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Willingness to Pay in CGE Models

Estimating the benefits of improved customs efficiencies within the WTO Trade Facilitation Agreement

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The ImpactECON working paper series focuses on adapting, testing and transitioning academic work for practical, real world use. The end goal is to improve CGE modeling with an emphasis on policy and investment analysis through improvements to data and modeling constructs.

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Acronyms

CES	constant elasticity of substitution
CGE	computable general equilibrium
C-TPAT	US Customs-Trade Partnership against Terrorism
DB	Doing Business
EV	equivalent variation
GDP	gross domestic product
GTAP	Global Trade Analysis Project
NTM	non-tariff measure
OECD	Organization of Economic Cooperation and Development
TFI	Trade Facilitation Indicators
TFA	Trade Facilitation Agreement
UNCTAD	United Nations Conference on Trade and Development
WTO	World Trade Organization

Abstract

The aim of this paper is to provide a new methodological approach for estimating the economic impacts of reducing customs delays within a computable general equilibrium (CGE) model. The new approach, which we will reference as the willingness-to-pay method, explicitly models the reduction in customs delays from the demand side as an increase in a consumer's willingness to pay for faster delivery. To illustrate our new approach, we estimate the impact of the WTO Trade Facilitation Agreement (TFA). Econometric estimates of willingness to pay for the reduction in customs delays are used to obtain ad valorem equivalents of the TFA. These are then applied as demand side shocks to a global supply chain model and the results compared to those obtained using the existing methodology based on Samuelson's iceberg approach (Samuelson, 1954). The implementation of the TFA using the iceberg approach, lowers the cost of trade, raising the quantity of imports consumed relative to the quantity sent or exported through an import-augmenting technological change, thereby raising real GDP and welfare. Alternatively, under the new approach the TFA has a smaller impact on real GDP; although prices, trade volumes and welfare are all higher when the TFA is explicitly modeled as a demand or preference shift in consumers' willingness to pay, rather than as a reduction in an iceberg cost.

1 Introduction

The implementation of non-tariff measures (NTMs) within global computable general equilibrium (CGE) models has been relatively simple, with modelers incorporating NTMs as tariff equivalents via export or import taxes or as import-augmenting technological change, depending on the modeler's judgment of the extent to which rents and costs matter, and how rents are distributed between importers and exporters. There are a number of problems with the current techniques and their implementation. One important problem for modelers is the lack of mechanisms available in CGE models to implement the diverse range of NTMs and their particular economic impacts. For instance, there are limited mechanisms to alter a consumer's willingness to pay in response to a change in a product standard, or to change an exporter's production costs in response to harmonization of product standards. As a result, existing mechanisms have been stretched beyond their intended purposes to implement the broad range of NTMs. Our research shows that the choice of transmission mechanism can have important consequences for estimates of GDP, welfare, and trade, and hence more careful consideration of the NTMs being investigated, the estimates being utilized, and the CGE mechanisms being used, could improve analysis.

In this paper we focus on trade facilitation, a unique type of NTM that encompasses the implementation of rules and procedures that impact trade. In the analysis of trade facilitation, the use of the import-augmenting technological change has become a widely accepted method (for example, Hertel, Walmsley and Itakura (2001); Fox, Francois and Londono-Kent (2003) and Francois, Van Meij and van Tongeran (2005)). This import-augmenting technological change, referred to as the iceberg approach, represents changes in importer costs deriving from NTMs. While it is a popular approach, the full implications of implementing the iceberg approach are not always well understood.

The aim of this paper is to provide a new methodological approach for estimating the economic impacts of reducing customs delays within a CGE model. The new approach, which we will refer to as the willingness-to-pay method, explicitly models the reduction in customs delays as a demand shock that increases a consumer's willingness to pay for faster delivery.

To illustrate our new approach, we estimate the impacts of the World Trade Organization (WTO) Trade Facilitation Agreement (TFA) on global welfare and gross domestic product (GDP) and contrast the results with the existing method. Negotiations for the WTO TFA were completed in December 2013 and will simplify customs rules and procedures; it is expected to raise the efficiency of goods moving through customs. The decision to model the TFA in order to illustrate the new willingness-to-pay method, and cast light on the iceberg approach, was based in part on our ability to derive robust estimates of the willingness of importers to pay to reduce shipping times (e.g., Hummels et. al. (2007) combined with more recent estimates of TFA impacts on customs times constructed later in this paper). The development of CGE methods is best carried out when the researchers clearly understand the available data and estimation methods used to generate that data. The willingness-to-pay method we use here is based on the utility maximizing framework underlying Hummels' estimation of the value of time in trade.

While Hummels' estimates of the willingness-to-pay to reduce shipping delays provides a convenient data set for the purposes of this paper, we note that economic researchers in regulatory surveys often employ willingness-to-pay, such as those used to identify societies' willingness to pay for environmental, climate change and social policies (see Kotchen, Boyle and Leiserowitz, 2011). The willingness-to-pay method, outlined here, paves the way for including willingness-to-pay into value chain analysis, incorporating a fundamental component of modern value chains, which focus on maximizing value to the final consumer in addition to minimizing cost.

Trade facilitation holds a unique position in the analysis of international trade and trade barriers. Today, trade facilitation is most frequently defined as a constellation of best practice customs policies and procedures which have an augmenting effect on trade volumes and prices.[1] The constellation of rules and procedures the TFA represents are expected to result in faster movement of cargo through customs with greater reliability. These procedures include advance rulings on product classifications; cooperation of customs officials; publication of rules, procedures and charges; as well as risk management techniques. In this paper, the TFA is treated holistically by estimating its impacts as countries meet "all" the WTO definitions and best practices, not individual elements. In addition, we control for the level of economic development within a country.

In order to define the trade enhancing potential of the TFA and its potential impacts within a CGE model, we employ the Organization of Economic Cooperation and Development (OECD) Trade Facilitation Indicators (TFI) data set to estimate the potential of the TFA to reduce customs clearance times (to be combined with Hummels' estimates of the willingness-to-pay to

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[1] Many international institutions and governments have different definitions of the policies and procedures covered under the topic "trade facilitation". For example, the WTO definition does not include port facilities. The US Government does include port facilities under its definition for development purposes. Other differences can be identified with careful examination. In this paper, the subject is the WTO TFA, so we maintain the WTO definition.

save a day in trade). The econometric method employed in this paper share some similarities with Hillberry and Zhang (2015), which estimates the potential for the TFA to reduce customs clearance times.

These estimates of the reduction in customs delays in days are then converted into ad valorem equivalents employing Hummels' estimates and incorporated into a global CGE supply chain model[2] in order to examine the impact of the TFA agreement. The two CGE methods outlined above—the willingness-to-pay and iceberg methods—are examined and the results compared. The benefit of using a supply chain model to compare the two methods is that we can also investigate the impact of each importing agents' preferences for reduced time on the overall results. In global models based on the GTAP database (Narayanan, Aguiar and McDougall, 2012), where imports of all agents—households, firms and government—are aggregated into a single imported commodity, all agents will receive the import-augmenting technological change shock or, alternatively, our proposed increase in willingness-to-pay. We find that the iceberg method leads to a significantly larger increase in real GDP in contrast to the willingness-to-pay method, due to productivity gains. In contrast, the willingness-to-pay method has a more expansionary effect on trade volumes and causes the terms of trade to improve. In both cases the gains are predominantly due to the impact of reduced time delays on firms, although the gains to private households from reduced time delays become relatively more important under the willingness-to-pay method. Welfare is also higher under the willingness-to-pay method.

This paper is organized as follows. First the TFA is reviewed in the context of non-tariff measures as broadly defined by the trade community. We also review the literature on the implementation of NTMs in CGE models. We pay particular attention to the existing methods and literature for the inclusion of trade facilitation measures in CGE models. Next, we outline the willingness-to-pay method and contrast it with the existing methods in the CGE literature. We then, briefly, provide our results of estimating the potential of the TFA to reduce customs clearance times, as defined by all countries moving toward best practices, and the value of time in trade estimates derived from Hummels et. al. (2007). These estimates of the ad valorem equivalents of the TFA are then applied in the new willingness-to-pay method and contrasted against the iceberg approach.

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2 A global comparative static, Arrow-Debrue type model with Armington and perfect competition assumptions, based on the GTAP model (Hertel, 1997).

2 NTMs, the TFA and CGE modeling

NTMs are defined broadly as any "policy measures, other than ordinary customs tariffs, that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD, 2012). NTMs, therefore, encompass a broad range of technical and non-technical measures applied to both imports and exports, such as standards, fees, quotas, voluntary export restraints, licenses, subsidies, competition measures, rules of origin, intellectual property regulations, among others. Trade facilitation, as defined by the WTO, does not significantly overlap with the United Nations Committee on Trade and Development's (UNCTAD) categories of NTMs. That is largely because the TFA is cast in terms of efforts members can make to facilitate trade by advancing their customs regulations and procedures to best practices, in contrast to the majority of NTMs which are outright barriers to trade. Nevertheless, trade facilitation is expected to have impacts on the quantities and potentially the prices of traded goods, and therefore fits the broader definition of NTMs.

Numerous papers have sought to examine the impact of NTMs, including econometric and CGE modelling techniques. Econometric or price gap methods are generally used to estimate the restrictiveness of an NTM on trade. CGE models then take these estimates of restrictiveness, often in the form of tariff or ad valorem equivalents, as inputs to the model to estimate the impact of removing the barrier on an economy or on economic variables such as wages, employment, GDP, and welfare.

While the nature of NTMs is nuanced and complex (UNCTAD lists over 100 categories), CGE models have employed a limited set of approaches to incorporate NTMs into their model theory. CGE methods for implementing NTMs can be categorized into three basic approaches, depending on the extent to which they are implemented through shifts of the supply or demand curves or as transaction costs such as fees and charges. Fees and charges are frequently incorporated as ad valorem shipping charges or, in some cases, as trade taxes.

Supply curve shifts, which could represent decreasing foreign production costs due to harmonization of standards, would seem a popular method in CGE models, though their use is limited by the need to separate production destined for the domestic markets from production destined for international markets.

Instead, GTAP-type models tend to implement supply shifts or technology shifts coarsely by employing the export or import taxes which affect traded goods and services (Fugazza and Maur, 2008). While ordinarily import and export taxes would be used to incorporate changes in taxes or other fees and charges, NTMs are often not associated with an additional tax or fee. In such implementations it is argued that the NTM causes economic rents, most likely due to imperfect competition, that accrue to either the importing or exporting country, and that changes in rents from the existence of NTMs can be modelled as changes in import and export taxes. This approach is possible because in the GTAP model these rents do not accrue to any party in particular, instead they feed back into the income of the regional household, which is comprised of both private households and the government. Alternatively, technology shifts are modeled by embedding a variable into the Armington import equation.[3] The most prominent implementation of this method is the stylized implementation of Samuelson's (1954) iceberg effect in the Armington equation of the GTAP model, termed the iceberg method and discussed further below.[4]

Finally, NTMs may also result in demand shifts, modeled as gains or losses in the willingness to pay for imports or changes in the elasticity of substitution between imported goods. For example, the imposition of a standard on a traded good that removes doubt over the quality or safety of the good may provide an additional benefit to the importer or exporter of the good for which they are willing to pay. Alternatively, in the case of lengthy customs procedures, importers may be willing to pay to reduce customs delays. While demand shifts are less frequently applied when implementing NTMs in CGE models, the importance of the willingness-to-pay concept and its impacts on welfare in the context of NTMs has been recognized in a number of cost-benefit studies of NTMs, and in particular the analysis of food regulations (Tongeren, Beghin and Marette (2009), Tongeren, Disdier, Komorowska, Marette and Lampe (2010), Beghin, Disdier, Marette, Tongeren (2012) and Beghin, Disdier, Marette and Tongeren (2013)). These papers argue that the efficiency gains or losses from NTMs may be less important for welfare than consumers' preferences for the health and safety standards or other concerns these NTMs were intended to address, particularly when the NTM is non-discriminatory. Analysis of NTMs, for instance harmonization of standards, should therefore address both the demand- and supply-side dimensions of NTMs.

Analysis of the full range of NTMs and their impacts in CGE models is therefore likely to require a wider selection of demand and supply-side techniques than those currently used, which tend to concentrate on the efficiency gains or supply-side. Moreover, NTMs are unlikely to fit neatly under just one of these techniques, with many expected to involve a combination

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3 For example, the AMS variable in the GTAP model.

