandeplas. (2015). *Quality Standards, Value Chains, and International Development: Economic and Political Theory*. Cambridge University Press, 2015.

Trefler, D. (1993). Trade liberalization and the theory of endogenous protection: an econometric study of US import policy. *Journal of political Economy*, 138-160.

Turnes, P. B. and .R. Ernst. (2015). "A framework for transparency in international trade." *Investigaciones Europeas de Dirección y Economía de la Empresa* 21.1 (2015): 1-8.

Vancauteren, M., and B. Henry de Frahan. (2011). Trade policy, competition and productivity: The impact of EU harmonization in the Dutch food processing industry. *De Economist*, *159*(4), 483-509.

Vancauteren, M. (2013). "EU harmonisation of regulations and mark-ups in the Dutch food industry." *European Review of Agricultural Economics* 40:1163-189.

Van Tongeren, F., J. C. Beghin, and S. Marette. (2009). *A cost-benefit framework for the assessment of non-tariff measures in agro-food trade*. No. 21. OECD Publishing.

Winchester, N., M.L. Rau, C. Goetz, B. Larue, T. Otsuki, K. Shutes, C. Wieck, H.L. Burnquist, M. J. Pinto de Souza, and R. N. de Faria. (2012). "The Impact of Regulatory Heterogeneity on Agri-food Trade." *The World Economy* 35, no. 8: 973-993.

World Trade Organization (WTO). 2015. Committee on Sanitary and Phytosanitary Measures. “Overview regarding the level of implementation of the transparency provisions of the SPS Agreement” - Note by the Secretariat – Revision 8.

World Trade Organization (WTO). 2016. Committee on Technical Barriers to Trade. “Twentyfirst Annual Review of the Implementation and Operation of the TBT Agreement. Note to the Secretariat.

World Trade Report. (2012). “Trade and Public Policies: A Closer Look at Non-Tariff Measures in the 21st Century.” The World Trade Organization. https://www.wto.org/english/res_e/publications_e/wtr12_e.htm

Xiong, B. Forthcoming. “The impact of TPP and RCEP on tea exports from Vietnam: The case of tariff elimination and pesticide policy cooperation,” *Agricultural Economics*.

Xiong, B., and J.C. Beghin. (2014). "Disentangling Demand-Enhancing and Trade-Cost Effects of Maximum Residue Regulations." *Economic Inquiry* 52.3: 1190-1203.

Yue, C., J.C. Beghin, and H.H. Jensen. (2006). “Tariff Equivalent of Technical Barriers to Trade with Imperfect Substitution and Trade Costs.” *American Journal of Agricultural Economics* 88(4): 947–960.

Annex. Derivation of economy-wide effects of technical measures and TRIs

We derive an economy-wide framework to show the impact of technical measures in a small distorted economy ridden by tariffs and production subsidies, and in the presence of potential external effects in demand. The framework slightly extends Beghin, Disdier, and Marette (2015) by having technical measures influencing both domestic and foreign suppliers. As explained before, technical measure can influence the externality (a shift in demand)—it potentially raises the cost of production at home (a shift of the marginal cost of production) and abroad (an increase in the price at the border). In addition, the pathways of the welfare effects are through the externality, the impact on prices, and the impact on general-equilibrium income, a new dimension.

These effects of technical measures on the economy are aggregated in the change in the TRI, which indicates the tariff ad valorem equivalent to all policy interventions in the economy (tariffs, technical measures, other distortions) and holds welfare constant. It is a welfare metric proportional to conventional Marshallian surplus measures indicating the welfare cost associated with the policy interventions. The MTRI provides a tariff equivalent to the same distortions but holding the value of trade constant rather than welfare. In this latter case, the metric focuses on the impact of multiple distortions on trade.

The utility of the aggregate consumer is *u(x, H(NTM))* with market goods *x* and a negative externality *H*. The externality is impacted by technical measure(s) *NTM*. The usual derivative properties are $u_x = \partial u / \partial x > 0;\ u_H = \partial u / \partial H < 0; H = H(NTM)$ with $\partial H / \partial NTM < 0$. Consumer prices *p* comprise the world price *wp* assumed parametric for a small country, a tariff *τ*, and the price equivalent *t* of the domestic *NTM* imposed at the border on foreign suppliers allowing them to sell in the domestic market, or $p = wp + \tau + t(NTM)$.

