Welfare and trade effects of the Canada-European Union Comprehensive Economic and Trade Agreement considering tariff line detail

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Abstracts

We provide an analysis of the EU-Canada Comprehensive Economic and Trade Agreement between the European Union and Canada, which foresees the full removal of tariffs with the exemption of sensitive products in the agri-food sector. We employ a global Computable General Equilibrium with 57 sectors extended for the EU-Canada trade links to over 5,000 HS6 tariff lines based on additional demand and supply nests represented by constant elasticity of substitution and constant elasticity of transformation functions, respectively. Comparing our results to a standard pre-model tariff aggregation, we find that trade impacts are lower in both regions. Furthermore, we find the welfare improvement in Canada doubles but that of the EU halves. Our analysis, based on open-source and access code underlines that such analysis at least at the level of bi-lateral Free Trade Agreement can be readily used.

Keywords: free trade agreements, policy analysis, aggregation bias, tariff line analysis, computable general equilibrium.
1. Introduction

The EU-Canada Comprehensive Economic and Trade Agreement (CETA) between the European Union (EU) and Canada aims at the full removal of tariffs with the exemption of sensitive products in the agri-food sector. Sensitive goods are either exempted from the liberalization or included in Tariff Rate Quota (TRQ) regimes. As both the EU and Canada are in the top four exporters of agri-food products worldwide, a substantial liberalization of their bi-lateral agri-food trade may have far reaching consequences for that sector globally. We aim at a comprehensive economic analysis of CETA with a focus on the agri-food sector; considering both impacts on the free trade agreement (FTA) partners and global spill over effects.

Traditionally, data availability imply a rather large level of sectoral aggregation in CGE modelling, limiting their ability for detailed assessments of FTAs. The current version of the global analysis project (GTAP) database (Aguiar et al., 2016), underlying the majority of existing large-scale CGEs, offers consistent data on 57 sectors for the economy as a whole. The rather high aggregation reflects limited detail in data on consumption and supply. Although trade statistics and trade policy data are readily available at the very detailed level of tariff lines, trade policy data are typically aggregated pre-model to the level of commodity balances, introducing systematic biases in simulated trade and welfare impacts (Bach and Martin 2001, Anderson 2009, Himics and Britz, 2016).

The bias that traditional (fixed weight) tariff aggregation approaches introduce in simulation outcomes generally increases with more tariff dispersion. In agri-food trade, where protection rates frequently differ considerably even between different tariff lines of quite similar products, fixed weight aggregation quickly becomes significantly biased. Tariff aggregates relying on bilateral trade statistics are also subject to an endogeneity bias, as traded volumes can be heavily affected by applied tariff rates. The higher tariff rates are the lower the observed traded volumes tend to be. Consequently, highly protected tariff lines systematically get small weights in the tariff aggregation, typically resulting in an underestimated measure of aggregate border protection, and vice-versa.

Another challenge with particular relevance to agri-food trade, and also to our CETA analysis, is the impact of variable tariff rates under TRQ. Applied tariff rates under a TRQ endogenously depend on the quota fill rate and thus imported volumes. As the quota fill rate is expected to change after liberalization, the applied tariff rate, and the aggregate protection level depending on it, cannot be correctly determined ex-ante using fixed aggregation weights.
Specific methods have been developed to address the above biases. The reference group method for aggregation, for example, which is also used to derive the MacMap tariff database underlying the GTAP database (Guimbard et al., 2012), aims at reducing the endogeneity bias by calculating aggregation weights based on the observed trade patterns of a (reference) group of countries, not solely based on bi-lateral trade flows. The same method converts TRQs into ad-valorem tariff equivalents, but as the conversion is based on observed quota fill rates, it is vulnerable to endogenously changing applied rates under TRQs.

Another strand of literature aims at welfare-consistent aggregation for the general equilibrium, eliminating the aggregation bias in simulated welfare changes entirely (Bach and Martin, 2001; Anderson, 2009). Himics and Britz (2016) further extends the approach to cover TRQs. Others circumvent the aggregation issue either by iteratively linking more aggregated CGE models with partial equilibrium models operating at the tariff line (Grant et al., 2007) or by directly extending CGEs to the tariff line with additional nesting (Narayanan et al., 2010).