4 Readers interested in the impact of using taxes compared to the iceberg approach are referred to Fugazza and Maur (2006).

of supply shifts, fees and willingness-to-pay impacts. Some modelers (CEPR (2013), ECORYS (2009), and Andriamananjara, Dean, Feinberg, Ferrantino, Ludema and Tsigas (2004)) have attempted to apportion NTM tariff equivalents across the two main methods (iceberg and taxes) based on their research about the cost and rent implications of the NTM, although as mentioned previously few CGE studies have considered willingness-to-pay or demand side shifts. Unfortunately, at this point in time, the commonly employed econometric techniques are not sufficiently sophisticated to provide separate ad valorem equivalents according to the implication of the NTM. Economic modeling requires abstraction and simplification of otherwise complex processes, and CGE modelers have not been immune from that requirement.

Our focus in this paper, trade facilitation, differs from many other areas of NTMs in that customs procedures bring into focus the often long processes of clearing customs and a willingness to pay to receive goods earlier than later (a willingness to pay to avoid delays). While customs delays are often perceived as a developing country issue, one has only to look at recent security requirements which mandate advanced notifications of container packing and supply chain information and scanning requirements to see that importers and exporters in high income countries are equally concerned about shipping delays due to customs procedures (ECORYS 2009).[5] Analysis by Hummels et al. (2007) estimated the value of customs delays to exceed tariff costs in many cases. Many stakeholders in the shipping sector join programs, such as the US Customs-Trade Partnership against Terrorism (C-TPAT), to expedite cargo through customs, despite the high cost of membership.[6]

Trade facilitation, therefore, is not particularly well suited to the most commonly applied NTM modeling approaches, which usually entail incorporating technological or pecuniary costs into the model as a productivity shock or an import or export tax equivalent. Instead, we would expect trade facilitation to create a demand shift, in contrast to a shift in the supply curve.

One of the earliest papers to take up the issue of demand shifts in CGE was based on early research of European integration by Harrison, Rutherford and Tarr (1994) and is reviewed here as a reference point, since it is one of the only CGE papers to model preferences.[7] In that study, the authors argued that the primary issue at the border within the European Community was product standards and the willingness of importers to substitute between domestic and imported products. The authors reasoned that the major benefit of European integration was not the elimination of tariffs, but the harmonizing of standards, which are not well represented by tariffs or trade costs. Instead, the authors recalibrate the nesting structure and the substitution elasticities to simulate what was perceived to be greater substitution between

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5 http://www.cbp.gov/border-security/ports-entry/cargo-security/importer-security-filing-102. Enhanced security may provide a benefit to importers and a willingness to pay for security could likewise be measured.

6 Also See https://en.wikipedia.org/wiki/Customs-Trade_Partnership_Against_Terrorism. We note that Jones and Seghetti (2015) report that smaller importers "balk" at the fixed costs to join these programs to expedite cargo. While most large importers pay substantial fees and accept increased operating costs to participate in them.

7 Our literature review benefited from and is largely based on work done by Fugazza and Maur (2006).

domestic and imported goods. Harrison et al. focus on the implication of product standards and unification of markets and their research represents an initial step in modeling the demand shifts derived from standards. In this study we offer an alternative method for altering preferences that does not rely on altering the elasticities of substitution.

Hertel, Walmsley and Itakura (2001) directly address the issue of customs delays in the context of a proposed trade agreement between Japan and Singapore. In that paper, the authors employ early estimates by Hummels on U.S. importers' willingness to pay to reduce shipping times. Hummels' reported the willingness-to-pay in the form of ad valorem equivalents. Hertel et al.'s paper is one of the first documented uses of the "iceberg effect" in the modeling of trade facilitation in CGE models. The iceberg method itself was first elaborated by Samuelson (1954) in a simple two-by-two theoretical exposition, where by "value melts away" as a result of shipping.[8] Notably, Samuelson's approach reduced the quantity arriving in the importing market, in contrast to that which left the dock in the exporting country. The loss of the quantity was deemed a stylized payment for shipping, however, it was only a thinly veiled attempt to model non-tariff barriers as reducing the value of imports—it was left to the reader to conceive of the sources of those losses. Likewise, Hertel et al. introduce a "technical efficiency" term into the import demand equation (Armington) which changes the quantity received by the importer. We review the implementation of the iceberg effect in the model later in this paper.

Ganslandt and Markusen (2001) explore the theoretical possibilities of modeling import preferences in relation to product standards. Like Harrison et al. (1994), Ganslandt and Markusen consider the possibility of recalibrating elasticities, but they also elaborate the willingness to pay as an alternative. Like Hertel et al., they characterize the willingness to pay as getting the same utility level from less quantity. Alternatively, this could be viewed as the willingness-to-pay more for the same quantity. Harrison et al. point out the two methods are not identical and can result in different welfare implications. The modeler must decide which method is appropriate. Ganslandt and Markusen's exposition contrasts with Hertel et al.'s "technical" transformation of quantities in that Ganslandt and Markusen and Harrison et al. focus on shifting or changing the slope of utility curves.

The CGE community has tended to adopt the Hertel et al. approach, which is now referenced as the AMS or iceberg approach, for modeling trade facilitation. For example, Fox, Francois and Londono-Kent (2003) employee the AMS approach in modeling border delay costs between the US and Mexico. Francois, Van Meijl and van Tongeran (2005) employ it as a means of broadly modeling the WTO trade facilitation agreement, which at the time of their analysis was part of the overall WTO Doha agenda. Francois et al. justify the use of AMS by arguing that the majority of trade facilitation impacts would cause a reduction in "dead weight losses".

8 This aphorism perhaps hides more than it reveals. A more accurate description of Samuelson's iceberg effect is: the processes by which real quantities melt away in shipping, with the end result being a change in value at constant prices.

Fugazza and Maur (2008) survey the current methods employed in CGE models for implementing NTMs. Those authors find the current modeling structures to be lacking in a number of ways, most notably, the lack of a good fit between estimates of NTMs and the model structures used to represent them. They call for further work to be done to extend modeling of NTMs. Fugazza and Maur point out that the AMS method has a number of implications for welfare calculations and suggest the AMS method is best suited to modeling issues in trade facilitation. Our own research, outlined below, finds that substantial impacts on real GDP are a major outcome of the application of the AMS method—welfare results also matter, but relatively less so. Fugazza and Maur note, the particular type of shock that AMS represents, a technical change in quantities, is likely to be of limited practical use. It is therefore suggested that its use be limited to small shocks—noting that in reality there is “sand” in the wheels, not “rocks”.[9] [10]

In the following section we further reflect on the use of the AMS or iceberg approach for modelling trade facilitation. Our goal is to raise awareness of the need to consider alternative modeling methods for investigating NTMs.

9 A more realistic analogy would be that we see individual cargo containers fall off ships, but we rarely see whole cargo ships “slip beneath the ocean” with their cargo.

10 McCann (2005) also raises similar concerns about the use of the iceberg method in practical applications of new economic geography models.

3 Willingness to pay for reduced customs delays

There are a number of ways to implement the TFA agreement in a CGE model depending on the transmission mechanism conceived. Two mechanisms stand out: pecuniary transaction costs, such as fees and charges, and the willingness to pay for reduced shipping times by moving goods rapidly through customs. In this paper we restrict our analysis to modeling the value of time in customs. Previous CGE research studies which include the value of time in trade share two elements, they rely on estimates of the willingness to pay for reduced shipping delays estimated by David Hummels and they employ the same CGE modeling constructs—the iceberg method (Samuleson 1954). In addition to the iceberg method, we contrast and implement a new approach in this paper, which we refer to as the willingness-to-pay method. Under this method, as the name suggests, the reduction in shipping time, including the time to clear customs, is assumed to affect the purchasers' willingness to pay to receive a good earlier than later. [11]

3.1 The iceberg method

As reviewed earlier, the most commonly employed approach for modelling trade facilitation in the GTAP model is the AMS or iceberg method. Hertel et al. (2001) state that AMS has two effects on trade within the Armington structure:

11 As an aside, one might argue that willingness to pay could also cause 'rents' for the relevant parties that could be implemented using tariff variables (as discussed earlier in the overview of NTMs and CGE modeling). In this particular case it might be argued that the delays in receiving imports, increase demand for domestic goods and hence result in higher rents for domestic producers. We are assuming these time delays do not produce rents for the domestic producers, our producers are assumed to be perfectly competitive and delays in shipping have always occurred; if rents do exist, they exist in particular industries due to imperfect competition and need to be dealt with through the implementation of imperfect competition in those sectors.

— AMS reduces the importer's price causing substitution towards that good and an increase in quantity demanded;[12] and

— AMS reduces the amount that needs to be imported to satisfy a given level of demand.

These two effects work in opposite directions, although, in practice, the first effect is often larger than the second due to the fact that the price effects are multiplied by an elasticity which is frequently greater than one.[13] Model users, therefore, observe the desired result—the demand for imports rises as a result of lowering the NTM. An important outcome of the second effect, is that the calculated or "algebraic" quantity observed by the importer is changed in direct proportion to the size of the NTM.[14] This last effect maintains balance in the initial accounting, i.e., value of foreign good i from country j ($V_{i,j}^F$) still equals price ($P_{i,j}^F$) times quantity ($X_{i,j}^F$):

$$V_{i,j}^F = \frac{P_{i,j}^F}{AMS_{i,j}^F} . X_{i,j}^F . AMS_{i,j}^F \qquad (1)$$

Where: Commodity i (where there are m commodities, i ∊ 1...m)

Country j (where there are n countries, j ∊ 1…n)

$AMS_{i,j}^F$ is the Armington augmenting iceberg cost on foreign good i from country j.

Importantly, this second effect, is a productivity shock applied entirely to the importing agents. Importing firms and final consumers reduce their orders with exporters in foreign markets, but still receive the same amount of imports. The argument put forth to explain this direct change in the quantity imported versus the quantity originally exported is that there is potential for less spoilage, theft, breakage or loss in shipment. From a firm's perspective, the increased quantity of goods imported is equivalent to a technological change to the importing firm, akin to a reduction in the production costs. While this explanation may find some basis in a firm's supply chain, the role of a productivity shock for households and government is difficult to reconcile. It's important to note here that an often used explanation for the productivity shock on government and households is that it can be interpreted as a change in quality. However, this explanation is inconsistent with the impacts on real GDP that the productivity shock creates and is not consistent with standard definitions of real GDP.

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

13 The operative equation is qxs(i,r,s) = -ams(i,r,s) + qim(i,s) – ESUBM(i)* [pms(i,r,s)-ams(i,r,s)-pim(i,s)] for sector i, from region r, to region s. The quantity exported, qxs, being a function of ams, the NTM shock, qim, a trade weighted average of imports, ESUBM the elasticity of substitution between imports, pms the market price for imports, unadjusted, and pim, the average price of imports, adjusted for the ams variable.

14 The term "algebraic quantity" was first referenced by Samuelson (1954).

This stylized shock has implications the modeler must consider. First, it breaks the equivalence of quantities in the model. For example, assuming a positive AMS shock, the quantity imported (*qim*) will be higher than the quantity exported (*qxs*).[15] This raises a problem for the model user when deciding which variable to enumerate when reporting results of "real trade" volumes. Second, it has the effect of raising real GDP in the importing country, since there is the equivalent of a technological change shock that allows all agents (firms, households and government) to satisfy an initial demand with less imports (as seen from the exporter's perspective).[16]

The iceberg effect is appropriate to the extent that time delays lead to real costs for the importing firms, such as when vegetables spoil due to long delays in customs or when the delay of an imported part required to fix a machine causes a coal mine to stop and workers to be sent home. In many cases such time delays are an inconvenience, rather than a real cost. The estimates produced by Hummels and Schaur (2013) and Hummels et al. (2007) do not distinguish between a firm's willingness-to-pay to reduce production costs or that for the convenience of faster delivery, hence using the iceberg method is likely to over-state the impact of the TFA on real costs and hence real GDP. Ideally, a combination of iceberg and willingness-to-pay approaches is likely to yield the best results (as implemented in cost-benefit studies of NTMs (Tongeren, Beghin and Marette, 2009), although until better econometric estimates are available, assumptions would need to be made about how to separate the two effects.