The expenditure function of the consumer is $e(p, \bar{u}, \bar{H}) = \underset{x}{Min}(p'x \mid u \geq \bar{u}; H \leq \bar{H})$, with the usual derivative properties $e_p = \partial e / \partial p = x(p, u, H(NTM)) \geq 0,$ and $e_H = \partial e / \partial H \geq 0.$ Homogeneity and curvature properties in prices lead to $p'e_{pp}=0$, $e_H=p'e_{pH}$, $e_u=p'e_{pu}$; $e_{pNTM} = e_{pH} H_{NTM}$, and $f'e_{pp}f \leq 0$ for any arbitrary vector *f* of similar dimension as *p* and with e_{pj} denoting the partial derivative of the consumption vector with respect to variable *j*. The marginal damage associated with the externality, e_H, is positive holding utility constant. The marginal utility of income is positive implying that the partial derivative e_u is positive.

The impact of technical measures on demand is ambiguous. The demand enhancing case (outward shift of demand for good *n*) is $e_{p_n NTM} = e_{p_n H_{NTM}} > 0$. Protectionism is implied by H_{NTM} = 0, that is, the policy does not address the externality. Other cases include a reduction in externality but no shift in demand (no impact of the externality on a particular consumption of good *n*) (H_{NTM}<0, $e_{p_n H} = 0$), or a reduction in demand for good *n*, (e.g., a mandated warning label), which reduces the consumption and the externality (H_{NTM}<0, $e_{p_n H} > 0$).

On the production side, domestic supply decisions in competitive industries are derived from the *gdp* function $gdp(p^p, NTM, \bar{z}) = \max_y (p^{p}{}' y \mid g(y, NTM, \bar{z}) \leq 0)$, with *y* being the output vector, $\bar{z}$ the vector of the economy's fixed endowments and p^p the vector of producer prices. Producer prices include production subsidies, *s*, such as farm subsidies, not seen by consumers, $p^p = wp + \tau + t(NTM) + s$. Technical measures *NTM* affect the feasible set and the resource used to produce goods optimally. Envelope and homogeneity properties are $gdp_p = \partial gdp / \partial p^p;\ p^p{}' gdp_p = gdp;\ p^p{}' \partial y / \partial p^p = p^p{}' gdp_{pp} = 0;\ f' gdp_{pp} f \geq 0$ for any f. In addition, we have $gdp_{pNTM} = y_{NTM} = \partial y / \partial NTM$. The latter derivative captures the shift in supply brought by the technical measure(s). If the technical measure reduces the feasible set, then supply will shift to the left and y_{NTM} is negative. Conceivably, although less frequent, *NTM* could also shift supply to the right if a production externality was present before the measure was put in place (e.g., exotic pest policies increase yield once the pest is controlled as in Peterson and Orden, 2008).

Imports *m* are $m(p, p^p, u, H, NTM, \bar{z}) = x(p, u, H(NTM)) - y(p^p, NTM, \bar{z})$. The latter equation captures the three effects of *NTM* on imports via price *p* with *t(NTM)*, externality *H*, and supply *y*. One can differentiate imports *m* with respect to all the arguments while holding utility constant. This step provides a basic trade impact induced by changes in the determinants of imports, including technical measures and other policy interventions in the economy, holding utility constant. Not all these determinants have to change at once of course. For a single good case (good n) determined by its own price we obtain

$$\text{(A1)}\quad \begin{array}{l} dm^n = (\partial m^n / dp^n) d\tau^n - (\partial y^n / \partial p^n) ds^n + \\ [(\partial m^n / dp^n)(\partial t^n / \partial NTM^n) + (\partial x^n / \partial H)(\partial H / \partial NTM^n) - \partial y^n / \partial NTM] dNTM^n - (\partial y^n / \partial z^n) dz^n \end{array}.$$

Equation (A1) also suggests that an empirical strategy will be necessary to separate the impact of technical measures in a given sector n, NTM^n, on supply y^n and demand x^n to identify demand enhancing effects form supply shifts induced by higher cost of production under the technical measures.

Next, the balance of trade function *B* is used to derive welfare implications. Function *B* indicates the amount of foreign exchange necessary to sustain utility *u* given *NTM*, *wp*, *z*, *s*, *τ* and externality *H*. Homogeneity in prices and envelope properties of *e* and *gdp* lead to a simple expression of *B* as follows:

(A2) $B(p, p^P, wp, \bar{z}, H, NTM, u) = (wp + t(NTM))'(x(p, u, H(NTM)) - y(p^P, NTM, \bar{z})$.

