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It is all in the details: A bilateral approach for modelling trade agreements at the tariff line

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Abstract

Policymakers are increasingly relying on computable general equilibrium (CGE) models to provide economy-wide impacts of trade agreements; however, these assessments often make the simplifying assumption of complete bilateral tariff elimination. But agreements typically involve partial tariff elimination for sensitive sectors—which are often differentiated at the tariff line. As such, applying a uniform tariff reduction in a CGE sector that encompasses many products could introduce bias. We propose a tariff line approach for modelling exemptions for sensitive goods in CGE models with the aim of reducing this bias. This approach is tested for the Canada–EU trade agreement, and systematically compared to standard approaches to bilateral trade liberalisation in CGE analysis. We find that more common approaches might systematically overestimate trade and welfare impacts by neglecting partial liberalisation in selected sectors and/or not considering substitution across tariff lines.

KEYWORDS

aggregation bias, CETA, computable general equilibrium, free trade agreements, sensitive products, tariff line analysis, trade policy

Résumé

Les décideurs s'appuient de plus en plus sur des modèles d'équilibre général calculable (EGC) pour estimer les effets des accords commerciaux sur l'ensemble de l'économie. Cependant, ces évaluations considèrent souvent l'hypothèse simplificatrice d'une élimination complète des droits de douane entre les pays signataires. En pratique, ces accords incluent généralement des produits dits sensibles : le taux de protection final des lignes tarifaires concernées ne sera que partiellement (ou pas) supprimé. Dans les modèles EGC, la méthodologie classique consiste à traiter ces lignes tarifaires à l'extérieur du modèle et à agréger ensuite les tarifs finaux en secteurs compatibles avec la résolution du modèle. Pour réduire les biais potentiels de cette méthode, nous proposons une modélisation fine, au niveau des lignes tarifaires pour prendre en compte les exemptions des produits sensibles dans les modèles EGC. Nous testons notre approche en simulant l'accord commercial Canada-UE et nous comparons systématiquement nos résultats aux approches standards des accords commerciaux dans la littérature EGC. Nous concluons que les approches plus utilisées pourraient systématiquement surestimer les effets sur le commerce et le bien-être en négligeant la libéralisation partielle dans certains secteurs et/ou en ne considérant pas les substitutions possibles au niveau des lignes tarifaires.

1 | BACKGROUND AND LITERATURE REVIEW

Policymakers are increasingly relying on computable general equilibrium (CGE) models to provide assessments of potential free trade agreements (FTAs), given their ability to provide a global, economy-wide perspective, with interindustry linkages and bilateral trade relations. For example, the United States Trade Representative requires a CGE-based analysis for any trade agreement under discussion in the United States; similarly, CGE models have provided ex ante impact analyses of changes in European Union (EU) trade policy (e.g., Jean et al. (2014) for Chile; Fontagne et al. (2013) with the United States; European Commission (2017) with Canada; Antimiani and Salvatici (2015); and Boulanger et al. (2016) on the combined effects of several EU agreements). Most CGE analyses rely on the Global Trade Analysis Project (GTAP) database (Aguiar et al., 2019), given that it provides global data on bilateral trade, production and consumption. This database distinguishes most countries individually; however, its product differentiation at 65 sectors is much more aggregated than where trade negotiations are focused (at the tariff line). But considering all individual tariff lines in a CGE model is practically impossible, given that there are more than 5,300 products at the HS 6 level.

The current practice aggregates bilateral trade data from the tariff line to the GTAP sector level before they enter the CGE model. Such pre-model aggregation of trade and tariff data remains challenging for at least two reasons. First, FTAs tend to fully liberalise the majority of tariff lines, with some exemptions for sensitive products (often specified at the HS6 or HS8 level). As research is often conducted before the (final) legally binding text detailing all exemptions is available, CGE models often either assume full tariff liberalisation[1] or underrepresent exemptions for sensitive products. As such, tariffs might be reduced according to the percentage of tariff lines in a sector exempted from full trade liberalisation (see Jafari and Britz (2018) for a review). Second, even if exemptions are considered, tariff aggregators can provoke systematic bias since high tariff rates tend to decrease traded volumes more than lower tariffs, resulting in underestimated average border protection (Anderson, 2009; Bach & Martin, 2001; Himics & Britz, 2016). The related bias generally increases with greater initial tariff dispersion and with larger tariff cuts. To illustrate how the lack of commodity details might lead to aggregation bias, consider two exporters who do not face direct competition at the HS6 level in weak substitutes such as butter and cheese. At the aggregate GTAP level these exporters would appear as competitors since the data combines the two into one ‘dairy product’ sector.

Two approaches have been developed to address the tariff aggregation bias: the full or partial extension of the model to the tariff line or improved pre-model aggregation. First, CGE models can be extended to the tariff line to avoid aggregation bias. One approach iteratively links the CGE model to a detailed partial equilibrium (PE) model operating at the tariff line (Grant et al., 2007). Another adds model equations to the model itself and splits up selected elements in the production and demand structure to the tariff line (Narayanan et al. (2010) and Beckman and Arita (2016) for pork and poultry; Chepeliev et al. (2019) for vegetables and fruits). In both cases, demand and bilateral trade information must be available and rendered consistent to the overall data base (Hertel, 2012), which is often challenging. Ultimately, neither the partial disaggregation nor the iterative PE-CGE link scale up well as it is numerically difficult to extend them to many or all commodities (Himics & Britz, 2016). Regarding the second approach, the so-called reference group method (Guimbard et al., 2012) is frequently applied for pre-model aggregation. This approach decreases endogeneity bias by calculating aggregation weights based on the observed trade patterns of a (reference) group of countries, rather than using country specific bilateral trade flows, which would miss prohibitive tariffs without bilateral trade flows.