In the case of the iceberg method's application to NTMs other than the value of time in trade, other concerns may also arise. Namely, should productivity gains from NTMs be acquired largely by the importing country? There are a number of cases, such as standards compliance of traded commodities, where one might expect at least some of the productivity gains to accrue to producers in exporting countries, since the harmonization of international standards would lead to reduced efforts to tool assembly lines and products to foreign standards. This further emphasizes the lack of mechanisms for dealing with NTMs; however, while it is important, we do not focus on this aspect of the iceberg method in this paper.

3.2 Willingness-to-pay

Since the iceberg method does not fully reflect how the TFA (and other NTMs) impact economies, we provide an alternative method. Consistent with Hummels and Schaur (2013) and Hummels et al. (2007), the alternative approach postulates that goods delivered more quickly are preferred to those that are delayed. That is because consumers derive more utility

15 When aggregated appropriately using the same shares.

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

from goods delivered earlier than later and are thus willing to pay more for them. As an example, those authors note the popularity of a toy, which corresponds with market demand, is often not known well before the Christmas selling season. The ability to delay importing decisions until better market knowledge is obtained, and then receive those imports quickly once the decision has been made, has distinct advantages that the retailers and importers exploit. The same could be said for electronics, clothing, pharmaceuticals and many other goods. In essence, the willingness-to-pay is the foundation of modern markets and value chains.

We focus on the Armington nest that determines foreign demand by source country ($X^F_{i,j}$), as originally conceived by Armington (1969).

The constant elasticity of substitution (CES) utility function at this level is:

$$U_i^F = \left[\sum_{j=1}^{n} B_{i,j}^F . \left(X_{i,j}^F\right)^{-\rho_i^F}\right]^{-\frac{1}{\rho_i^F}} \quad (2)$$

Where:

Commodity i (where there are m commodities, i ∊ 1...m)

Country j (where there are n countries, j ∊ 1…n)

U^F_i is utility derived from foreign consumption of good i

$B^F_{i,j}$ are the distribution parameters of foreign good i from country j ($\sum_{j=1}^{n} B_{i,j} = 1$)

$X^F_{i,j}$ is the quantity of foreign good i from country j

ρ^F_i is a substitution parameter. It is related to the elasticity of substitution between commodity i from different foreign sources, σ_i^F, ($\sigma_i^F = \frac{1}{1+\rho_i^F}$)

In equilibrium, we know that the ratio of marginal utilities of commodity i from country j and k should equal the ratio of prices of commodity i from countries j and k:

$$\frac{B_{i,j}^F}{B_{i,k}^F} . \left[\frac{X_{i,k}^F}{X_{i,j}^F}\right]^{1+\rho_i^F} = \frac{P_{i,j}^F}{P_{i,k}^F} \quad (3)$$

and maximizing (1) subject to the budget constraint gives us the following CES demand function:

$$X_{i,j}^F = {B_{i,j}^F}^{\sigma} . X_i^F . \left(\frac{P_{i,j}^F}{P_i^F}\right)^{-\sigma_i^F} \quad (4)$$

Where:

X^F_i is the quantity of foreign good i

$P^F_{i,j}$ is the price of foreign good i from country j

P^F_i is the composite price of good i

σ_i^F is the elasticity of substitution between commodity i from different foreign sources, j

Hummels and Schaur (2013) and Hummels et al. (2007) derive estimates of the importers' willingness to pay for a reduction in time to trade and convert these into ad valorem price equivalents, ω. This means that the reduction in time to trade increases an importers' willingness to pay more for $X^F_{i,j}$ by ω. This is equivalent to a rise in the marginal utility of ω (3a), and is implemented as a change in $B^F_{i,j}$.[17] The model will then calculate a new equilibrium where the ratio of prices equal the ratio of marginal utility, at the new higher level of marginal utility for commodity $X^F_{i,j}$.

$$\frac{B_{i,j}^F(1+\omega)}{B_{i,k}^F}.\left[\frac{X_{i,k}^F}{X_{i,j}^F}\right]^{1+\rho_i^F} = \frac{P_{i,j}^F}{P_{i,k}^F} \qquad (3a)$$

Armington (1969) postulated that the distribution parameters ($B^F_{i,j}$) were fixed and the sum of the $B^F_{i,j}$'s were assumed to always equal one in order to ensure the adding up constraints. In this paper we relax the assumption that the distribution parameters are fixed, although we must still ensure the adding up constraint. To do this we recognize that it is relative changes in the distribution parameters that matter in determining demand, just as it is relative prices that matter. Hence we define B^F_i as the sum[18] of the distribution parameters over all j, such that:

$$X_{i,j}^F = \left(\frac{B_{i,j}^F}{B_i^F}\right)^{\sigma_i^F}.X_i^F.\left(\frac{P_{i,j}^F}{P_i^F}\right)^{-\sigma_i^F} \qquad (5)$$

In percentage changes our demand function becomes:

$$\hat{x}_{i,j}^F = \sigma_i^F\left(\hat{\beta}_{i,j}^F - \hat{\beta}_i^F\right) + \hat{x}_i^F - \sigma_i^F\left(\hat{p}_{i,j}^F - \hat{p}_i^F\right) \qquad (6)$$

where $\sigma_i^F\left(\hat{\beta}_{i,j}^F - \hat{\beta}_i^F\right)$ is now added to the original specification in Armington (1969); and $\hat{\beta}_i^F$ is the percentage change in the average distribution parameter, henceforth we refer to $\hat{\beta}_i^F$ as the average, rather than as the sum.[19]

The impact of this new distribution parameter on demand is very similar to the impact of a change in relative prices, but with the opposite sign: a rise in an agents' willingness to pay has the same impact on demand as a decline in the actual price. Their separation provides another

17 Note the difference between the willingness-to-pay and a tariff. A reduction in the tariff reduces the actual PFi,j on the right hand side of equation (3), while the willingness to pay raises the marginal utility from that good on the left hand side of equation (3). In both cases a new equilibrium will be found where more of the good is purchased.

18 This ensures that the sum of this ratio of distribution parameters $(\frac{B_{i,j}^F}{B_i^F})$ continue to equal one in the demand function, when $B_{i,j}^F$ is shocked. In percent change form, the $\hat{\beta}_i^F$ is then the average.

19 This average is calculated as a weighted sum of the changes in the distribution shares, using trade weights. This is similar to the way in which composite prices are calculated.

avenue through which a shock can impact demand, without directly changing the price (or rents) received by the supplier of the good. The underlying revenue flows are not changed except where a change in demand effects purchasing patterns and hence government revenue and firm sales—this stands in contrast to the use of tax variables to represent NTMs.[20] A new equilibrium price will then be determined where supply equals demand, at the new higher level.

Figure 3-1 (panel A) illustrates how the change in the preferences affects the indifference curve. Goods X_{i1} and X_{i2} denote the quantity of commodity i from countries 1 and 2 respectively. Following Armington (1969), goods X_{i1} and X_{i2} are imperfect substitutes with indifference curve U0 and budget constraint. When the time to trade of good X_{i1} falls, consumers derive greater utility from the good and are hence willing to pay more. The indifference curve rotates[21] and shifts downwards to U0, reflecting the fact that less X_{i1} is required to obtain the same level of utility (U0).

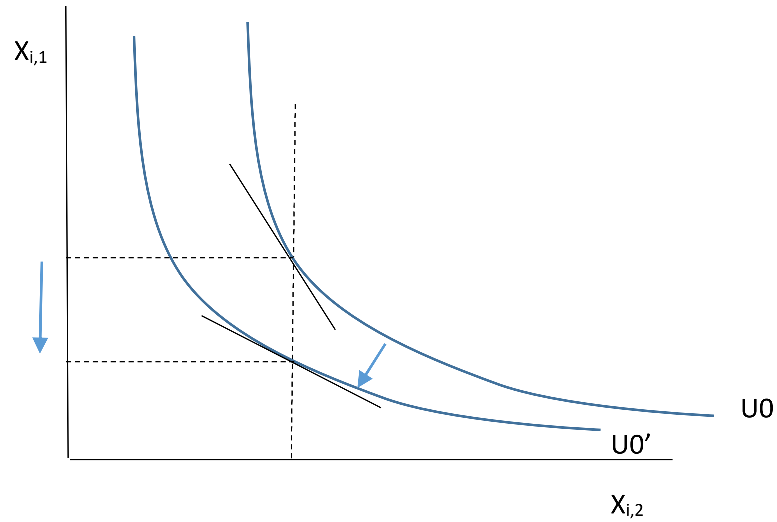
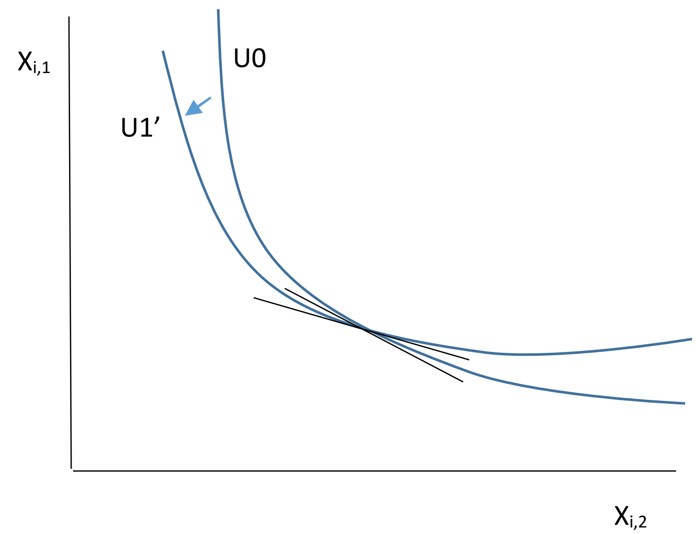
The rotation and the shift are captured separately in our implementation. The relative changes in willingness to pay, implemented through changes in the distribution parameters relative to the average, cause a rotation in the indifference curve (U0 to U1′ in Figure 3-1, panel B) that results in the ratio of the marginal utilities (slope) adjusting by (1+ ω). It is these relative changes in preferences that affect demand and cause substitution between X_{i1} and X_{i2}. The downward shift of the indifference curve (Figure 3-1, panel A) or the higher utility of the initial consumption bundle (U1 in Figure 3-1, panel B) is captured in any upper levels of the nesting structure and in our calculation of utility and welfare. Thus assuming a two level Armington nesting structure (domestic v imports and imports by source[22]) changes in the average distribution parameter for imports from all sources are then expected to also affect demand for imports versus domestic goods.

20 In some instances, consumers may pay for services to "expedite" cargo in shipping or customs. To the extent these payments are made, the willingness to pay creates a revenue stream. Our focus is on trade facilitation, a set of rules and procedures which importers do not have to "pay" extra to receive the benefits. Likewise, we do not include estimates of the outlays governments may make to modify rules, procedures and systems.

21 The curve rotates due to the fact that only the willingness to pay of X_{i1} is being increased. As less X_{i1}, and more X_{i2}, is purchased the curves remain closer together.

22 As in the GTAP model, Hertel and Tsigas (1997).

Figure 3-1: Alternative treatments of preference changes

A: Rise in preferences	B: Twist of preferences
	

Source: Figure A adapted from Gandant and Markusen (2001). Figure B authors' analysis.

Changes in the average distribution parameter B_i^F from the lower level, relative to its average, then appear in the upper nest of domestic and foreign good substitution, just as average price changes affect the upper levels. If the preferences for one import have risen, then the preferences of imports in general have risen, relative to domestic goods and hence the changes in preferences should also impact the upper levels. For instance, we obtain the following demand equations at the domestic-import Armington level:

$$\hat{x}_i^F = \sigma_i\left(\hat{\beta}_i^F - \hat{\beta}_i\right) + \hat{x}_i - \sigma_i(\hat{p}_i^F - \hat{p}_i) \qquad (7)$$

and

$$\hat{x}_i^D = \sigma_i\left(\hat{\beta}_i^D - \hat{\beta}_i\right) + \hat{x}_i - \sigma_i(\hat{p}_i^D - \hat{p}_i) \qquad (8)$$

Where:

$\hat{\beta}_i^D$ is the percent change in the distribution parameters of the domestic good i;

$\hat{x}_i^D$ is the percent change in the quantity of domestic good i;

$\hat{p}_i^D$ is the percent change in the price of domestic good i;

$\hat{p}_i^F$ is the percent change in the price of foreign good i;

$\hat{\beta}_i$ are the percent change in the distribution parameters of good i from domestic and foreign sources;

$\hat{x}_i$ is the percent change in the quantity of good i from domestic and foreign sources;

$\hat{p}_i$ is the percent change in the price of good i from domestic and foreign sources; and

σ_i is the elasticity of substitution between domestic and foreign commodity i.