1.2. Trade restrictiveness indices with externality

The TRI is a scalar *T* equivalent (holding utility constant) to technical measures *NTM*, tariffs *τ*, and production subsidies *s* to apply as a tariff surcharge on world prices such that:

(A3) $$B(wp(1+T), wp(1+T), wp, \bar{z}, H(0), 0, u_0) = \\ B(wp + \tau_0 + t(NTM_0), wp + \tau_0 + t(NTM_0) + s_0, wp, \bar{z}, H(NTM_0), NTM_0, u_0) = B_0 .$$

The tariff surcharge accounts for several components: tariffs *τ*, domestic production subsidies *s*, and technical measures *NTM* through three conduits, the demand shift via H_{NTM}, the supply shift via y_{NTM}, and the "protectionist" effect from raising foreign unit cost by *t*(*NTM*) to satisfy technical measure *NTM*.

Following Anderson, Bannister and Neary (1995), we hold *u* constant and differentiate equation (A3) with respect to *T*, *τ*, *s*, and *NTM* to derive the change in *T* rather than *T*. This step yields:

(A4) $$dT = [(B_p^{'} + B_{p^p}^{'})d\tau + B_{p^p}^{'}ds + ((B_p^{'} + B_{p^p}^{'})\partial t / \partial NTM \ \text{-} B_H H_{NTM}^{'} + B_{NTM}^{'})dNTM] / (B_p^{'}wp + B_{p^p}^{'}wp),$$

with partial derivatives $B_p^{'} = -\tau^{'} e_{pp}$, $B_{p^p}^{'} = (\tau + s)^{'} gdp_{pp}$, $B_H = (wp + t(NTM))^{'} e_{pH} > 0$, and $B_{NTM} = y_{NTM}$.

Equation (A4) is a welfare metric indicating the consequences of changing policy interventions in the economy. It shows that welfare effects of the *NTM* component is the sum of three elements: the "protectionist" effect relative to foreign goods with Harberger triangles through a tariff equivalent *t*, which is increasing in *NTM*, a demand effect via reduced externality *H* (a shift of demand), and a change in the feasible set to produce the good affected by the measure and shifting supply. The sign of this protectionist effect on welfare (and imports) is clear, but the effect of *NTM* via *H* on welfare (and trade) is potentially positive; the effect via *y* on welfare is often negative by increasing cost and the corresponding impact on trade is then positive in these cases. The sum of the three effects is presumably ambiguous and has to be determined empirically.

From *dT*, we recover the TRI *T* equivalent to the initial tariffs, subsidies, and technical measures relative to a world with all policies set to 0. It is done by integrating both sides of (A4) with respect to *T* going from zero to *T* and policies going from (0,0,0) to (τ, *s*, *NTM*). We get

(A5) $T = \sqrt{(B'_p + B'_{p^p})\tau + B'_{p^p} s + ((B'_p + B'_{p^p})\partial t / \partial NTM \ \text{-} B_H H'_{NTM} + B'_{NTM})NTM)} \, / \sqrt{(wp'(gdp_{pp} - e_{pp})wp}$.

If *NTM* is a purely protectionist policy not addressing an externality, and if domestic producers incur no cost or less cost than foreign producers to satisfy the measure, then $B_H H_{NTM} = B_{NTM} = 0$ (no demand and supply shifts). In this case, the dead weight loss from the tariff equivalent *t(NTM)* is added to the sum of deadweight losses. If the technical measure truly addresses an externality and enhances demand and only increases the domestic cost of production moderately, then the measure could lead to a welfare gain other things being equal. Removing the technical measure decreases welfare. If the latter effect dominates the distortionary effect of tariffs and subsidies, then *dT* is negative and *T* cannot be recovered using (A5). Then the change in TRI, *dT*, is the form of choice to measure welfare implications.

To derive trade effects in general equilibrium, we hold aggregate imports (*wp'm*) constant and derive the MTRI to look at the full trade impact of technical measures. Recall equation (A1) looks at a single market and involves import changes holding utility constant. The MTRI yields the tariff equivalent to all distortions holding aggregate trade unchanged but allowing for welfare variation. Utility is then endogenous. The MTRI is

(A6) $T_c^{merc} = wp'[m_p \tau - y_{p^p} s + (m_p \partial t / \partial NTM \ + x_H H'_{NTM} - y_{NTM})NTM] / (wp' m_p wp)$.

These indices are those we refer to in section 3, in which we discuss the empirical computation of welfare and trade impacts of NTM policies based on econometric estimates of the impact of trade distortions on trade flows.