Given the discussion above, pre-model aggregation remains the dominant approach in CGE-based analysis of FTAs with many using the “Tariff Analytical and Simulation Tool for Economists” (TASTE) tariff aggregation tool (Horridge

[1] For example, most CGE studies examining the Transatlantic Trade and Investment Partnership (TTIP) assume complete tariff removal. This is despite a large number of sensitive products traded between the EU and United States (see Jafari et al., 2019 for a review). Moreover, frequent examples can be found on the website of European commission and CEPII. The European Commission considers at least one scenario of full liberalizing tariffs for all goods in EU agreements with New Zealand (2017), Australia (2017), Indonesia (2019), Mercosur (2020) and Canada (2011).

& Laborde, 2008), developed as an add-on for the GTAP database.[2] However, simulation results with the TASTE-GTAP combined approach face an aggregation bias, because the pre-model aggregator does not consider substitution effects between commodities at the tariff line. An unchanged CGE model cannot help here as it considers substitution at the limited number of (highly aggregated) sectors.

We propose extending the CGE model structure directly to the tariff line. Our approach requires less data (i.e., no need for detailed data on production and consumption), requires less additional equations and it still reduces the tariff aggregation bias. We test this approach using the EU–Canada Comprehensive Economic and Trade Agreement (CETA), which fully removes tariffs on many traded goods between the EU and Canada, but exempts several tariff lines in the agri-food sector from full liberalisation. As discussed before, neglecting these exceptions could lead to significant aggregation bias, especially as they represent a substantial share of trade. Given that CETA might significantly alter global agri-food markets due to trade diversion effects (since the EU and Canada are both among the top four exporters of agri-food products worldwide), it is an inviting case for testing our approach. We extend a CGE model to the HS6 tariff line level, relying on policy data directly extracted from the legal text of the CETA agreement, and taking into account sensitive products. In order to evaluate the advantages of the proposed approach, we compare our simulation results to two traditional approaches: (i) a full liberalisation scenario, where sensitive goods are neglected and (ii) a scenario with weighted average tariff cuts (including sensitive tariff lines) calculated with the pre-model aggregation tool TASTE.

2 | A REVIEW OF THE IMPACT ASSESSMENTS OF THE CETA

Several studies have analysed the potential economic impacts of CETA, comprising of work dating back to when discussions were informal up to assessments using the text of the ratified agreement. Our review (Table 1) focuses on studies that used CGE models, with most applying some variant of the GTAP model or database. The comparison of the three official impact assessments of the negotiating parties shows an increasing level of detail over time, both in terms of sensitive products considered and with respect to regional and sectoral aggregation: Hejazi and Francois (2008)[3] assumed full tariff liberalisation; Kirkpatrick et al. (2011) exempted some GTAP sectors from tariff cuts (but did not account for sensitive tariff lines); finally, European Commission (2017) calculated the impact of tariff line-exceptions on the sector-level tariff cuts with a pre-model aggregation approach, from 6-digit level to GTAP sectors. Note that Table 1 indicates that the impact on bilateral trade and welfare tends to decrease in more recent studies with more sectoral and regional detail, and by adding more exceptions for sensitive products. Philippidis and Kitou (2012) consider three scenarios, full tariff elimination as opposed to two different offers, with differences in the lists of sensitive products. Results indicate that even small changes in the list of sensitive products can alter results significantly. Boulanger et al. (2016) vary the size of the partial tariff cuts for sensitive products (25% or 50% cut) and find that variances in bilateral import changes. These systematic differences highlight the need for more disaggregation in CGE studies and show that taking into account even a small number of sensitive products can alter significantly the simulated impacts.[4]

3 | EXTENSIONS TO TARIFF LINE DETAILS

3.1 | Conceptual framework

Similar to most Armington based equilibrium models, the standard GTAP model uses a three-tier representation of demand. The top-level demand for individual (aggregated) commodities is broken down to a two-stage nested Armington demand structure (Figure 1). The first Armington stage decomposes total demand for each agent[5] and commodity i (XA_i)

[2] Similar to the reference group method, the aggregation weights in TASTE are based on trade flows between countries of similar economic profiles.

[3] Hejazi and Francois (2008) is often referred to as the 'joint study', as it was commissioned jointly by the negotiating parties. Kirkpatrick et al. (2011) is part of the sustainability impact assessment (SIA) of the EU. European Commission (2017) is part of the final economic impact assessment of the European Commission.

[4] The need for more disaggregated databases is also illustrated by comparing country specific studies with the EU aggregate studies. For example, Francois and Pindyuk (2013) calculate a potential increase of +131% in Austrian exports to Canada in the processed food sector, which is larger than any simulated impacts at the EU aggregate level. Although we keep the EU as one region in our study, we break down the sectors to the tariff line level in the EU–Canada bilateral trade direction to better depict product heterogeneity within the sectors.