The inclusion of willingness to pay at the higher levels allows changes at lower levels to affect upper levels, just as they do when there is a change in the actual price. These changes in utility from consumption due to the increased willingness to pay for reductions in the time to trade appear in the two nested levels in this example, but they should appear at all levels of a particular nesting structure. Note that the inclusion of distribution parameters at all levels of the nesting structure also allows the user to impose changes in the distribution parameters at any level of the nesting structure, for instance, impose non-discriminatory changes in the willingness to pay for imports from any source or for domestic goods.

As mentioned above, $\hat{\beta}_i^D$ is the percent change in the distribution parameters of the domestic good i. It is assumed that the use of a preferable imported commodity by firms in the production of a domestic good also makes the domestic good more preferable, depending on the extent to which the imported good is used in the production of the domestic commodity.[23] Hence the

23 Note that this mechanism can be 'turned off' by the user, so that changes in the willingness to pay for imports does not impact demand for domestic commodities that use imported goods.

consumers' willingness to pay for the domestic good is the share weighted sum of any changes in the willingness to pay for its inputs in production:

$$\hat{\beta}_i^D = \sum_k \left[S_{k,i}^D \hat{\beta}_k^D + S_{k,i}^F \hat{\beta}_k^F \right] \qquad (9)$$

where: $S_{k,i}^D$ is the share of the domestic intermediate input k in production costs of good i

$S_{k,i}^F$ is the share of the imported intermediate input k in production costs of good i

This is consistent with the idea posited by Hummels and Schaur (2013) that faster delivery of intermediate goods through the supply chain improves final delivery times and increases the consumers' willingness to pay for the final product. The concept is based on the realistic observation that firms would only be willing to pay more for faster delivery of imported inputs if final households were willing to pay more for the domestically produced product because it employed the imported inputs in production. The extent to which the willingness–to-pay for domestic goods increases will depend on the share of the imports in its cost structure (equation (9)).[24]

Since, imports are domestically produced goods and services from other countries, the change in willingness to pay for the imported good will depend directly on the TFA shock applied plus any derived increase in the willingness to pay for the imported good resulting from the use of preferred (imported) intermediate goods used in its production (equation (9)). This derived willingness-to-pay is evident in the welfare numbers, which will be taken up in section 5.

3.2.1 UTILITY AND WELFARE

As Harrison, Rutherford and Tarr (1994) remark: "in most circumstances, economists are reluctant to consider changes in preferences as the basis for a policy exercise, in large part because the created difficulties in evaluating welfare measures, such as Hicksian equivalent or compensating variation" (p18 Harrison, Rutherford and Tarr, 1994). While others have chosen to avoid allowing changes in preference to impact welfare, it is the impact of changes in willingness-to-pay on welfare that is of interest in the analysis of the TFA.

It is expected that the changes in willingness to pay resulting from the implementation of the TFA would raise utility and hence welfare. With the inclusion of B_i^F in the demand function, the utility function itself does not change, although the utility is now derived from the composite quantity and distribution parameter B_i^F.

$$U_i^F = {B_i^F}^{-\frac{1}{\rho_i^F}} . X_i^F = \left[\sum_{j=1}^n B_{i,j}^F . \left(X_{i,j}^F \right)^{-\rho_i^F} \right]^{-\frac{1}{\rho_i^F}} \qquad (2a)$$

[24] An alternative interpretation is that faster delivery times can translate into reduced inventory costs, which would impact the final cost of the good or service. Here, we focus on the demand aspect of the willingness to pay.

Similarly, the changes in the distribution parameters are expected to directly impact the equivalent variation (EV), our measure of welfare. The impact on EV of the changes in the distribution parameters is the value weighted sum of the underlying changes in the distribution parameters.

3.2.2 CONTRASTING THE WILLINGNESS TO PAY WITH ALTERNATIVE APPROACHES

The willingness-to-pay approach can be compared to Dixon and Rimmer's (2007) approach which employs changes in tastes as a *twist* to preferences, but differs in some important aspects. First, in the willingness-to-pay approach the relative changes in the distribution parameters are multiplied by the relevant elasticity of substitution,[25] which allows the shock to be implemented as a change in ad valorem equivalent. Second, the willingness-to-pay approach assumes that the changes in these average distribution parameters affect utility and the upper levels of the nesting structure. Third, Dixon and Rimmer exogenously apply shocks to the quantities (X_{i1} or X_{i2}), and allow the distribution parameters to adjust endogenously to ensure Equation (3) continues to hold. If the ratio of prices is assumed constant, then the distribution parameters will adjust to fully offset the change in the ratio of quantities; however, prices are usually endogenous and therefore the distribution parameters adjust by the remainder required to ensure the new exogenous quantities and equation (3) hold. The approach developed by Dixon and Rimmer (2007) is used for incorporating historical information into baselines. *Twists* adjust preferences to match historical or expected future changes in demand or supply that cannot be explained by relative price changes. Since they are not trying to examine the impact of changes in preferences per se, they wish to implement these changes without affecting utility or welfare hence they do not allow these *twists* to affect higher levels of the utility nest. The Dixon and Rimmer (2007) *twist* is therefore equivalent to the rotation of the utility curve in Figure 3-1, panel B towards the new exogenously shocked ratio of quantities with no change in the average distribution parameter; for instance, $B^F_{i,1}$ rises and $B^F_{i,2}$ falls such that the average remains unchanged.

The GTAP model (Hertel and Tsigas, 1997) also includes some of these distribution parameters (*dppriv*, *dpsave*, *dpgov*) at the top level where the regional household allocates income across private and government consumption and savings.[26] These distribution parameters are also incorporated relative to an average, just as those included in the Armington under the willingness-to-pay method outlined above. These top-level distribution parameters are usually

25 Multiplication by the elasticity is not necessarily required since the parameters could also just be redefined to equal the distribution parameter to the power of the elasticity, although it would impact the shock applied...

26 In the case of the GTAP model, the distribution parameters are included at the top level which is essentially Cobb Douglas and hence the elasticity is equal to 1.

used to implement alternative macro closures, such as fixing government spending, savings or the trade balance. Like Harrison, Rutherford and Tarr (1994) and Dixon and Rimmer (2007), the welfare implications of altering these distribution parameters in the GTAP model have been adjusted to minimize their impact on welfare.[27] This ensures that decisions about closure do not give spurious welfare gains. Since we are interested in the implications for welfare, we adjust the welfare measure to allow the distribution parameters to have their full impact on welfare.

Finally, the willingness-to-pay method is somewhat different from the recalibration of elasticities undertaken by Harrison, Rutherford and Tarr (1994). In that case greater substitution between domestic and foreign goods was assumed which would increase the degree of substitution caused by future relative price changes or shocks, while in this case there is a one-off permanent change in the consumers' willingness to pay for the imported commodity. The willingness-to-pay method, outlined here, is more closely related to the approach discussed in Ganslandt and Markusen (2001).

3.3 The supply chain model and database

To compare the two methods for examining the impact of the WTO's Trade Facilitation Agreement we incorporate the willingness to pay theory outlined above into a CGE model—the ImpactECON global supply chain model and database. The supply chain model and database is an updated version of that developed in Walmsley, Hertel and Hummels (2014) and Hertel, Hummels and Walmsley (2014).[28]

The ImpactECON supply chain model differs from the GTAP model in that it tracks imports by both agent and source. The model relies on a detailed database of supply chains that contains the value of imports of commodity i, from region s, purchased by firm j located in region r, as well as bilateral imports of commodity i purchased by households, and by the government. With this additional data the model can account for how the TFA will impact OECD households' imports of light manufacturing from middle income countries differently from firms' demand for the same products. In Figure 3-2 the structure of the supply chain model

27 The impact of changes in the distribution parameters on welfare must be explicitly added to the welfare calculation using equation (10a), otherwise the changes in welfare due to changes in the distribution parameters will not be captured. In the case of the GTAP model, the impact of the distribution parameters on welfare has been partially incorporated. The extent to which they are included can be seen by examining the preferences component of the GTAP welfare decomposition (Hertel and Huff (2001) and McDougal (2003)). Given that the purpose of the distribution parameters in the GTAP model are to allow the user to change closures this approach to welfare is justified. For those interested in further details we refer you to McDougall (2003).

28 The supply chain database has been further revised with updated BEC concordances produced by the UN. Minor changes were also made to separate investment goods from final demand and to the balancing programs and model code.

(Figure 3-2B) is compared to the GTAP model (Figure 3-2A) structure. The figure illustrates three separate Arminigton equations in the supply chain model for each agent (*qips-private households*, *qifs-firms*, and *qigs-government*), as compared to the GTAP model where all agent imports are aggregated (*qxs*). This allows us to apply the iceberg and willingness-to-pay parameters directly into each agent's Armington equation (Equations (11), (12) and (13)), facilitating decomposition and comparison of the results by agent.[29]

Private household:

$$qips(i,r,s) = qpm(i,s) - aips(i,r,s) - ESUBM(i).\big(ppms(i,r,s) - aips(i,r,s) - ppm(i,s)\big)$$
$$+ESUBM(i).\big(dppms(i,r,s) - dppim(i,s)\big) \qquad (11)$$

Government:

$$qigs(i,r,s) = qgm(i,s) - aigs(i,r,s) - ESUBM(i).\big(pgms(i,r,s) - aigs(i,r,s) - pgm(i,s)\big)$$
$$+ESUBM(i).\big(dpgms(i,r,s) - dpgim(i,s)\big) \qquad (12)$$

Firms:

$$qifs(i,j,r,s) = qfm(i,j,s) - aifs(i,j,r,s)$$
$$- ESUBM(i).\big(pfms(i,j,r,s) - aifs(i,j,r,s) - pfm(i,j,s)\big)$$
$$+ ESUBM(i).\big(dpfms(i,j,r,s) - dpfim(i,j,s)\big) \qquad (13)$$

Where *aifs*, *aips* and *aigs* represent the iceberg variable (*ams* in the GTAP model) for firms, private and government agents respectively; and *dpfms*, *dppms* and *dpgms* represent the distribution parameters and *dpfim*, *dppim* and *dpgim* the average distribution parameters firms, private and government agents for the willingness-to-pay method.

As outlined earlier, it is assumed that domestically produced goods are also affected by changes in the willingness to pay for imported goods to the extent that imported goods are intermediate inputs in the production process. Note that these changes in willingness to pay affect all agents'—firms, households and firms—demand for imports, including the decision of whether to save or consume. Since the 'savings' good is dependent on the capital or investment good assembled in each region, demand for savings may also be affected by the change in preferences. To the extent that capital goods consist of the more preferable imported commodities, households may choose to save more as a result of the reduction in time to trade. Since savers will change their savings behavior as a result of the reduction in time to trade, it is