Still, the dominant approach in CGE-based policy analysis is to implement trade liberalization (tariff cut) scenarios based on weighted average tariffs, as for instance implemented in the so-called Tariff Analytical and Simulation Tool for Economists (TASTE) (Horridge and Laborde, 2008), developed as an add-on for the GTAP database. Similar to the reference group method, TASTE aims at reducing endogeneity bias by defining aggregation weights based on trade flows between countries of similar economic profiles.

We propose an approach builds upon the precedent work of Himics and Britz (2016) and Himics et al. (2017), who extended advanced tariff aggregation to deal with bilateral TRQs. Instead of their pre-model aggregation approach, however, we rather extend directly the CGE structure to the tariff line level. The bilateral exports and imports of aggregated commodities are split to the tariff line level at specific trade links only. The split of the export supply and import demand functions also includes explicit TRQ equations, which model-endogenously define the applied tariff rates under TRQ at the tariff line level. By only disaggregating the bi-lateral trade flows of interest we can significantly reduce the data requirement and the additional complexity to the model extension. The proposed approach is first introduced in a CGE framework to evaluate the trade and welfare impacts of CETA, and then systematically compared to simulated results with the standard TASTE tariff aggregation.
2. Extensions to tariff line details and TRQs implementation

2.1. Conceptual framework

The GTAP database provides a mapping of bilateral merchandise trade data at tariff lines to 57 sectors, based on the United Nations Commodity Trade Statistics Data Base and associated trade protection data based on Market Access Map (MacMap) database.¹ These 57 sectors are often further aggregated in model applications. This implies that information on protection measures at tariff line, which might also comprise complex instruments such as Tariff Rate Quotas (TRQs), needs to be aggregated to GTAP sector level and beyond. That might provoke aggregation bias (cf. Himics and Britz 2016). Analysis especially of (potential) Free Trade Agreements requires often details beyond the 57 sectors of GTAP. We detail here a framework fully integrated in the GTAP model which allows the analysis of (potential) FTAs at tariff line level for selected bi-lateral trade links along with an explicit representation of bi-lateral TRQs where the applied tariff rates become endogenous due to the switch between in-quota and out-of-quota market regimes. The proposed structure provides a fully consistent aggregation from tariff line to commodity level. We first introduce the extension to the GTAP model and subsequently discuss the methodology that is used to tackle the endogeneity bias associated with TRQs.

The most straightforward way for incorporating tariff line detail in a CGE model is applying the existing equations relating to sectors and commodities to disaggregated tariff lines. This however implies what is called a “split”, i.e. dis-aggregation the complete global data set to tariff line detail. While tariff line specific data on bilateral trade and associated protection level are readily available, information on production and consumption at tariff line is missing. Furthermore, such an approach renders the data base and model quite large which increases the computational burden and makes the interpretation of the results more difficult.

As an alternative, we present an approach that only requires the split of bilateral trade data to the detailed tariff lines without further information on domestic supply and demand. The proposed approach will keep the model at more manageable size, removes core reasons for the aggregation bias, and coupled with the methodology to tackle the endogeneity of applied tariff rate under TRQs, provides an improved toolkit for empirical trade policy analysis. The proposed approach could be employed in any partial and general equilibrium model drawing

¹ The bilateral services trade data in GTAP database is based on the bilateral services trade data for the OECD countries coming from CPB and International Monetary Fund (IMF) data.
on the Armington approach. We introduce the framework here into the standard GTAP model as the most prominent platform for empirical trade policy analysis.

The demand representation in the standard GTAP model as in most Armington based equilibrium models on a three-tier representation. The top-level demand function depicts the aggregated demand for individual commodities at agent level followed by a 2-stage Armington nest, see figure 1. The first stage Armington decompose the total agent demand for commodity $i$ ($X_A_i$) into domestic sales ($X_D^i$) and aggregate imports ($X_M_i$) using a Constant Elasticity of Substitution (CES) preference structure. The second stage Armington nest decompose the aggregate import demand by region of origin, $s (X_W^i_s)$. In principle, the second stage Armington could also be done at the agent level. For data available reasons and to reduce model size, instead an aggregate importing agent allocates the aggregate import demand of all agents across regions of origin using a CES function. Analogously to the implementation of import demand, the allocation of domestic supply might use a nested Constant Elasticity of transformation (CET) structure, see figure 4. First, domestic supplier allocates supply, $X_S$, between domestic (i.e. regional) market ($X_D^s$) and an aggregate exporter ($X_E^i$) using a CET function. The second CET nest allocates the aggregate export across the various regions of the model thereby determining bilateral export supply ($X_W^{i,s}_d$).

