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Modelling heterogeneous firms and non-tariff measures in free trade agreements using Computable General Equilibrium

Yaghoob Jafari *, Wolfgang Britz

Institute for Food and Resource Economics, University of Bonn, Germany

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ABSTRACT

A vast body of literature supports with empirical evidence the findings of Melitz (2003) which has led to various attempts to integrate it into Computable General Equilibrium (CGE) models to distinguish the intensive and extensive trade margin and to consider love of variety effects as well as variable and fixed costs of bilateral trade. These viewpoints are especially important for modern free trade agreements (FTAs) analysis where impacts depend largely upon changes in non-tariff measures (NTMs) affecting trade cost. However, existing Melitz extensions for CGEs seem to struggle with numerical stability problems limiting sectoral and regional detail. That greatly reduces their usefulness for policy relevant analysis. We, therefore, develop a Melitz extension for a modular CGE with a focus on a numerical stability. Using the Transatlantic Trade and Investment Partnership (TTIP) proposal as an illustrative example, we treat 22 manufacturing out of 57 sectors based on Melitz in an application with ten global regions and compare our findings to an Armington specification. Our results confirm the larger welfare and trade changes under the Melitz setting suggested both by theory and by empirical findings. We finally compare the sensitivity of trade and welfare impact when the same cost savings associated with reduced NTMs are differently allocated to variable and fixed cost of bilateral trade. We find in our application that the change in traded quantities is more sensitive to bilateral variable cost while welfare increases are more driven by reduced fixed cost, reflecting love of variety effects. Overall, the application underlines that our numerically robust implementation of the Melitz model in a CGE allows applications with high sectoral detail and thus opens the door to a more widespread application in impact assessments.

1. Introduction

The rapid expansion of bilateral and regional FTAs since the mid-1990s in both number and depth (Horn et al., 2010) has led to higher demands for their quantitative impact analysis. While early FTAs mainly targeted tariff elimination, modern FTAs take into focus NTMs which are quite diverse in nature and thus affect the economy through different mechanisms (Limao, 2016). Equally, FTA negotiations and agreements encompass often highly differentiated concessions by sector and partner country. Besides gravity based approaches, impact assessment of FTAs relies mainly on global CGE models (Hertel et al., 2007) which cover bi-lateral trade and further economic transactions across all sectors and consider the interactions of various policy instruments (Devarajan and Robinson, 2002).

Since Armington (1969) proposed to treat imported and domestic varieties of the same (aggregated) goods as imperfect substitutes that approach dominated applied CGE analysis. It provides a powerful, but relatively simple framework for studying international trade policy, not at least as it can accommodate any observed pattern of trade flows and pertinent prices (i.e., the intensive margin of trade). However, preferences for each origin in the Armington model are fixed, such that changes in trade cannot impact average imported qualities per firm on a trade link. It hence neglects potential variations at the extensive margin of trade such as trade flows in new products and with new partners which are found as important in empirical analysis (Hummels and Klenow, 2005; Chaney, 2008).

The pioneer paper by Melitz (2003) introduced firm productivity heterogeneity drawing from Hopenayn (1992) into the monopolistic competition framework by Krugman (1980). The Melitz model can be understood as an extension of the Armington approach as it combines changes at the intensive and extensive margins of trade by allowing firms to self-select new export markets based on their productivity level. Many papers applying the model (Bernard et al., 2003, 2006; 2007; Eaton et al., 2004) could reproduce salient trade patterns observed in recent

* Corresponding author. Institute for Food and Resource Economics, University of Bonn, Nußallee 21, 53115 Bonn, Germany.
E-mail address: yaghoob.jafari@ilr.uni-bonn.de (Y. Jafari).

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micro-level studies. Consequently, there have been a number of efforts to introduce it into CGE models (Zhai, 2008; Balistreri et al., 2011; Oyamada, 2014; Akgul et al., 2016; and Dixon et al., 2016). The Melitz model adds to the explanatory power of Armington type models (Hosoe, 2017) by considering changes at the extensive margin of trade and in industry productivity level with implications on both trade and welfare (Melitz and Redding, 2014). However, assessment of FTAs based on Melitz-type CGE models is still scarce. For example, none of the impact assessment reports of FTAs by the EU Commission mentions an application of a Melitz-type CGE model.[1] A possible reason is the increased complexity of a Melitz compared to an Armington model, mirrored by a modest sectoral and regional resolution in published application. The paper on GTAP-HET by Akgul et al. (2016), to give an example, uses a stylized example with three regions and two sectors, only. Balistreri et al. (2011) proposes a decomposition algorithm, where partial equilibrium models for Melitz sectors interact with an Armington model for perfectly competitive one. In their example, the authors include firm heterogeneity in just one sector. Dixon et al. (2016) and Oyamada (2014) include firm heterogeneity in variants of the global trade analysis project (GTAP) model coded in General Equilibrium Modelling PACKage (GEMPACK), but seem to run into dimensionality problems. Indeed, all studies up to present offer analysis with a rather limited number of sectors treated a la Melitz. Bekkers and Francois (2016), to give an example, report a maximum of 4 countries and 3 Melitz sectors for these applications.