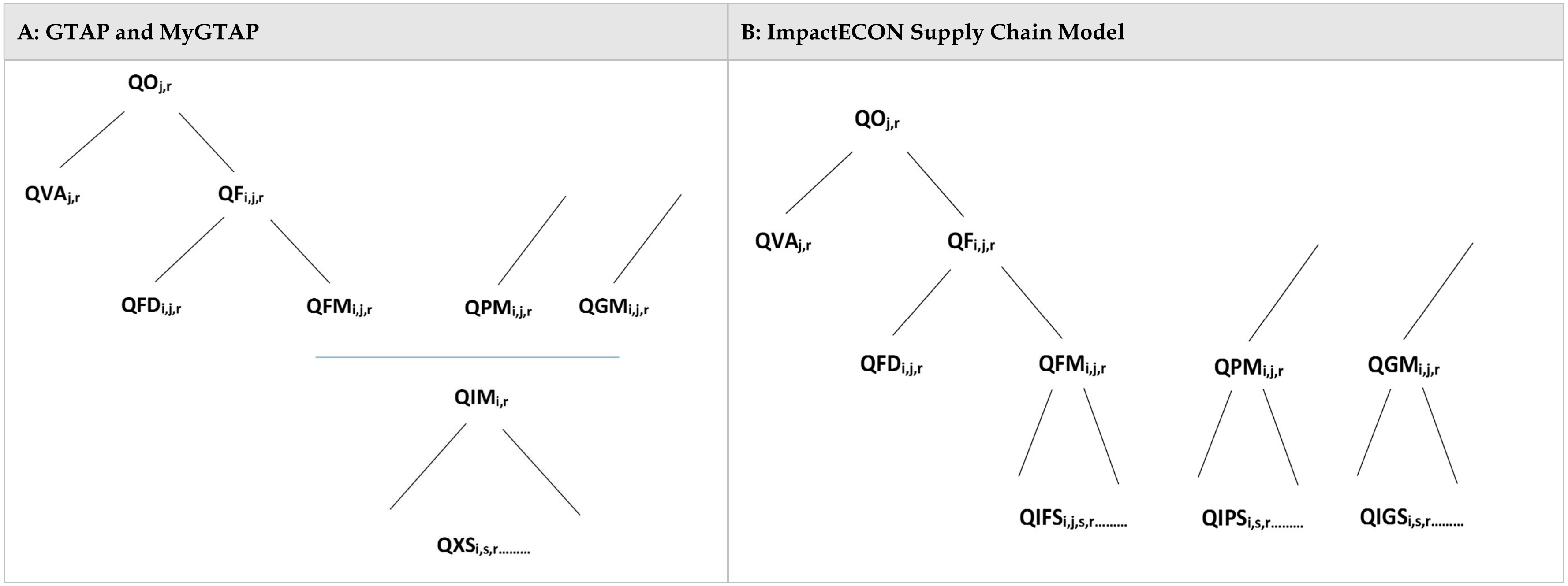
29 For those familiar with GTAP notation, this is akin to the Armington equation seen below, where the second line is added to reflect willingness-to-pay:
$qxs(i,r,s) = qim(i,s) - ams(i,s) - ESUBM(i).\big(pms(i,r,s) - ams(i,s) - pim(i,s)\big)$
$+ESUBM(i).\big(dpms(i,r,s) - dpm(i,s)\big)$

reasonable that investment, funded by that savings, will also be affected by the reduction in time to trade. To include this in the model we assume that the increase in willingness to save flows through to the investment allocation, such that countries with greater willingness to pay for capital goods are also allocated more of the global savings (i.e., more investment occurs in that country).

The impact of the changes in the distribution parameters are then incorporated into the equivalent variation measure and into the Hertel and Huff (2001) welfare decomposition. The impact on EV of the changes in the distribution parameters is a value weighted sum of the underlying changes in the distribution parameters. This is most easily achieved by summing the changes in the average distribution parameters at the top level, since the average distribution parameters at the top level are aggregates of the lower level distribution parameters that include changes in the willingness to pay of both domestic and imported goods purchased by all agents.

With the model adapted, the supply chain database is then aggregated to seven commodities and five regions for the analysis (see Appendix). The choice of aggregation reflects the need to disaggregate those sectors and regions most affected by the TFA, while recognizing that the primary purpose of this paper is to illustrate theoretical differences between the two proposed methods, rather than provide detailed policy analysis. The ad valorem equivalents for implementing the TFA are developed and outlined in the following section. In Section 5 these ad valorem equivalents are then applied to the CGE model using the two alternative methods: iceberg and willingness-to-pay. The initial shocks applied to the iceberg and willingness to pay variables are therefore identical, facilitating comparison. A standard neoclassical closure with full employment and perfectly competitive firms is assumed. The results are examined and compared in Section 5.

Figure 3-2: Production and Armington structures



4 TFA impacts on customs clearance times

WTO members concluded negotiating the TFA at the Bali Ministerial in December of 2013. The TFA will enter into force once two-thirds of WTO members ratify it.[30] When the TFA is ratified, WTO members will be required to implement changes to customs rules and procedures such as improved information and reporting, advanced rulings, reporting fees and charges, document simplification, automation and coordination. Efficiency in customs is expected to reduce costs of compliance and time required to move goods through customs. The analysis in this paper estimates the economic impacts of one element of the TFA: its promise to move goods through customs more rapidly. Specifically, we estimate the reduction in customs clearance times which could result from the TFA and importer's willingness to pay for goods shipped with shorter delivery time.

Once the TFA is ratified, it is to be phased in over several years, with flexibilities for developing and least developed countries, commonly referred to in the Doha Round as special and differential treatment. For example, developing countries will have to notify the WTO of their intention to implement the TFA in three stages: 1) elements which will be implemented upon ratification of the agreement; 2) elements they will implement in the future (with firm dates); 3) elements for which they will require donor assistance. These flexibilities make it impossible to predict when the TFA will be fully implemented. We therefore assume, in our analysis, that all elements of the TFA are implemented and all parties advance their performance to best practices. As we outline in Section 4.1, the advancement of a country to best practices does not mean they will all experience the same customs clearance times. Our analysis takes into account a country's size and level of development when estimating outcomes in terms of customs clearance times.

30 As of December 10, 2015, 57 countries out of 162 WTO countries have ratified the agreement.

4.1 Modeling customs clearance times

To estimate the potential reduction in customs clearance times resulting from the WTO TFA, we employ two data sets: the World Bank Doing Business (DB) Trading Across Borders Data and the OECD Trade Facilitation Indicators (TFI) (Moise, Orliac, and Minor 2011).

The World Bank's DB Trading Across Borders data set, a subset of its Doing Business Indicators, includes estimates for each of three stages of exporting and importing: inland transport, customs clearance, and port handling times. Times are surveyed for a sample of representative products.[31] Our research focuses on customs clearance times, since we are interested in an importer's willingness to pay to receive a good earlier than latter. The time to prepare documents is excluded as a variable since documents can be prepared at various stages of production, shipping and delivery and often occur in parallel with the activities of shipping and production. The variable of interest for our purposes is freight movements. Port handling, which does impact freight movement, is not likely to be significantly impacted by the TFA, but would instead be impacted by infrastructure investment, and hence is also excluded.

The DB-Trading Across Borders data reports time to clear customs in discrete days. So, a good which requires 0.5 days to clear customs for one country and 1.4 days to clear customs in another country will both be recorded as 1 day due to rounding.[32] This attribute of the Trading Across Border data results in a large number of data estimates clustering in the order of one, two or three days to clear customs. Recent research conducted by the World Bank (Hillberry and Zhang 2015) recognizes the error introduced by this rounding and estimates a non-linear model of "discrete time transition" to account for the non-continuous nature of the values and the rounding of time into days. While this approach is warranted, it comes with its own limitations. Notably, due to the non-linear form of the model coefficients are not easily interpreted, therefore, Hillberry and Zhang employ simulations to illustrate the importance of individual variables, in contrast to a linear model, where direct interpretation of coefficients is possible along with confidence intervals.[33] We elect to employ the linear model, for two reasons. First, to test alternative model structure, along with its strengths and limitations. Second, the World Bank Doing Business survey recently changed its methodology to provide time measured in number of hours, in contrast to earlier reporting in days, meaning future research will likely be based on a variable well suited to the linear model, proving an

31 For a description of the methodology, see: http://www.doingbusiness.org/data/exploretopics/trading-across-borders/what-measured

32 Starting with the 2015 DBI-Trading Across Borders data, times are recorded in hours, not in days, providing a more precise measures.

33 The interpretation of a co-efficient in a linear model will depend on the form of the data. For example, a log on log transformation can be interpreted as an elasticity.

opportunity to assess the differences in the data sets, holding the methods constant.[34] We contrast our results with Hillberry and Zhang where helpful.[35]

In order to reduce the error entered into our model from the non-continuous values of customs clearance times, we average three years of the DB-Trading Across Borders. Since the other dataset we are using, the OECD TFI data, corresponds to the period 2010-2011, we choose to average the DB-Trading Across Borders data for the three years around this period – i.e, 2010 to 2012. The resulting averages for each country in the DBI-Trading Across Borders data set then become our dependent variable.

We employ a multiple linear regression. As mentioned above, the dependent variable is an average of the days to clear customs. For the independent variables, we use the OECD Trade Facilitation Indicators collected over the 2010-2011 period (Moise et al. 2011). The OECD TFIs include 12 variables covering the major aspects of the WTO TFA.[36] The 12 indicators include: information availability, involvement of the trade community, advanced rulings, appeal processes, fees and charges, formalities—documents, formalities-automation, formalities-procedures, cooperation-internal, cooperation-external, consularization, governance and impartiality.

The OECD TFIs were collected for 133 countries. The TFI index for a given customs element such as documents or customs fees and charges, ranges from 0 to 2 with "2" indicting full implementation of customs procedures in line with the WTO TFA. We regress each of the TFI variables (independents) on the DB-Trading Across Borders data (dependent) "time to clear customs" import and export number of days reported separately. We tested several variables such as land area, GDP, and a country's access to a port (landlocked), per capita GDP and an indicator for OECD membership.

The model fit or adjusted R^2, is approximately 0.5, indicating our model explained about 50 percent of the variation in import and export clearance times. Achieving this fit required modification in sample size and variable selection. In our sample, the TFI variable for governance and impartiality was found to interact with per capita GDP. We therefore elect to use the per capita GDP variable, since it provides a control variable for governance and is more graduated then the OECD indicator.[37]

Of the TFI variables, for import clearance times, only fees and charges, formalities-documents and formalities procedures were found to be significant along with the non-TFI variables per

34 Currently, published 2015 DB-Trading Across Border data combine port and customs delays.

35 While this methodology was developed at approximately the same time as Hillberry and Zhang, our paper benefited from the sharing of results with Hillberry at early stages. We wish to thank Russell Hillberry for his generosity with sharing results.

36 While these twelve indicators were developed to correspond to the major TFA areas, they were also crafted to reduce the possibility of co-linear variables which would impede their usefulness in statistical analysis.

37 The use of real GDP as an independent variable is also likely to reflect other potential attributes in addition to governance, thereby simplifying the estimation procedure. Since the estimation and the paper are focused on the WTP, further exploration of this issue is left for future work.

capita GDP and the OECD indicator. A similar regression was found for exports, except that fees and charges was not significant in that case. The remaining TFI variables were not found to be significant, and they often carried the wrong sign, indicating they were a poor fit in our linear regression.

Perhaps a limitation of our approach is that missing variables in many indicators reduced the sample size by 40 percent or more. This fact is notable, since complete information on these variables might well improve their significance as they would contribute to a larger data set. It's important to note, our work stands in contrast to Hillberry and Zhang 2015, since their research method employed a "multiple imputation (MI)" method to fill missing data.[38] An important difference in our results is that the variable Formalities—automation, which was found to be a significant factor in Hillberry and Zhang was not found to be significant when the variables for Formalities—documentation and Formalities—procedures were included in our model. It was a significant variable when it was included on its own—without other formality variables. In conclusion, while there appears to be a strong case for the impacts of trade facilitation on customs clearance times, it is less clear exactly which elements of the TFA are operatively important. Complete data are required to discriminate the importance of specific elements of the TFA. Our goal is to estimate the potential economic impacts of the TFA, not to determine which elements are most significant, so we employ the model as specified earlier, since its predictive power is relatively high.

Table 4-1 illustrates the fit of our model for import customs clearance times. All variables are significant to the five percent level except fees and charges, which is significant at the six percent level. Including fees and charges improved the overall fit of our model, so we maintain it.

Table 4-1: Estimates of log number of days to clear customs—imports

Variable	Parameter Estimate	Standard Error	Significance
Intercept	2.76314	0.33821	<.0001
E-Fees and charges	-0.18261	0.09606	0.0605
F-Form-Documents	-0.28854	0.11243	0.0119
H-Form-Procedures	-0.31187	0.14294	0.0317
Log per capita GDP	-0.08883	0.04228	0.0384
OECD indicator (0 or 1)	-0.66688	0.14978	<.0001

Source: Linear regression. F< .0001; Adj-R 0.512; OBS=97.

ln(average customs clearance time-days) = B_0+B_1 *(TFI_E)+*B_2*(TFI_F)+*B_3*(TFI_H)+*B_4*(PCGDP)+*B_5*(OECD).*

38 The 2010-2011 OECD TFI data set include 130 observations. Our estimation data set included 97 observations, after eliminating observations with missing variables and insignificant variables. Requiring the inclusion of all insignificant variables would reduce our dataset to approximately 75 observations. In contrast, Hillberry and Zhang employ a data set with 180 observations, suggesting imputation of variables for a range of 50 (39 percent) to 105 observations (80 percent of observations).