Our approach splits selected bi-lateral trade flows from commodity level to tariff line level, see extensions in figure 1 and 2. The split makes only sense for flows where tariff changes occur. As we keep the existing supply and demand structure at the commodity level unchanged, our approach does not require disaggregated data on domestic sales and consumption. The new demand nest at the tariff line decomposes the bilateral import demand for each individual commodity $i$ by tariff lines, $t$ ($X_W^i_{t,s(i)}$) using a CES preference structure. The subscript $t$($i$) refers to the tariff line, $t$, belonging to the aggregate commodity level $i$. Equally, a new CET nest is used to allocate the bilateral export supply of each individual commodity across the various tariff lines associated with that aggregate commodity ($X_W^i_{t,d(i)}$). Henceforth we skip the notation $t$($i$) and simply refer to it as $t$. The proposed approach dramatically reduces data needs, as it requires tariff line information on trade flows and protection data only for some bi-lateral links, namely those in the focus of the analysis. Hence, it keeps the model at a manageable size even if some bi-lateral trade flows are depicted with rich dis-aggregated tariff line information.
2.2. Mathematical framework

Implementation of the above conceptual framework requires incorporation of the following equations into the model:
• Two equations that define the bi-lateral exports and imports at tariff line level
• Two matching dual price aggregators that define the bi-lateral export and import prices at bilateral commodity level.
• A market clearing condition equalizing the bilateral export supply and import demand at the tariff line replacing the one at commodity level.
• Three equations linking the bilateral trade prices at tariff line replacing those at commodity level.

In the standard GTAP, the allocation of aggregate imports across all source regions, indexed by \( s \) is represented by Equation (1). The variable \( XW^d_{s,i,r} \) represents the demand for exports from region \( s \) to region \( r \) for commodity \( i \). The variable \( PM \) is the purchasers’ price of bilateral imports at commodity level that is tariff inclusive, later to be modified in our implementation. The formulation allows for changes in trade preferences as measured by the variable \( \lambda^m \). Parameter \( \alpha^w \) is CES share parameter and \( \sigma^w \) represents the substitution elasticity. The price of aggregate imports, \( PMT \), is defined in equation (2) using the CES dual price expression.

\[
XW^d_{s,i,r} = \alpha^w_{s,i,r} XMT^m_{r,i} \lambda^m_{s,i,r} \sigma^w_{r,i} \left( \frac{PM_{r,i}}{PM^w_{s,i,r}} \right)^{w_{r,i}} \tag{1}
\]

\[
PM_{r,i} = \left[ \sum_s \alpha^w_{s,i,r} \left( \frac{PM^w_{s,i,r}}{\lambda^m_{s,i,r}} \right)^{1-w_{r,i}} \right]^{1/(1-w_{r,i})} \tag{2}
\]

Building on equations (1) and (2), we introduce the following two equations that represent the new demand nest at the tariff level. The variable \( XWT^d_{s,t,l,r} \) represents the demand for exports from region \( s \) to region \( r \) for each tariff line \( tl \) that maps to commodity \( i \). The variable \( PMTL^d_{s,t,l,r} \) is the purchasers’ price of bilateral imports that is tariff inclusive. The price of bilateral import at commodity level, \( PM \), is defined in equation (4) as an aggregation over the tariff-line prices using the CES dual price expression.

\[
XWT^d_{s,t,l,r} = \alpha^w_{s,t,l,r} XW^d_{s,i,r} \left( \frac{PM^w_{s,i,r}}{PMTL^w_{s,t,l,r}} \right)^{w_{r,t,l}} \tag{3}
\]

\[
PM^w_{s,i,r} = \left[ \sum_{t,l} \alpha^w_{s,t,l,r} PMTL^w_{s,t,l,r} \right]^{1/(1-w_{r,t,l})} \tag{4}
\]

On the supply side, the formulation of export supply depends upon the elasticity of transformation across export markets. Equations (5) represents the second-level CET supply functions in the case of imperfect transformation across export markets, \( XWs \), that represents the exports from region \( r \) to region \( d \) for commodity \( i \). The price \( PE \) represents the export price;
\( \gamma^w \) and \( \omega^w \) are the share parameter and the transformation elasticity, respectively. The price \( \text{PET} \) represent the price of aggregate exports. In the case of perfect transformation, the supply function is replaced by the law-of-one-price such the producer price of exports across all regions of destination, \( \text{PE} \), is set equal to the producer price of domestic output. Equation (6) represents the “market clearing” condition for bilateral export supply at commodity level. In the case of imperfect transformation, it is represented by the CET dual price expression and in the case of perfect transformation, the total export supply is the sum of bilateral export supply at commodity level.