[5] We do not show the subscript for each agent here.

TABLE 1 Ex-ante impact assessments of the CETA

Study	Modelling approach	Database	Sectoral and regionalaggregation	Tariff aggregation approach	CETA scenarios	Trade impacts	Welfare impacts
Cameron and Loukine (2001)	Static CGE; GTAP	GTAP v4 (reference year 1995)	10 sectors; six regions, including Canada, EU and countries in accession negotiations at the time of the study	Pre-model	Full tariff liberalisation with and without exception for agricultural sectors (no tariff cuts)	Canada bilateral exports: from +0.78% to +0.86% EU bilateral exports: from +1.1% to +1.2%	Welfare as a percent of GDP: from +0.03% to +0.04% for Canada, around four times smaller gains for the EU (+770 million USD)
Hejazi and Francois (2008)	Static CGE; Copenhagen Economics model	GTAP v7 (reference year 2004, projected to 2007 and 2014)	Not reported	Pre-model aggregation (TASTE)	Full liberalisation; no exceptions for sensitive products	Bilateral export increases: +36.6% for the EU, +24.3% for Canada bilateral processed food exports: +326% for EU, +142% for Canada bilateral Primary agriculture exports: +6% to the EU, +42% for Canada	Impact measured as equivalent variation: +10.5 billion EUR for the EU, +8.4 billion EUR for Canada GDP gains: +0.08% for EU, +0.77% for Canada
Kirkpatrick et al. (2011)	Static CGE; GTAP	GTAP v7 (reference year 2004)	Sectors not reported; 10 regions, including Canada and the EU	Pre-model aggregation (TASTE)	Partial liberalisation; full tariff cuts for most GTAP sectors no tariff cuts for sensitive GTAP sectors (‘dairy products’ and ‘other foods nec’ for Canada, ‘meats’ and ‘meat products nec’ for the EU)	EU exports +0.05% to +0.07% Canada exports +0.54% to +1.56%	Real GDP increase: the EU: 0.02% to 0.03% Canada: 0.18% to 0.36%

(Continues)

TABLE 1 (Continued)

Study	Modelling approach	Database	Sectoral and regionalaggregation	Tariff aggregation approach	CETA scenarios	Trade impacts	Welfare impacts
Philippidis and Kitou (2012)	Static CGE; Defra-Tap (agricultural variant of GTAP)	GTAP v7 (reference year 2004)	32 sectors; 18 regions, including Canada, UK, EU- 4 (Austria, Germany, Netherlands, Sweden), rest of the EU	Pre-model aggregation (TASTE)	Partial liberalisation; partial tariff cuts for sensitive products calculated by TASTE, aggregating from HS6 to sectoral level pre-model	Trade balance changes in agriculture and fisheries: Canada: +19 to +386 million EUR, the EU: −46 to −455 million EUR Trade balance changes in Food processing: Canada: −434 to +3 million EUR; the EU: −205 to 1307 million EUR	Welfare gains measured as equivalent variation: from +2.5 billion EUR to +3.3 billion EUR (+0.46% of per capita real income) for Canada, at constant 2004 prices from +3.1 billion EUR to +4.1 billion EUR (+0.04% of per capita real income) for EU, at constant 2004 prices
Francois and Pindyuk (2013)	Static CGE; Copenhagen Economics model	GTAP v8 (reference year 2007)	Sectors not reported; nine regions, including Canada, Austria and rest of the EU	Pre-model aggregation (TASTE)	Partial liberalisation, tariff reduction and NTM reduction aggregated to sector level	Only Austrian results are provided: 'agriculture, forestry and fisheries' sector: −1.8% exports to Canada, +124.8% imports from Canada 'processed food' +131% exports to Canada, +112.8% imports from Canada	Only Austrian results are provided: +0.215% in national income

(Continues)

TABLE 1 (Continued)

Study	Modelling approach	Database	Sectoral and regionalaggregation	Tariff aggregation approach	CETA scenarios	Trade impacts	Welfare impacts
Boulanger et al. (2016)	Recursive dynamic CGE; MAGNET	GTAP v9 (reference year 2011)	57 sectors; 19 regions, including Canada and the EU	Pre-model aggregation (TASTE)	Partial liberalisation; partial tariff cuts for sensitive products (25% or 50% cut), aggregated to GTAP sectors	Bilateral exports increase: the EU +4.8% Canada +10.6% to +11.1%	Not comparable, as other EU FTAs are included in the scenarios
European Commis-sion (2017)	Dynamic CGE; GDyn (dynamic version of GTAP)	GTAP v9 (reference year 2011)	57 sectors; 13 regions, including Canada and EU-28	Pre-model aggregation (TASTE)	Partial liberalisation; tariff schedule mapped/aggregated (pre-model) from tariff line to GTAP sectoral level; combined with assumptions on reduction of non-tariff barriers	Canada bilateral exports: +8.13% in value EU bilateral exports: +8.04% in value	EU: annual GDP gains between 1.7-2.1 billion EUR Canada: annual GDP gains between 2.4-3.0 billion EUR
Tamminen et al. (2017)	Static CGE; Copenhagen Economics model	GTAP v9, (reference year 2011)	57 sectors; four regions (Canada, Finland, the UK and rest of the EU)	Pre-model aggregation (TASTE)	Partial liberalisation: full cuts except dairy sector (25% cut) and other food products (50%) explicit cut on non-tariff barriers	Only Finnish exports reported: 'Primary products' to Canada +0.1 million EUR 'Food and beverages' to Canada +1.2 million EUR	Real GDP changes: Canada +0.34%, the EU +0.026%, Finland: +0.039%
Devadoss and Luckstead (2018)	Heterogeneous firms (Melitz type) model, partial equilibrium	GTAP v9 (reference year 2011)	Focus on food processing sector; four regions (Canada, the EU, the United States and rest of world)	Pre-model aggregation (TASTE)	Tariff removal combined with firm level cost changes (incl. fixed trade cots)	Results of tariff removal scenario: +83.9% EU exports to Canada +107.5% Canada exports to the EU	Comparable results not reported