Table 4-2 illustrates the fit for the days to clear customs for exports. All variables are significant to the five percent level. We note, the adjusted R is slightly lower than the import model.

Table 4-2: Estimates of log number of days to clear customs—exports

Variable	Parameter Estimate	Standard Error	Significance
Intercept	2.42939	0.31472	<.0001
F-Form-Documents	-0.39141	0.10499	0.0003
H-Form-Procedures	-0.26343	0.12967	0.0451
Log per capita GDP	-0.09614	0.03948	0.0168
OECD indicator (0 or 1)	-0.56082	0.13723	<.0001

Source: Linear regression. F< .0001; Adj-R 0.48; OBS=97.

ln(average customs clearance time-days) = $B_0+B_1\,(TFI\_F)+B_2(TFI\_H)+B_4(PCGDP)+B_5(OECD)$.

4.2 Estimated reduction in days to clear customs

From the regression equations in Table 4-1 and Table 4-2 we estimate the number of days to clear customs when each of the indicators is set to "2" for full compliance with the TFA. This estimate of full compliance is then subtracted from the actual DB-Trading Across Borders estimate to provide an estimate of the potential reduction in customs delays which can be attributed to the TFA.[39] The estimates from this calculations, the reduction in customs delays, are reported in Table 4-3. High income OECD countries have the lowest reduction in customs delays for imports, just 0.6 days in total. This relatively low value is due to the fact that many high income OECD countries already satisfy the requirements of the TFA. In contrast, other regions see a reduction in import customs delays of 0.9 to 1.9 days.[40]

The TFA will effect customs clearance for both imports and exports. Up to now, we have focused on reduced customs clearance times for imports. Exports require their own customs procedures and estimates of the reductions in these delays must be considered in turn. In our analysis, a day reduction in export delays is treated equivalent to a day reduction in import delays—what is important is the total delivery time. In order to represent this important

39 It has been suggested that employing a barrier free benchmark, such as trade between EU customs union members could be useful in estimating the potential of the TFA to lower customs barriers. It is worth noting, the TFA objectives are substantially different from a customs union. The current estimation technique focuses on just the elements of customs the TFA will impact and it takes into account the socioeconomic stage of development of each WTO member (each member will have different experiences implementing the TFA based on their level of development).

40 Our estimates of reduced customs delays compare surprisingly well with Hillberry and Zhang (2015), who report a simple average reduction in import customs clearance times due to the TFA of 1.7 days. The comparable number from our simple linear model is 1.6 days for imports.

element, we trade weight estimated reductions in export delay times for an importing country's trading partners, which is presented in Table 4-3 as exports-partners. In the case of reduced delays for exports, most countries are projected to reduce shipping delays by 0.8 to 0.9 days.[41] The total number of day reduction in shipping delays for each region is the combination of the reduced delays by their exporting partners and their own customs delays.

Table 4-3: Estimated number of days reduction in customs clearance times due to TFA

Customs point	High Income OECD countries	High Income non-OECD countries	Middle Income countries	Low income countries	Rest of world
Imports-own	0.6	1.2	1.4	1.9	0.9
Exports-partners	0.8	0.9	0.9	0.9	0.9
Total	1.4	2.1	2.2	2.7	1.9

Source: Authors' estimates based on all TFI indicators set to best practice. Estimates are trade weighted averages.

4.3 Willingness to pay to avoid delays

In the prior section we estimated the potential reduction in customs clearance times due to the TFA in days. The model requires that a value be assigned to time as measured in dollars or in ad valorem equivalents of existing values. Hummels et al. (2007) estimate the willingness to pay of US importers to pay to reduce international shipping times by Harmonized System (HS) four digit categories. Similar to the modeling method applied in this paper for willingness to pay, Hummels et. al. (2007) outline a demand system where a "quality shifter" is estimated as the consumer's perception of quality stemming from timely delivery. Other things being equal, consumers get more utility from a good which arrives sooner than later. In order to estimate the willingness to pay for reduced delivery, Hummels' et. al (2007) and Hummels (2001) employ a data set of US imports divided between air and ocean transport along with the difference in shipping via either mode and the time savings implied by employing airfreight over ocean freight. Consumers reveal their willingness to pay to reduce shipping times by modal choice and the price premium they pay per day saved is the willingness to pay for more rapid delivery. The willingness to pay for reduced time delays are expressed in ad valorem equivalents (like import taxes, however, no revenue is recorded, since it is a willingness to pay, not actual payment). Table 4-4 summarizes the trade weighted ad valorem equivalents of the willingness to pay to reduce international shipping times by country income group. Importantly, the trade weighted average of high income OECD countries is the lowest, at 0.45

41 Our estimates of reduced customs delays contrasts with Hillberry and Zhang (2015), who report an average reduction in customs clearance times for exports of 2 days (this amounts to a total elimination of delays for exports in their model). The comparable number from our linear model is 0.9 days, or less than half.

percent per day. Values for other regions range between 0.71 percent and 0.81 percent. The relatively low value of the willingness to pay for reduced shipping times by high income OECD countries results from an important attribute of our data for that region. The TFA is projected to bring customs clearance processes to WTO standards, in the case of the European Union (EU), many of those countries already have free movement of cargo across EU borders—they are a customs union. In order to account for this aspect, and to not overestimate the impacts of the TFA, we set the willingness to pay for reduced shipping times to zero for intra-EU trade. This is unlikely to be accurate, all traders are likely to value reduced shipping times. However, our model structure requires that a single estimate of customs clearance times can be entered per agent per country. Reducing the value of time to zero for intra-EU trade is equivalent to reducing the estimated reduction in customs clearance times due to the TFA to zero—it has the desired effect of eliminating intra-EU TFA effects to zero.

Table 4-4: Willingness to pay for reduced shipping times (percent ad valorem equivalent per day)

High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world
0.45	0.71	0.74	0.81	0.76

Source: Authors' calculation from Hummels et al. (2007).

In the following section, the underlying data from Table 4-3 and Table 4-4 are combined to create the total ad valorem equivalent of the willingness to pay for the reduction in international shipping times resulting from our estimated impacts of the TFA on customs clearance times.

4.4 TFA shocks

The data in Table 4-3 show the reduction in customs clearance times in number of days and can be merged with detailed data on the willingness to pay to reduce shipping delays which are summarized in Table 4-4. Table 4-5 illustrates the combination of the two data sets, number of days reduction in customs clearance times with the willingness to pay for reduced shipping times. The data in Table 4-5 illustrate the changes or shocks applied to the model in Section 5.

Before beginning with the analysis it is useful to examine the shocks applied under the TFA. Table 4-5 provides the trade weighted shocks applied by commodity and importing country, by commodity and exporting country, by importing agent and country and bilaterally. The averages depend on the time to trade estimates and on the trade shares—in terms of partners and commodities. The largest changes occur for the low income economies, which tend to be hampered by inefficient customs procedures. The high income OECD countries, on the other hand, have the smallest shock. This is due to the fact that they trade mostly with other high income OECD countries, where the opportunities for reducing customs delays under the TFA are limited. The rest of the world as an exporter also gains very little (see bilateral shocks, Table 4-5). This is due to the fact that the rest of world region primarily export oil, gas and coal – where willingness to pay does not rise. In terms of commodities there are no shocks to basic extraction (coal, oil and gas) or services. The largest shocks tend to be on other mining and extraction, which includes precious metals, such as gold, base materials, such as marble and tiles, followed by manufactures and then agricultural goods.[42] Finally, most of the increased willingness to pay occurs for firms and private households, with government's willingness to pay relatively small in most cases, due to low consumption of imports. As mentioned above the same shocks are applied under both methods. The average shocks by commodity and importer represent those applied to the Armington under both methods.

42 Estimates of the willingness to pay for extractives, in general, were subject to limited observations, in part due to the fact that they are not frequently transported by air freight, a key variable in estimating the willingness to pay for reducing shipping delays.

Table 4-5: Average TFA shocks (percent ad valorem equivalents)

	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world
TFA shocks (commodity by importer)					
Primary agriculture	0.46	1.00	0.55	0.19	0.20
Processed agriculture and food	0.46	1.32	1.27	1.38	1.05
Oil, coal and gas	0.00	0.00	0.00	0.00	0.00
Other mining and petroleum	1.26	1.47	2.11	4.07	2.39
Light manufactures	0.53	1.64	1.51	2.53	1.09
Heavy manufactures	0.83	1.98	2.15	2.65	1.66
Services	0.00	0.00	0.00	0.00	0.00
TFA shocks (importing agent by importing country)					
Firms	1.29	0.56	2.20	2.20	1.60
Private households	1.61	0.68	2.12	2.12	1.47
Government	1.56	0.10	0.31	0.31	1.85
TFA shocks (commodity by exporter)					
Primary agriculture	0.27	0.27	0.88	0.47	0.50
Processed agriculture and food	0.61	1.05	0.95	1.15	0.60
Oil, coal and gas	0.00	0.00	0.00	0.00	0.00
Other mining and petroleum	1.02	2.89	1.74	1.64	1.19
Light manufactures	0.61	1.08	0.92	1.45	0.75
Heavy manufactures	1.16	1.44	1.58	5.01	2.28
Services	0.00	0.00	0.00	0.00	0.00
Bilateral TFA shock (exporter by importer)					
			Importers		
Exporters:					
High income OECD countries	0.47	1.58	1.71	1.71	1.12
High income non-OECD countries	0.65	0.56	1.33	2.93	1.15
Middle income countries	0.88	1.34	1.64	2.14	1.41
Low income countries	1.11	0.97	1.83	3.93	1.81
Rest of world	0.39	0.79	0.58	0.56	0.77

Note: Country and sectoral definitions provided in Appendix.

Source: Authors' calculations based on Table 4-3 and Table 4-4. The shock is calculated as the reduced number of days delay in import and export customs times the average daily ad valorem equivalent of the willingness to pay for reduced shipping delays.

5 Results

In this section, the CGE model results showing the impact of the TFA are examined and the two methods compared. First, the macroeconomic implications are examined, followed by sectoral results and finally the welfare implications and decomposition.

5.1 Macro implications

The impact of the TFA on real GDP is illustrated in Table 5-1. Real GDP rises in all countries although the percent changes are greatest in the low income countries where the estimated reduction in customs delays from the TFA are greatest (Table 4-3 and Table 4-5). Moreover, the low income countries trade more intensely with countries outside of the high income OECD, where the benefits from reducing time to trade are also higher.

As expected the impact of the TFA agreement on real GDP differs considerably depending on the method used to implement the TFA agreement the CGE model. The iceberg method causes a technological change that raises real GDP, relative to the willingness-to-pay method. Table 5-1 decomposes these changes in real GDP calculated based on income into changes in factor incomes, taxes and technological change. The table shows that between 85 and 98 percent of the gains in real GDP under the iceberg method are due to technological change—that is the increase in consumption caused by getting more imports than were purchased. Most of these technological gains (at least 70 percent) are due to the improvement in productivity imposed on imported intermediates purchased by firms and used in production, although up to 28 percent of the gains in real GDP are due to increased "productivity" of private households' imports (Table 5-1). While productivity gains obtained by importing firms from trade facilitation may reduce a firm's costs of production, leading in turn to more efficient allocation of resources and increased domestic production in the importing country, the mechanism by which "productivity" gains obtained by private and government consumers' raises real GDP is ambiguous. National accounting in the GTAP model attributes the increase in final consumption relative to imports as an increase in real GDP, even though there is no corresponding increase in domestic production.[43] This suggests that up to a third of the gains in real GDP, resulting from the increased "productivity" of private household and government imports, are not matched by increases in domestic production, and are therefore probably more accurately described as increases in the "effective quantity", quality or utility of the consumed imported commodities—which are not part of the definition of GDP.

Table 5-1: Decomposition of TFA impact on real GDP based on income (percent changes)

	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world
ICEBERG					
Factors	0.00	0.00	0.00	0.00	0.00
Taxes	0.00	0.03	0.09	0.17	0.04
Technological change					
Of which:					
Firms	0.11	0.40	0.43	0.64	0.34
Private households	0.05	0.18	0.08	0.22	0.17
Government	0.00	0.03	0.01	0.00	0.00
Total - real GDP	0.16	0.63	0.60	1.03	0.56
WILLINGNESS TO PAY					
Total - real GDP	0.01	0.07	0.14	0.29	0.09

Note: Country definitions provided in Appendix.