Some authors (Dixon et al., 2016, for example) claim that Melitz models are not necessary, as Armington models are able to replicate their trade impacts with higher than usual elasticities of substitution. Dixon et al. (2016) used a trial and error approach to find the value of substitution elasticities in Armington–type CGE models that generates almost equal overall trade impacts compared to a Melitz-type CGE model in their simple two-sector modelling exercise. Balistreri and Rutherford (2013) draw the conclusion from such exercises that Armington-type models might produce almost any desired pattern of trade if modelers consider substitution elasticities as parameters of choice. Furthermore, even an Armington model tuned to replicate simulated trade pattern of a Melitz model will still not reproduce the welfare implications of considering fix cost at industry and trade link level along with love of variety.

Additionally, the differentiation between fixed and variable costs in bi-lateral trade embodied in Melitz-type CGE models allows a more realistic quantitative assessment of NTMs (Fugazza and Maur, 2008). That seems important as ad valorem equivalent estimations of NTMs suggest that their (partly) elimination is often more important than tariff reductions in FTAs (Horn et al., 2010). The need for more advanced approaches beyond the relatively simple assumption underlying an Armington model seems also be seen by governments; the European Commission (2016), namely, asks to make full use of the available information and techniques in the impact assessment of FTAs.

Our paper aims to discuss and finally ease the use of the Melitz model in detailed CGE analysis such that both the extensive and intensive margin of trade and productivity effects can be considered. It contributes to literature as follows. We discuss the development of a Melitz model into the modular and flexible CGE modelling platform CGEBox (Britz, 2017), focusing on numerical stability when working with many sectors and regions, a point we consider salient for policy relevant applications. Further, we present a sensitivity analysis of different approaches to model NTMs in the Melitz framework and compare resulting trade and welfare impacts to a standard Armington implementation.

We take TTIP between the US and EU as an illustrative case. Both the EU and US apply a multitude of non-harmonized complex sanitary and phytosanitary (SPS) measures as well as technical barriers to trade (TBT) regulations (Arita et al., 2014) which together with other trade-related regulatory differences create obstacles to trade. Thus, TTIP aimed not only to eliminate or to reduce tariffs, but also to unify "behind the border barriers (i.e., differences in regulations)". It offers hence an interesting case where bilateral trade modelling, high NTMs and the complex nature of NTMs are the core. To illustrate the impact of NTMs in different model configurations, we consider NTM reductions in all sectors.

2. Modelling framework

Global CGE models are considered especially suited to provide an ex-ante appraisal of trade agreements as they consider bi-lateral trade and related barriers in a consistent behavioral framework while accounting for interlinkages between sectors. The most widely used database, GTAP, currently offers 57 sectors and 140 regions (Aguiar et al., 2016). Still, the sectoral breakdown of the GTAP database is often considered insufficient to assess detailed trade negotiations. Therefore, CGE applications are regularly complemented by analysis at the tariff line; either based on a separate partial equilibrium model or by using a pre-model aggregation from changes at the tariff line to the GTAP sector with software such as TASTE (Narayanan et al., 2010). As tariff line detail is not at the focus of our paper and the example of TTIP is only illustrative, we leave out tariff line complications in the remainder of our paper, but work with the full sectoral resolution of 57 sectors. We use here the flexible and modular CGE model CGEBox. A full documentation of all equations of that open-source platform for CGE modelling offers Britz (2017). The model, encoded in the General Algebraic Modelling Language (GAMS), can provide an exact replica of the standard GTAP model (Hertel, 1997), but also allows to mimic features of many other well-known CGEs. We extend that CGE model platform by incorporating a module based on Melitz (2003). It considers firm heterogeneity, firm entry and exit in the industry as a whole and on specific trade links, and love of variety by the different agents, resulting in monopolistic competition. Below we discuss briefly the general structure of the standard GTAP model that treats sectors as perfectly competitive and subsequently provide detail on the Melitz module.

2.1. Perfectly competitive sectors as in the standard GTAP model

Sectors with perfect competition are depicted as in the standard GTAP model (Hertel, 1997), a comparative static, global CGE model based on the Walrasian general equilibrium structure. It assumes cost-minimizing behavior under constant returns to scale production technologies along with utility maximizing consumers in competitive markets. There is a single virtual representative household in each region that owns the production factors and receives factor returns net of taxes. That so-called regional household also collects income from taxation such as tariff revenues and rents accruing from export or import licenses, depicted as exogenous ad-valorem price wedges. The regional income is then allocated to different agents (private household, government, and saving) based on a modified Cobb-Douglas (CD) utility function. The private household's demands for Armington commodities are derived from a non-homothetic constant difference elasticity (CDE) implicit expenditure function,[2] while government and saving demands for Armington commodities are driven by constant elasticity of substitution (CES) functions. A CES composite of domestic and import demand for each and product agent defines their Armington demands. The import demand composition from bi-lateral trade flows is depicted by a second CES nest that is not agent specific. On the supply side, production is defined as the Leontief aggregate of value added and intermediate inputs bundles; the value added composition is based on a CES aggregate of primary factors while the composition of intermediate demand is based on fixed physical input coefficients. Each sector features its own Armington nest to determine the composition of intermediate input demand for each

[1] See the documents archive of the European Commission on trade policy analysis, http://ec.europa.eu/trade/policy/policy-making/analysis/.

[2] The CDE can be classified as somewhat more flexible as the CES and linear expenditure system (LES) functional forms as it allows for marginal budget shares varying with expenditure levels (Hertel, 1997).