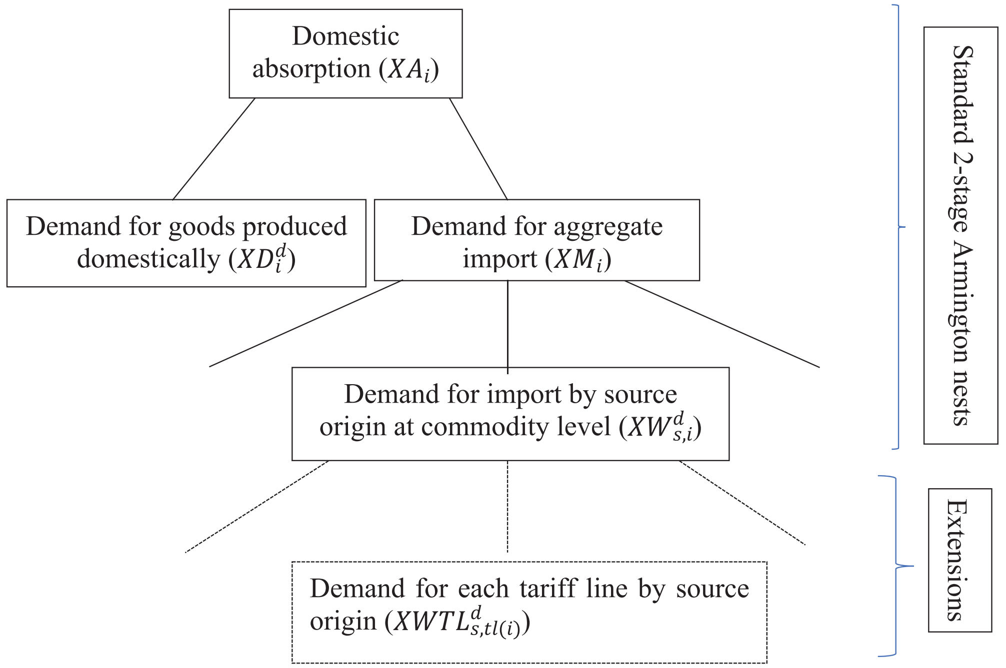

FIGURE 1 Nested Armington demand

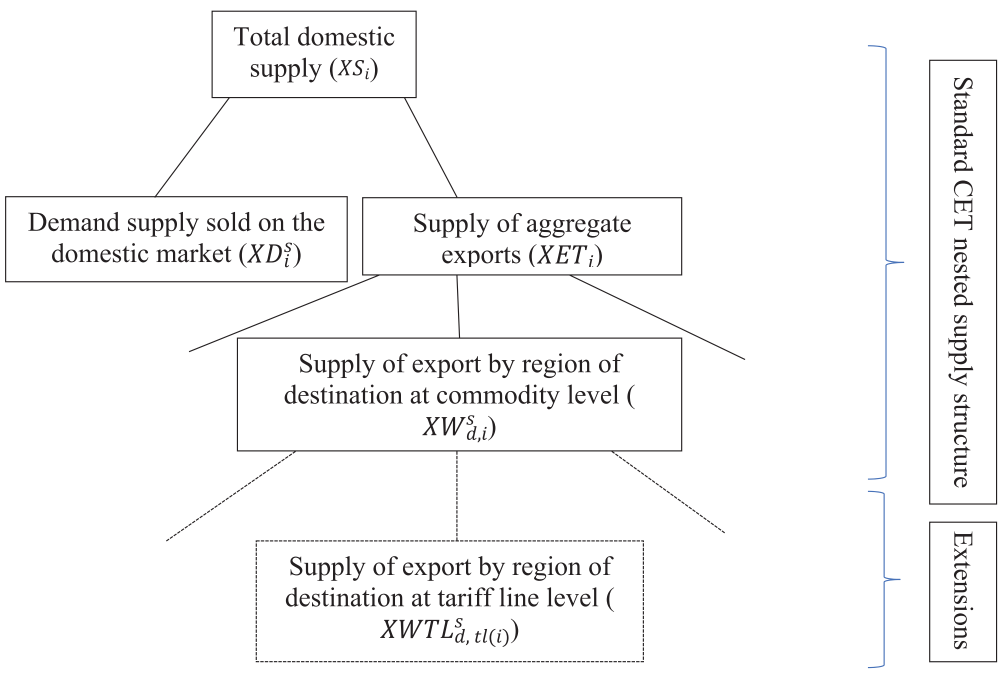

FIGURE 2 Nested CET supply

into domestically produced (XD_i^d) and imported (XM_i) goods, which represent a constant elasticity of substitution (CES) preference structure in final consumption goods or a CES technology in intermediate demand. The second Armington stage decomposes aggregate import demand by source of origin, ($XW_{s,i}^d$), where s denotes the partner country. Due to data availability and to reduce model size, there is only one aggregate agent that allocates aggregate import demand across regions of origin, again based on a CES functional form.