\[
\begin{align*}
XW^s_{r,i,d} &= \gamma^w_{r,i,d} XET_{r,i} \left( \frac{PE_{r,i,d}}{\text{PET}_{r,i}} \right)^{\omega^w_{r,i}} \text{ if } \omega^w_{r,i} \neq \infty \\
PE_{r,i,d} &= \text{PET}_{r,i} \text{ if } \omega^w_{r,i} = \infty
\end{align*}
\]

\[
\begin{align*}
\text{PET}_{r,i} &= \sum_d \gamma^w_{r,i,d} \left( PE_{r,i,d} \right)^{1+\omega^w_{r,i}} \left( \text{PET}_{r,i} \right)^{-\omega^w_{r,i}} \text{ if } \omega^w_{r,i} \neq \infty \\
XET_{r,i} &= \sum_d XW^s_{r,i,d} \text{ if } \omega^w_{r,i} = \infty
\end{align*}
\]

Linked to the equations (5) and (6) at commodity level, the following two equations at tariff line level are introduced. The variable \( XWTL^s_{r,tl,d} \), in the case of imperfect transformation, denotes the bilateral export supply at tariff line level, \( tl \), from the region \( r \) to the destination region \( d \). The variable \( \text{PETL} \) is the price of bilateral exports at tariff line level gross of export/import taxes. The price of bilateral export at commodity level, \( \text{PE} \), is defined in equation (8) as an aggregation over the tariff-line prices, using the CET structure. In the case of perfect transformation, the bilateral export supply at tariff line is replaced with the law-of-one-price, where the producer price of bilateral export at tariff line is set equal to the producer price of bilateral export for the commodity to which those tariff lines are mapped. Accordingly, the “market clearing” condition ensures that the bilateral export supply at commodity level is equal to the sum of their belonging bilateral export supply at tariff line level.

\[
\begin{align*}
XWTL^s_{r,tl,d} &= \gamma^w_{r,tl,d} XW^s_{r,i,d} \left( \frac{\text{PETL}_{r,tl,d}}{PE_{r,i,d}} \right)^{\omega^w_{r,tl}} \text{ if } \omega^w_{r,tl} \neq \infty \\
\text{PETL}_{r,tl,d} &= PE_{r,i,d} \text{ if } \omega^w_{r,tl} = \infty
\end{align*}
\]
Next, there are fundamentally two market equilibrium conditions in the standard GTAP model for goods and services. The first guarantees equality of supply and demand for domestically produced goods sold on the domestic market. The second, as reflected in equation (9), guarantees equality of supply and demand for each bilateral trade node at commodity level.

\[
XW_{r,i,d}^s = XW_{s,i,r}^d \quad \text{if } \omega_{r,t}^w = \infty
\]

With the tariff detail, this equation is replaced with equation (10) which instead ensures the equality of bilateral supply and demand at tariff lines, and essentially determines the price PETL.

\[
XWTL_{r,t,l,d}^s = XWTL_{s,t,l,r}^d
\]

In addition, there are four bilateral trade prices corresponding to three price wedges, see figure 3.

**Figure 3:** trade price linkages

Producers in region \( r \) receive the price PETL for delivering goods at tariff line \( tl \) to region \( d \). A bilateral export tax or subsidy at tariff line ( \( \tau^e \) ) is applied to the producer price, PETL, and determines the export border price (or the free on board—FOB price), \( PETL_{r,t,l,d}^{fob} \) as represented in equation (11).\(^2\) The price for international trade and transport services for each trade node \( \zeta^{mg} \) is added to the FOB price to determine the cost-insurance–freight- CIF price, \( PMTL_{r,t,l,d}^{cif} \) as in equation (12). In order to obtain the transport margin at tariff line for each mode of transport, we split the transport margin for each mode and for each individual commodity into their related

\(^2\) Although our formulation allows for export tax and subsidies, in our application export taxes/subsidies are not differentiated at tariff line level and that the trade margins are assumed identical for all tariff lines belonging to the same commodity.
tariff lines using benchmark trade values as weights. Equation (13) determines the purchaser’s import price at tariff line where the import tax or subsidy at tariff line \((\tau^m)\) is applied to the CIF price.