Source: Authors' calculations.

In Table 5-2, the impact on real GDP is further decomposed according to the agent importing the commodity. The supply chain model allows us to examine each importing agent separately. Although firms are the most significant source of real GDP gains in both methods, we find that the willingness-to-pay method increases the relative importance of households. The increasing importance of households under the willingness to pay approach stems from the fact that households tend to purchase more domestic goods and services (which purchase imported intermediate goods)—both of which experience increased preferences under the willingness to pay approach, but not the iceberg approach, as increased willingness to pay for imported intermediates feeds into increased willingness of consumers to pay for the domestically produced goods and services.

Table 5-2 also illustrates the impact of the TFA on several macroeconomic variables, such as trade, prices and investment under the two methods. Trade rises more under the willingness-

43 To clarify, real GDP is traditionally calculated as C + I + G + X – M. Under, the iceberg method C and G rise as final consumers consume more imports due to the decline in spoilage, however actual imports (M) purchased and exported from abroad remain unchanged. The result is a rise in real GDP, even though the additional goods consumed were not produced domestically, nor did they raise the productivity of domestic producers.

to-pay method; global trade rises by 1.96 percent under the willingness-to-pay method and by 0.98 percent under the iceberg method. The cause of greater trade under the willingness-to-pay method is straight forward—the willingness-to-pay method increases an agents' import demand to satisfy the increased utility they receive from them, while the iceberg method allows agents to buy less imports to satisfy the same import demand (utility).

Imports rise by a higher percentage in most countries, except the high income OECD countries and the rest of the world, where exports rise more, regardless of the method used. This is due to the smaller shocks imposed under the TFA on the high income OECD countries and the rest of the world (Table 4-5). With the smaller shocks, imports rise less in the high income OECD countries and the rest of the world, however, they still benefit from the other countries increasing their imports, resulting in an increase in demand for the exports of the high income OECD countries and the rest of the world exports.

Of course, there remains the question of which measure of trade should be used; we are using imports valued at c.i.f world prices (*qiwreg* for those familiar with the GTAP model) and exports at f.o.b. world prices (*qxwreg*). These measures of trade do not include the iceberg cost changes; they reflect changes in the quantities of goods actually sent from the exporting country to the importing country. When aggregated over regions, taking account of transport margins, the change in total global exports equals that of global imports when employing these variables, approximately 0.98 for the iceberg method and 1.96 for the willingness-to-pay method.

Imports inclusive of iceberg effects, aggregated over commodities using market prices (based on *qim*), are also included in Table 5-2 to illustrate the inconsistency regarding the appropriate variable to report. We refer to these as *qimreg* to reflect the fact that these are the quantities (or effective quantities) available to consumers in the importing region at market prices. Under the iceberg method, the changes in imports inclusive of iceberg effects (*qimreg*) are significantly higher than the changes in imports (*qiwreg*) actually sent by the exporter. In contrast, the two measures of imports are consistent under the willingness to pay approach and provide the same results.[44]

The similarity in the magnitudes of the iceberg augmented imports (*qimreg*) found under the iceberg method and the willingness-to-pay imports (*qiwreg* or *qimreg*), masks a significant source of difference between the two approaches. Under the iceberg effect, the fact that importers receive more imports without having to buy the corresponding amount of exports, because of the receipt of previously lost goods, translates into the productivity gain that raised

44 Technically, the two variables will not provide identical results due to difference in imports valued at world prices, exclusive of tariffs and fees, and imports valued at domestic market prices that do include taxes. But for these differences, the results would be identical.

real GDP (Table 5-1). Under the iceberg method, there is no equivalence between these iceberg-inclusive imports and exports, so it is difficult to justify comparing imports and exports with the iceberg effect included.[45]

As a result of the increases to real trade volumes, prices tend to rise more in the willingness-to-pay method than under the iceberg method (see export and import prices under the terms of trade results in Table 5-2). Prices fall under the iceberg approach as the costs of production have fallen due to the productivity change. Under the willingness to pay approach, prices rise, as firms and hence factors are able to capture most of the increase in consumers' willingness-to-pay. Nominal wages and returns to factors therefore rise more under the willingness-to-pay method. Real factor returns rise further under the iceberg method, due to the general fall in prices caused by the productivity effect and related cost reductions.

Investment rises in both methods, due to the increased rates of return resulting from higher returns to capital relative to the price of capital goods. Although investment is greater under the iceberg method, because of the relatively higher real returns to capital and greater decline in the price of capital goods, the gains under the willingness-to-pay method are larger than expected given the differences in rates of return and real GDP gains. This is due to increased global savings, resulting from the higher willingness to pay for imported heavy manufactures, an important input into the assembly of capital goods. With more global savings, this is then allocated across regions based on the rate of return and increased willingness to pay.

45 Unless the modeler wishes to emphasize the amount of spoilage or loss no longer occurring or the extent of the reduction in production costs, in which case both should be presented.

Table 5-2: Impact of TFA on macroeconomic variables (percent changes)

	Iceberg method					Willingness-to-pay method				
	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world
Real GDP	0.16	0.63	0.60	1.03	0.56	0.01	0.07	0.14	0.29	0.09
of which										
Firms	0.11	0.42	0.50	0.76	0.39	0.00	0.04	0.11	0.19	0.06
Households	0.05	0.18	0.09	0.27	0.17	0.01	0.03	0.03	0.10	0.03
Government	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports*	0.84	0.82	1.42	0.67	1.90	1.58	0.37	3.76	1.58	3.16
Imports*	0.57	0.90	2.16	2.68	1.24	1.22	2.38	3.92	4.68	2.14
Imports inclusive of iceberg effects**	1.14	2.32	3.80	4.90	2.46	1.22	2.43	3.97	4.74	2.18
Terms of Trade	-0.03	-0.03	0.07	0.89	0.07	-0.16	0.19	0.27	1.00	0.21
Export prices	-0.38	-0.38	-0.30	0.62	-0.24	-0.13	0.24	0.33	1.20	0.27
Import prices	-0.36	-0.35	-0.37	-0.26	-0.31	0.03	0.05	0.06	0.20	0.07
Real wages of										
Skilled	0.19	0.87	0.71	1.67	1.05	-0.06	0.06	0.13	0.77	0.18
Unskilled	0.17	0.75	0.57	1.33	0.88	-0.06	0.03	0.09	0.49	0.12
Real rental on capital	0.18	0.78	0.56	1.36	0.80	-0.06	0.10	0.09	0.57	0.11
Investment	0.07	0.51	0.69	1.67	1.75	-0.12	0.46	0.53	1.44	1.01

**Exports are obtained using the variable qxwreg and imports, qiwreg. These measures reflect trade at world prices (f.o.b and c.i.f respectively) and are based on exported quantities, not amounts received by the importer, which are larger than exports due to the iceberg effect losses.*

***Imports inclusive of iceberg effects are imports aggregated using market shares (qimreg). The differences between 'imports' and 'imports inclusive of iceberg effects' is the increase in quantity caused by the TFA when using the iceberg method. Under the iceberg method, the TFA increases the quantity of imports received relative to those sent from abroad. Under the willingness-to-pay method the TFA does not impact quantities like the iceberg effect and hence the two definitions of imports are identical.*

Source: authors' calculations

5.2 Trade and production

Table 5-3, Table 5-4 and Table 5-5 provide the sectoral results due to the estimated impacts of the WTO TFA. In general, the results show that trade rises in commodities and sectors where the TFA shocks were the largest. Real trade volumes under the willingness-to-pay method are generally larger than under the iceberg method, as expected (Table 5-3 and Table 5-4). Low income economies increase production (Table 5-5) and exports (Table 5-3) of heavy manufactures the most, due to the higher TFA shocks for these goods. Trade in oil, gas and coal and services falls due to the fact that these are not affected directly by the TFA shock. The decline in oil, gas and coal and services is smaller under the willingness-to-pay method because the use of more preferred intermediate (imported) inputs in their production causes some increase, albeit small, in the willingness to pay for coal, oil and gas and services. For services, these positive indirect effects under the willingness-to-pay method are larger.

The impact on output (Table 5-5) under the two methods is similar, with what appear to be larger gains (or smaller losses) in output under the willingness-to-pay method, particularly in manufactures and other mining. This is surprising given the fact that real GDP changes found under the iceberg method are much larger than those found in the willingness-to-pay method, however at least part of that productivity shock is applied directly to final consumers (private households and government) and therefore does not benefit domestic production. Under the willingness to pay method, the increase in exports translates into increased production, since there are no productivity gains.

Table 5-3: Impact of TFA on exports at world f.o.b prices (percent changes)

	Iceberg method						Willingness-to-pay method					
	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world	World total	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world	World total
Primary agriculture	0.44	1.21	0.89	-3.86	-0.01	0.52	0.56	1.57	1.78	-2.56	1.00	0.99
Processed agriculture and food	1.05	2.86	0.51	-2.08	-0.97	0.87	1.55	3.74	1.38	-0.30	0.18	1.54
Oil, coal and gas	-0.07	-0.78	-0.27	-1.75	-0.23	-0.44	0.38	-0.74	0.06	-1.45	0.14	-0.20
Other mining and petroleum products	-0.21	4.28	0.93	-2.90	-0.58	0.93	0.95	6.77	3.02	-0.11	0.85	2.62
Light manufactures	0.60	3.09	1.49	1.18	-0.19	1.06	1.17	4.01	2.33	3.38	1.20	1.79
Heavy manufactures	0.77	1.29	3.54	21.75	6.09	1.50	2.08	2.68	5.35	29.81	9.64	2.95
Services	0.59	0.33	-0.66	-3.78	-0.93	0.30	0.74	0.24	-0.60	-3.39	-0.49	0.42

Note: Country and sectoral definitions provided in Appendix.

Source: authors' calculations.

Table 5-4: Impact of TFA on imports at world c.i.f prices (percent changes)

	Iceberg method						Willingness-to-pay method					
	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world	World total	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world	World total
Primary agriculture	0.08	0.66	1.39	2.35	0.63	0.53	0.56	1.49	1.91	2.07	0.44	1.01
Processed agriculture and food	0.34	0.94	2.28	3.59	1.22	0.88	0.75	2.14	3.54	4.78	1.89	1.56
Oil, coal and gas	-0.48	1.06	-0.63	-3.38	-1.03	-0.44	-0.34	1.98	-0.28	-3.04	-0.71	-0.20
Other mining and petroleum	0.56	1.22	1.43	2.24	1.42	0.91	1.92	2.95	3.63	5.84	3.66	2.61
Light manufactures	0.61	1.38	3.22	5.96	1.74	1.08	1.09	2.91	4.80	8.43	2.48	1.81
Heavy manufactures	1.03	1.05	2.96	2.48	1.57	1.51	2.02	3.21	5.42	5.30	2.98	2.97
Services	-0.12	0.22	0.81	2.81	0.87	0.10	-0.20	0.09	0.63	2.45	0.44	-0.01

Note: Country and sectoral definitions provided in Appendix.

Source: Authors' calculations.

Table 5-5: Impact of TFA on output (Percent changes)

	Iceberg method						Willingness-to-pay method					
	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world	World total	High income OECD countries	High income non-OECD countries	Middle income countries	Low income countries	Rest of world	World total
Primary agriculture	0.03	-0.12	0.05	-0.19	-0.08	0.02	0.03	-0.23	0.01	-0.30	-0.08	-0.01
Processed agriculture and food	0.12	0.03	-0.08	-0.77	-0.70	0.01	0.11	-0.08	-0.09	-0.65	-0.69	-0.00
Oil, coal and gas	-0.12	-0.17	-0.33	-0.68	-0.36	-0.23	0.13	0.07	-0.07	-0.35	-0.02	0.02
Other mining and petroleum	-0.49	1.18	-0.62	-3.53	-1.14	-0.40	-0.31	2.05	-0.27	-3.21	-0.81	-0.09
Light manufactures	-0.15	-0.56	0.00	-0.20	-1.09	-0.13	-0.08	-0.52	0.21	0.94	-0.84	-0.01
Heavy manufactures	-0.44	-1.31	-0.86	1.24	-0.63	-0.61	0.15	-0.65	-0.24	3.56	0.58	0.00
Services	0.08	0.28	0.28	0.49	0.33	0.13	-0.02	0.04	0.08	0.29	0.09	0.00

Note: Country and sectoral definitions provided in Appendix.