Analogously to the above nested import demand structure, domestic supply is allocated in our model to the domestic market and to export destinations using a nested constant elasticity of transformation (CET) structure (Figure 2). The first nest breaks down total domestic supply of commodity (XS_i), to domestic sales (XD_i^s) and aggregate exports (XET_i). The second allocates aggregate exports across all export destinations d to determine bilateral export supply ($XW_{d,i}^s$).

Our approach extends the above two-stage Armington approach and splits *selected* bilateral trade flows from commodity to the tariff line level. In the FTA policy analysis context, this allows us to identify the tariff lines treated as sensitive goods and to simulate endogenous substitution between tariff lines within the total bilateral imports and exports of the corresponding aggregate commodities. As we keep the existing supply and demand structure at the top level (aggregated commodities) unchanged, our approach does not require tariff line level (disaggregated) details on domestic sales and consumption. The additional CES nest decomposes bilateral import demand from country s to the tariff lines, tl ($XWTL_{s,tl(i)}^d$). The subscript tl(i) denotes tariff lines, tl, under the aggregate commodity level, i. Consequently, an additional CET nest allocates bilateral export supply to country d across the various tariff lines tl ($XWTL_{d,\,tl(i)}^s$). For increased readability we drop i from the notation of the tariff lines tl(i), as tariffs lines are assumed to belong to one aggregated commodity only (no overlaps).

3.2 | Mathematical framework

The proposed CGE extension requires the following additional equations:

- CES share equations for bilateral import demand at the tariff line level.
- CET share equations for bilateral export supply at the tariff line level.
- Dual price aggregators (price index equations) for bilateral export supply and import demand prices, from the tariff line to the aggregated commodity level.
- A market clearing condition equalizing bilateral export supply and import demand at tariff line level, replacing market clearing at the aggregated commodity level.
- Price transmission equations linking domestic prices to bilateral import and export prices at the tariff line. The price transmission equations take into account trade costs, including import tariffs, export subsidies and transport margins. The tariff line level price transmission mechanism replaces the one at the commodity level.

The following section presents the above equations in detail. In the standard GTAP model, the allocation of aggregate imports across all source regions, indexed by s, is represented by Equation (1). The variable $XW_{s,i,r}^d$ represents the demand for exports from region s to region r for commodity i. The variable PM is the purchasers' price of bilateral imports that is tariff inclusive, later to be modified in our implementation. The formulation allows for changes in trade preferences based on the preference shifter λ^m. Parameter α^w is the CES share parameter and σ^w represents the substitution elasticity for each commodity across importing regions. The price of aggregate imports, PMT, is defined in Equation (2) using the CES dual price expression.

$$XW_{s,i,r}^d = \alpha_{s,i,r}^w XMT_{r,i} {\lambda_{s,i,r}^m}^{\sigma_{r,i}^w - 1} \left(\frac{PMT_{r,i}}{PM_{s,i,r}} \right)^{\sigma_{r,i}^w}. \tag{1}$$

$$PMT_{r,i} = \left[\sum\nolimits_s \alpha_{s,i,r}^w \left(\frac{PM_{s,i,r}}{\lambda_{s,i,r}^m} \right)^{1-\sigma_{r,i}^w} \right]^{1/(1-\sigma_{r,i}^w)}. \tag{2}$$

Building on Equations (1) and (2), we introduce the following two additional equations that represent the new demand nest at the tariff line level. The variable $XWTL_{s,tl,r}^d$ represents the demand for exports from region s to region r for each tariff line tl that maps to commodity i. Here α^t is the share parameter for each tariff line and σ^t represents the substitution elasticity across tariff lines. Note that the latter is not the elasticity of substitution between importers for the same tariff line, but across tariff lines aggregated to the same product. The variable PMTL is the purchasers' price of bilateral imports that includes tariffs. The price of bilateral imports at commodity level, PM, is defined in Equation (4) as an aggregation over the tariff-line prices using the CES dual price expression.

$$\mathrm{XWTL}^{d}_{s,\mathrm{tl},r} = \alpha^{t}_{s,\mathrm{tl},r}\mathrm{XW}^{d}_{s,i,r}\left(\frac{\mathrm{PM}_{s,i,r}}{\mathrm{PMTL}_{s,\mathrm{tl},r}}\right)^{{}^{t}_{r,\mathrm{tl}}}, \tag{3}$$

$$\mathrm{PM}_{s,i,r} = \left[\sum_{\mathrm{tl}\varepsilon i}\alpha^{t}_{s,\mathrm{tl},r}\mathrm{PMTL}_{s,\mathrm{tl},r}{}^{1-\sigma^{t}_{r,\mathrm{tl}}}\right]^{1/\left(1-\sigma^{t}_{r,\mathrm{tl}}\right)}. \tag{4}$$