\[
\text{PETL}_{r,tl,d}^{fob} = \text{PETL}_{r,tl,d} \times (1 + \tau_{r,tl,d}^e + \tau_{r,tl}^e)
\]  
(11)

\[
\text{PMTL}_{s,tl,r}^{cif} = \text{PETL}_{r,tl,d}^{fob} + \tau_{s,tl,r}^{mg} \cdot PWMG_{s,tl,r}
\]  
(12)

\[
\text{PMTL}_{s,tl,r} = \text{PMTL}_{s,tl,r}^{cif} \times (1 + \tau_{s,tl,r}^e + \tau_{s,tl}^e)
\]  
(13)

Above three equations indicate the bilateral price relationships in the extended framework and thus replace those at commodity level. Accordingly, the purchaser’s price of bilateral imports at commodity level, \(PM\), in equation 1 and 2 depicts the CES weighted aggregate of bilateral import prices at tariff lines belonging to that commodity land.

In case where bi-lateral trade and protection data were available for all bi-lateral links of a commodity, it would be more natural to change the order of the CES and CET nests: total demand for a product would first be split to the tariff line and the total tariff line demand subsequently being distributed to domestic sales and imports, and from there to bi-lateral trade flows. Similarly, total supply would be first distributed to tariff lines. However, we opted for the proposed order as it reduces data demands and model size. Indeed, our approach can be seen as the implementation of the tariff aggregators proposed in Himics and Britz 2016.

Finally, we define the bilateral import tax at tariff line level in Equation 13, \(\tau_{s,tl,r}^m\), as a variable to render it endogenous under TRQs. For this purpose, we use a Mixed Complementarity Problem (Rutherford, 1995) approach to allow for tariff regime shifts under TRQs in the form of complementary slackness conditions:

\[
\text{Quota} - I^i \geq 0 \perp t^s \geq 0
\]  
(14)

\[
t^{out} - t^{in} \geq t^s \perp I^{out} \geq 0
\]  
(15)

\[
\tau^m = t^{in} + t^s
\]  
(16)

\[
I = I^{out} + t^{in}
\]  
(17)

This the usual approach found e.g. in the LINKAGE model (van der Mensbrugghe 2005), in the GLOBE model (Burrell et al. 2011) or Himics and Britz (2013) and Himics et al. (2017).

Equation (14) represents the regime switch between in-quota to out-of-quota market regimes under TRQs. If in-quota imports, \(I^i\), reach or exceed the quota level, \(\text{Quota}\), then the unit quota rent, \(t^s\) (the shadow tariff that defines the quota rent per unit of imports), becomes non-
zero, representing an out-of-quota market regime. Equation (15) defines bounds for the shadow tariff that should be equal to the difference of in- and out-of-quota rates \( t^{in} \) and \( t^{out} \), respectively) in case out-of-quota imports \( I^{out} \) occur. Equation (16) defines the endogenously determined applied tariff rates \( \tau^{m} \) based on the in-quota rate and the shadow rate, and finally equation (17) is the import balance defining total imports \( I \). This system of equations is defined for all tariff lines that are subject to bilateral TRQs.

2.3. Data and software

We introduce the model-endogenous tariff line aggregator in the flexible and modular platform for CGE modelling CGEBOX (Britz and Van Der Mensbrugghe, 2016) which also offers the choice between different approaches to depict bi-lateral trade including a Melitz (2003) implementation (Jafari and Britz 2018).

We use the latest GTAP database in combination with detailed data at the tariff line; and simulate the impact of changes in bi-lateral tariff and TRQs between EU and Canada according to the CETA agreement. We keep the full resolution of the GTAP database at 57 sectors, but aggregate globally to important trading partners of the EU and Canada.

3. Results and discussions

[To be inserted later]

4. Summary and conclusion

Our application suggests that is easily feasible to dis-aggregated all 57 sectors of the GTAP model to over 5,000 HS 6 tariff lines for one specific bi-lateral link including coverage of TRQs using CES and CET nests. Such an approach is suitable to analyse a FTA between two trading partners where typically detailed data on bi-lateral policy instruments and their changes are readily available. We are unable to assess the consequences on model behaviour from using that approach on a larger set of regions simultaneously. Compared to using the TASTE approach to aggregate the bi-lateral tariffs and apply the model at 57 sector we find that trade impacts are generally lower and welfare impacts substantially differs. We there conclude that
our approach, based on open-source and access code, provides a valuable and relatively easy to employ alternative to pre-model tariff aggregation.

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