Source: Authors' calculations

5.3 Welfare

In Table 5-6, the welfare results from the two methods are compared. We adapt the GTAP welfare decomposition developed by Huff and Hertel (2001) to explicitly show the impact of the changes in willingness to pay on welfare. Both methods increase welfare by similar magnitudes, although the willingness-to-pay method raises welfare more.[46]

The preference effect on welfare is found to be a similar order of magnitude as the iceberg method's technology effect, which is expected since the shock is the same but is applied to preferences in one case and as a technology shock in the iceberg method. The channels over which the two shocks are transmitted to the economy differ in an important way. The technological change effect works directly through imports of firms, households, investment and governments. The preferences effect works through demand for domestic goods employing imported intermediate in their production and imported goods destined for final consumers: households, government, and savings-investment. The omission of firms can be explained by the fact that firms are willing to pay more for reduced shipping delays because final consumers are willing to pay more. Hence final consumers obtain the additional utility, as firms' willingness to pay are captured in the domestic good and hence in the preferences of their customers: households, governments, savings-investment and exports.

The transmission of preferences in domestically produced products through firms to final consumers therefore causes utility gains to both domestic consumers and foreign consumers. As a result, countries like the high income OECD countries, where the direct shocks are relatively low and openness to trade is high, tend to gain as a result of importing utility from those countries, outside the high income OECD, where the direct shocks are relatively higher. Welfare as measured by the preference effect is therefore higher than the productivity effect in the high income OECD countries and lower in the other countries (Table 5-6) due to these 'transfers of utility', relative to the technology gains under the iceberg method.

In contrast, the iceberg method's productivity effects are transmitted only to imports of firms, households, government and investment. Note that, the domestic goods also benefit under the iceberg method, albeit through the price mechanism. The transmission of these productivity gains on imports to domestic products, and hence to foreigners through exports, occurs through changes in the price of the domestic commodity, which when exported, are captured in the terms of trade (prices of exports relative to imports).

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46 It is interesting to note that the welfare gains for the low income countries are relatively low under both methods, despite gaining the most in terms of real GDP. The reason for this is that the welfare gains depend on trade and hence on the extent to which the economies are open. As a result, the more open high income OECD and middle income economies gain the most. Fugazza and Maur (2006) found similar results when looking at the iceberg approach.

Table 5-6: Impact of TFA on welfare and its decomposition ($US millions)

	Allocative efficiency effect	Technological change	Terms of trade	Terms of trade (savings and capital goods)	Preferences	Total welfare
ICEBERG METHOD						
High income OECD countries	8	62,865	-2,786	-560	0	59,527
High income non-OECD countries	931	18,722	-538	673	0	19,789
Middle income countries	10,554	60,170	2,565	-206	0	73,083
Low income countries	317	1,599	428	89	0	2,433
Rest of world	488	5,637	326	4	0	6,456
WILLINGNESS-TO-PAY METHOD						
High income OECD countries	3,583	0	-14,756	-55	67,071	55,844
High income non-OECD countries	2,202	0	3,175	-139	18,635	23,874
Middle income countries	17,039	0	10,116	29	50,543	77,726
Low income countries	535	0	483	171	1,324	2,513
Rest of world	990	0	974	-8	5,391	7,347

Country definitions provided in Appendix.

Source: authors' calculations

Table 5-6 also shows that the allocative efficiency gains from the willingness-to-pay method are higher than those obtained under the iceberg method. This is due to the fact that there is a larger increase in trade and hence in allocative efficiency gains that accompany those increases in trade.

The difference between the two methods is most evident when looking at prices and the terms of trade effect in the welfare decomposition (Table 5-6). The higher demand for imports under the willingness-to-pay method causes the price of traded goods (including services and extraction) to rise in all countries except the high income OECD countries, while lower demand for trade and the productivity gains from importing causes prices to fall under the iceberg method (Table 5-2). The reversal in prices between the two methods is clear. Unless demand for their goods is very strong, as is the case of the low income economies, prices fall in the iceberg method; and unless demand is lackluster, as is the case in the high income OECD, prices rise in the willingness-to-pay method. The resulting impact on the terms of trade and on the terms of trade effect on welfare depends on the extent to which the price of exports and imports reverse. In the low income economies, the rise in the price of exports is almost exactly offset by the rise in price of imports (Table 5-2) leaving the terms of trade the same under both methods.

The differences in the terms of trade between the two methods is more apparent in the other countries.[47] In the high income non-OECD, middle income and the rest of the world the rise in the price of exports is greater than the rise in prices of imports leading to an improvement in the terms of trade. The terms of trade effects of the high income countries, those least affected by the TFA, decline as import prices rise relative to export prices—thereby reversing the terms of trade effect. The result is some significant differences in the terms of trade and the contribution of the terms of trade to welfare, although their impact on total welfare is minimal.

47 Readers interested in the potential reversal of terms of trade effects caused by the iceberg treatment of transaction costs are referred to Samuelson (1954).

6 Conclusions and summary

Successive rounds of multilateral, regional and bi-lateral trade agreements and arrangements have reduced tariffs globally (Hummels, 2007). Current trade negotiations have increasingly focused on NTMs, in contrast to tariffs. Harmonizing standards, reducing unnecessary inspections, and mutual recognition of certifications are now core areas of international trade negotiations. NTMs are complex instruments employed to manage trade and public safety—the UN provides over 100 categories of NTMs in its nomenclature. The number of mechanisms available in CGE models to represent NTMs stands in contrast to the diverse and complex nature of the NTMs they are meant to portray. For instance, the GTAP model has relied on a relatively narrow range of modeling methods to implement NTMs—three major methods, two of which are the use of existing tariff instruments already in the model.[48]To a some extent this lack of mechanisms is due to the complex nature of NTMs and the lack of estimates of the restrictiveness of NTMs. Improvements in the data and our understanding of how NTMs impact economies are required to improve analysis and better represent the complexities of NTMs.

In this paper a new methodological approach for estimating the economic impacts of demand-side changes in the willingness of consumers to pay in response to NTMs, such as reduced customs delays or the harmonization of standards, was introduced into a computable general equilibrium model. The new methodology incorporates changes in willingness to pay for imports directly into the Armington equation and into the upper levels of the nesting structure of demand by households, governments and firms. Changes in willingness to pay for imports are also reasoned to raise preferences for domestic commodities, through the use of preferred (imported) intermediates in the production process, and alter welfare.

To illustrate the new willingness-to-pay approach, we estimate the impact of the WTO Trade Facilitation Agreement (TFA), and compare the results with one of the existing approaches, the iceberg method. We find that employing the iceberg approach to reflect trade facilitation impacts on an economy overstates impacts on real GDP and distort measures of trade, particularly in contrast to the willingness-to-pay approach, which we argue, offers a more

48 These methods are sometimes complemented with implementations of “imperfect completion”.

complete and accurate characterization of how ad valorem equivalents of reduced customs delays are measured. The iceberg method, on the other hand, tends to overstate the importance of spoilage and the potential cost of time delays. Notwithstanding these issues with the iceberg approach, it is likely that the combination of a change in the willingness to pay and a carefully implemented change in the iceberg cost will yield the best results for examining the TFA, although it would be difficult to find empirical evidence or data to support the separation of the estimated ad valorem equivalents into the two effects, hence assumptions would have to be made.

In contrast to real GDP, the willingness-to-pay method has a greater expansionary effect on trade and causes the terms of trade to improve, rather than deteriorate, as in the case in the iceberg method. Under the willingness-to-pay method, global trade rises by 1.96 percent, compared to 0.98 percent under the iceberg method. The cause of the greater expansion of trade under the willingness-to-pay method is straight forward—the willingness-to-pay method increases an agents' import demand to satisfy the increased utility they receive from them, while the iceberg method allows agents to buy less imports to satisfy the same import demand. Likewise, the greater expansion of trade, raises prices, as firms capture most of the increase in consumers' willingness to pay as higher returns to factors of production; while reduced production costs caused by the increase in productivity, lead to the decline in prices obtained under the iceberg approach. In both methods the source of the gains is mostly due to reduced time delays by firms; although households become relatively more important under the willingness-to-pay method.

Welfare is also higher under the willingness-to-pay method. Our analysis finds that global welfare gains from the WTO TFA could reach US$167 billion per annum (2007 dollars) under the willingness-to-pay approach introduced here. Though its transmission mechanisms are different, the iceberg approach results in a similar US$160 billion (2007 dollars) a year improvement in welfare. Hence, despite differences in real GDP and trade, the impact of the TFA on welfare is roughly the same, regardless of whether the TFA is explicitly modeled as a demand or preference shift in consumers' willingness to pay or as an import-augmenting iceberg technological change. In the willingness-to-pay method, welfare rises as a result of higher utility obtained from consumption of more preferred, imported and domestically produced, commodities; while under the iceberg method, welfare rises as a result of the productivity gain from imports only.

The ability to alter preferences or willingness to pay in our models is likely to have numerous applications in modern economics where NTMs have increased in importance and firms seek to increase the value of their product to consumers, rather than merely reduce costs. For instance, harmonization of product standards, more accurate and meaningful labelling of products, or changes in environmental standards are all expected to impact consumers' willingness to pay.

Appendix

Table A1- 1: Regional aggregation

Aggregated region	Long name	Mapping to GTAP regions
HIOECD	High income OECD countries	Australia, New Zealand, Japan, Korea, Canada, United States of America, Chile, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Switzerland, Norway, Israel
HINOECD	High income non-OECD countries	Hong Kong, Taiwan, Singapore, Uruguay, Cyprus, Latvia, Lithuania, Malta, Croatia, Russian Federation, Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates
MIDINC	Middle income countries	China, Mongolia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Thailand, Viet Nam, India, Pakistan, Sri Lanka, Mexico, Argentina, Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Venezuela, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Hungary, Albania, Bulgaria, Belarus, Romania, Ukraine, Kazakhstan, Kyrgyzstan, Armenia, Azerbaijan, Georgia, Iran, Turkey, Egypt, Morocco, Tunisia, Cameroon, Cote d'Ivoire, Ghana, Nigeria, Senegal, Mauritius, Zambia, Botswana, Namibia, South Africa
LOWINC	Low income countries	Cambodia, Bangladesh, Nepal, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Tanzania, Uganda, Zimbabwe
OTHER	Rest of world	Rest of regions in GTAP 8 database

Source: Authors' aggregation of the GTAP database (Narayanan, Aguiar and McDougall, 2012)

Table A1- 2: Sectoral aggregation

Aggregated sector	Long name	Mapping to GTAP sectors
AG_PRIM	Primary agriculture	PDR Paddy Rice, WHT Wheat, GRO Other Grains, V_F Veg and Fruit, OSD Oil Seeds, C_B Cane and Beet, PFB Plant Fibers, OCR Other Crops, CTL Cattle, RMK Raw milk, WOL Wool, FSH Fishing
AG_PROC	Processed agriculture and food	OAP Other Animal Products, CMT Cattle Meat, OMT Other Meat, VOL Vegetable Oils, MIL Milk, PCR Processed Rice, SGR Sugar, OFD Other Food, B_T Beverages and Tobacco products, TEX Textiles
EXT_BAS	Oil, coal and gas	COA Coal, OIL Oil, GAS Gas
EXT_ADV	Other Mining and Petroleum	FRS Forestry, OMN Other Mining, P_C Petroleum and Coke, NMM Non-Metallic Minerals
MAN_LT	Light manufactures	WAP Wearing Apparel, LEA Leather, LUM Lumber, PPP Paper and Paper Products
MAN_HVY	Heavy Manufactures	CRP Chemical Rubber Products, I_S Iron and Steel, NFM Non-Ferrous Metals, FMP Fabricated Metal Products, MVH Motor vehicles and parts, OTN Other Transport Equipment, ELE Electronic Equipment, OME Other Machinery and Equipment, OMF Other Manufacturing
SERVICES	Services	ELY Electricity, GDT Gas Distribution, WTR Water, CNS Construction, TRD Trade, OTP Other Transport, WTP Water transport, ATP Air transport, CMN Communications, OFI Other Financial Intermediation, ISR Insurance, OBS Other Business Services, ROS Recreation and Other Services, OSG Other Services (Government), DWE Dwellings

Source: Authors' aggregation of the GTAP database (Narayanan, Aguiar and McDougall, 2012).

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