The formulation of the nested export supply system reflects the special treatment of an infinite elasticity of transformation parameter across export markets. Equation (5) represents the second-level CET supply functions for 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; γ^{w} and ω^{w} are the share parameter and the transformation elasticity for each commodity across exporting regions, respectively. PET represents the price of aggregate exports at commodity level i. Equation (6) represents the market clearing condition for bilateral export supply at the commodity level, represented by the CET dual price expression.

$$\begin{cases} \mathrm{XW}^{s}_{r,i,\,d} = \gamma^{w}_{r,i,d}\mathrm{XET}_{r,i}\left(\frac{\mathrm{PE}_{r,i,d}}{\mathrm{PET}_{r,i}}\right)^{\omega^{w}_{r,i}} \mathrm{if}\,\omega^{w}_{r,i} \neq \infty \\ \mathrm{PE}_{r,i,d} = \mathrm{PET}_{r,i}\mathrm{if}\,\omega^{w}_{r,i} = \infty \end{cases}, \tag{5}$$

$$\begin{cases} \mathrm{PET}_{r,i} = \left[\sum_{d}\gamma^{w}_{r,i,d}\mathrm{PE}_{r,i,d}{}^{1+\omega^{w}_{r,i}}\right]^{1/(1+\omega^{w}_{r,i})} \mathrm{if}\,\omega^{w}_{r,i} \neq \infty \\ \mathrm{XET}_{ri} = \sum_{d}\mathrm{XW}^{s}_{r,i,\,d}\mathrm{if}\,\omega^{w}_{r,i} = \infty \end{cases}. \tag{6}$$

Equations (7) and (8) introduce the additional nest in the CET structure at the tariff line level, and link it to the upper nests (Equations (5) and (6)). The variable $\mathrm{XWTL}^{s}_{r,\mathrm{tl},d}$ denotes bilateral export supply at tariff line level, tl, from the origin r to destination region d. The variable PETL depicts the price of bilateral exports at the tariff line level gross of export and import taxes. Here γ^{t} is the share parameter for each tariff line and ω^{t} represents the substitution elasticity across tariff lines. The price of bilateral exports at commodity level, PE, is defined in Equation (8) as an aggregation over the related tariff-line prices, using the CET structure.

$$\begin{cases} \mathrm{XWTL}^{s}_{r,\mathrm{tl},d} = \gamma^{t}_{r,\mathrm{tl},d}\mathrm{XW}^{s}_{r,i,d}\left(\frac{\mathrm{PETL}_{r,\mathrm{tl},d}}{PE_{r,i,d}}\right)^{\omega^{t}_{r,\mathrm{tl}}} \quad \mathrm{if}\,\omega^{t}_{r,\mathrm{tl}} \neq \infty \\ \mathrm{PETL}_{r,\mathrm{tl},d} = \mathrm{PE}_{r,i,d}\mathrm{if}\,\omega^{t}_{r,\mathrm{tl}} = \infty \end{cases}, \tag{7}$$

$$\begin{cases} \mathrm{PE}_{r,i,d} = \left[\sum_{\mathrm{tl}\varepsilon i}\gamma^{t}_{r,\mathrm{tl},d}\mathrm{PETL}_{r,\mathrm{tl},d}{}^{1+\,\omega^{t}_{r,\mathrm{tl}}}\right]^{1/(1+\omega^{t}_{r,\mathrm{tl}})} \quad \mathrm{if}\,\omega^{t}_{r,\mathrm{tl}} \neq \infty \\ \mathrm{XW}^{s}_{r,i,d} = \sum_{\mathrm{tl}}\mathrm{XWTL}^{s}_{r,\mathrm{tl},\,d}\mathrm{if}\,\omega^{t}_{r,\mathrm{tl}} = \infty \end{cases}. \tag{8}$$

The standard GTAP model includes two market equilibrium conditions for goods and services. The first condition 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 the commodity level.

$$\mathrm{XW}^{s}_{r,i,d} = \mathrm{XW}^{d}_{s,i,r}. \tag{9}$$

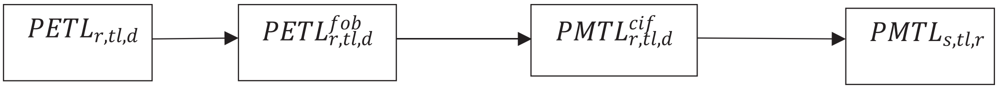

FIGURE 3 Trade price linkages

This equation is replaced with Equation (10) which ensures the equality of bilateral supply and demand at the tariff line level. The related shadow price determines the price of export supply at the tariff line level (PETL).

$$\mathrm{XWTL}^{s}_{r,\mathrm{tl},d} = \mathrm{XWTL}^{d}_{s,\mathrm{tl},r}. \tag{10}$$

In addition, export supply and import demand prices on the same trade link are directly related. Three price wedges translate export supply prices at the origin to the corresponding import price at the destination (Figure 3), taking into account bilateral export taxes or subsidies, as well as transport cost margins.

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 (τ^e) is applied to the producer price, PETL, and determines the export border price (or the free on board – FOB price), $\mathrm{PETL}^{\mathrm{fob}}$ as represented in Equation (11).[6] The price for international trade and transport services for each trade node ζ^{mg} is added to the FOB price to determine the cost-insurance-freight (CIF) price, $\mathrm{PMTL}^{\mathrm{cif}}$ as in Equation (12). In order to obtain the transport margin at the tariff line for each mode of transport, we split the transport margin for each mode and for each individual commodity into their related 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 (τ^m) is applied to the CIF price.

$$\mathrm{PETL}^{\mathrm{fob}}_{r,\mathrm{tl},d} = \mathrm{PETL}_{r,\mathrm{tl},d}{}^{*}\left(1+\tau^{e}_{r,\mathrm{tl},d}+\tau^{e}_{r,\mathrm{tl}}\right), \tag{11}$$

$$\mathrm{PMTL}^{\mathrm{cif}}_{s,\mathrm{tl},r} = \mathrm{PETL}^{\mathrm{fob}}_{r,\mathrm{tl},d} + \zeta^{\mathrm{mg}}_{s,\mathrm{tl},r}\mathrm{PWMG}_{s,\mathrm{tl},r}, \tag{12}$$

$$\mathrm{PMTL}_{s,\mathrm{tl},r} = \mathrm{PMTL}^{\mathrm{cif}}_{s,\mathrm{tl},r}\left(1+\tau^{m}_{s,\mathrm{tl},r}+\tau^{m}_{s,\mathrm{tl}}\right). \tag{13}$$

Equations (11)–(13) present the bilateral price relationships in the extended framework, replacing those at the commodity level. Accordingly, the purchaser's price of bilateral imports at commodity level, PM, in Equation (1) and (2) directly corresponds to a CES weighted price of import prices at tariff line level.

In this study, we set the elasticity to 10 between total exports and domestic sales, and to 15 across export flows, following Britz and Van Der Mensbrugghe (2018). The substitution elasticity in the benchmark scenario equals 2 across tariff lines, both in the CES and the CET nests and for all commodities.

The additional (third) level of the extended Armington system can be interpreted as a nonlinear (CES) tariff aggregator, with endogenously determined aggregation weights. This third level is not directly related to the Armington assumption, because it does not aggregate over regions, but over tariff lines of a given product and trade link. One advantage of our approach is that it allows for substitution between tariff lines, such that aggregation weights can change during simulation. A further advantage of integrating tariff aggregation in the model structure (as above) arises if trade policies allow tariffs rates to change, for instance, to let tariff rates under a tariff-rate quota (TRQ) depend on whether the imported quantities exceed quota thresholds.[7]

In our approach, the substitution between tariff lines is at the level of the individual bilateral trade flow of an aggregated product, versus substitution between importers depicted at the level of individual tariff lines in Chepeliev et al. (2019), since

[6] Although our formulation allows for export taxes and subsidies, in our application export taxes/subsidies are not differentiated at the tariff line level. In addition, trade margins are assumed to be identical for all tariff lines belonging to the same commodity.

[7] In this study we do not consider the possibility of endogenous ad-valorem tariffs at the tariff line. But the proposed approach is straightforward to extend with an equation system for modelling TRQs, with only a modest increase in the computational complexity.

we only split commodities to the HS6 level. With this approach, substitution between importers remains at the aggregated product level of the Armington nest, as in standard CGE-models. Note that the work of Chepeliev et al. (2019) requires a new set of Armington elasticities, because traded goods at the tariff line level are more homogenous than the aggregate products, which consumers tend to substitute in their consumption bundle differently. In our partial (bilateral) extension, there is no need to update the second level Armington elasticities, when the third level is added to the system.

4 | DATA AND SOFTWARE

We introduce the model-endogenous bilateral tariff line aggregator in the modular platform for CGE modelling 'CGEBox' (Britz & Van Der Mensbrugghe, 2018). CGEBox offers flexible nesting options for modelling production and factor supply, supports different functional forms for demand and includes optional trade models (e.g., the heterogeneous firm model).[8] We combine the GTAP Data Base (GTAP 10, 2014 reference year) with detailed bilateral trade data and protection levels at the tariff line, and simulate the impact of changes in import protection between the EU and Canada according to the CETA agreement.

Average bilateral Canada–EU trade data for 2015–2017 are taken from the UN-Comtrade Database at the six-digit HS level. Data on border protection in the form of Ad Valorem Equivalents (AVEs) of import tariffs and quotas are taken from the Market Access Map (MAcMap) database, for the year 2017, covering both applied and bound rates. Post-agreement bound rates are derived from the legal text of the agreement (European Union, 2017). In order to take into account the possible gaps between applied and bound rates (binding overhang), the post-agreement applied rates are estimated as the minimum of the post-agreement bound rate and the current applied rate. Given that our data on bilateral trade flows are more recent than the trade data underlying the GTAP version 10 database (2015–2017 vs. 2014), we opt for the more recent trade statistics in the tariff line model extension to harmonise trade and tariff statistics at the six-digit level. This requires the calibration of data on trade flows at the tariff line level to the given ones for standard GTAP commodities, based on uniform scaling factors.

We keep the full resolution of the GTAP database (GTAP 10, 2014 reference year) at 65 sectors, and keep important EU and Canada trading partners. The regional coverage includes Australia and New Zealand, East Asia, Southeast Asia, Canada, the United States and Mexico, Latin America, Middle East and North Africa, Sub-Saharan Africa and other regions.[9] For reporting purposes only, we aggregate the simulation results post-model for the extraction, manufacturing and services sectors. Similarly, simulated results for the regions other than the EU and Canada are aggregated post-model, and reported as 'Rest of the World' (ROW).

4.1 | State of trade between the EU and Canada

Table 2 presents base total and bilateral imports of the EU and Canada. Canada imports a large share (15.5%) from the EU, particularly in comparison with the relatively small share of EU imports from Canada (0.80%). Shares in agri-food trade are similar: 12.1% of Canadian agri-food imports are sourced from the EU, while only 0.65% of EU agri-food imports are from Canada. Larger shares of EU imports to Canada in agri-food sectors are found for 'beverages and tobacco products' (43%), 'animal products nec' (36%) and 'dairy products' (30%). Further agri-food products sourced with a relatively high share from the EU are 'vegetable oils and fats' (12%) and 'food products nec' (9%).[10] Regarding EU imports from Canada, 'wheat' (11%) and 'oil seeds' (3%) have significant import shares in total EU agri-food imports.

Table 3 breaks down bilateral import shares and tariffs. Agri-food trade represents 6.6% and 5.4% of bilateral imports of the EU and Canada, respectively at the benchmark. Other food (OFD), and wheat (WHT), each have a 26—30% share of EU agri-food imports from Canada while OFD and beverage and tobacco (B_T) constitute 29–45% of Canadian agri-food imports from the EU. The average tariff for agri-food products is 6.5% for the EU and 1.7% for Canada, respectively. These protection levels are considerably higher than the average trade-weighted average of all goods (0.86% for the EU and 0.96%

[8] See Jafari and Britz (2018).

[9] GTAP data base comprises many small entries, which can affect the numerical stability during the solution procedure of a CGE. We, therefore, filter out small transactions in relative terms in a systematic way after aggregation to our ten regions while maintaining a balanced global SAM (Britz & Van der Mensbrugghe, 2016).

[10] Products with very small import value such as WHT, and WOL are ignored in ranking Canada's import share of agri-food products from the EU.

TABLE 2 Importance of trade between the EU and Canada compared with the ROW

	EU import			Canada import		
	Total [Million USD]	From Canada [Million USD]	Share from CanadaEU (%)	Total[Million USD]	From EU [Million USD]	Share from the EU (%)
All sectors	7100.92	56.617	0.80	575.505	89.242	15.51
Agri-food	574.854	3.735	0.65	39.417	4.786	12.14
Paddy rice (PDR)	0.075	0.00	0.00	0.000	0.000	–
Wheat (WHT)	9.096	0.963	10.59	0.039	0.01	25.64
Cereal grains nec (GRO)	11.168	0.312	2.79	0.535	0.021	3.93
Vegetables, fruit, nuts (V_F)	67.524	0.312	0.46	7.721	0.177	2.29
Oil seeds (OSD)	16.994	0.507	2.98	0.63	0.007	1.11
Sugar cane, sugar beet (C_B)	0.525	0.000	0.00	0.007	0.000	–
Plant-based fibers (PBF)	0.862	0.000	0.00	0.023	0.000	–
Crops nec (OCR)	32.992	0.041	0.12	1.719	0.097	5.64
Cattle, sheep, goats, horses (CTL)	5.185	0.029	0.56	0.111	0.023	20.72
Animal products nec (OAP)	15.286	0.166	1.09	1.054	0.378	35.86
Raw milk (RMK)	0.147	0.001	0.68	0.000	0.000	–
Wool, silk-worm cocoons WOL)	5.195	0.000	0.00	0.06	0.017	28.33
Meat: cattle, sheep, goats, horse (CMT)	21.573	0.046	0.21	1.37	0.012	0.88
Meat products nec (OMT)	43.979	0.01	0.02	2.175	0.104	4.78
Vegetable oils and fats (VOL)	43.91	0.045	0.10	1.554	0.19	12.23
Dairy products (MIL)	43.438	0.021	0.05	0.629	0.186	29.57
Processed rice (PCR)	3.464	0.002	0.06	0.393	0.004	1.02
Sugar (SGR)	10.116	0.071	0.70	0.783	0.009	1.15
Food products nec (OFD)	183.611	1.128	0.61	15.615	1.4	8.97
Beverages and tobacco products (B_T)	59.715	0.082	0.14	5.001	2.153	43.05
Extraction	589.365	5.324	0.90	24.206	0.241	1.00
Manufacturing	4358.93	26.228	0.60	422.394	47.834	11.32
Services	1577.76	21.33	1.35	89.488	36.381	40.65

Source: GTAP database (GTAP 10, 2014 reference year).

for Canada). Furthermore, they also vary substantially among food products, peaking at 39% for the GTAP sector 'dairy products' for EU imports and 4.4% for Canadian imports of 'food products nec'.

5 | EMPIRICAL ANALYSIS AND RESULTS

5.1 | Scenario specifications

We simulate the impacts of CETA using two different model layouts and related scenarios (Table 4), with comparisons made based on trade and welfare. In the first scenario (partial liberalisation at the tariff line, PL_TL), we remove bilateral trade barriers at the tariff line level for all non-services sectors, while explicitly taking into account sensitive products exempted from liberalisation. This requires the tariff line extension module to implement shocks as negotiated in CETA. The second scenario, full liberalisation at the tariff line (FL_TL), uses the tariff line module as well but removes all bilateral tariffs. The third scenario, partial liberalisation at the sectoral level (PL_SL), uses the standard two-stage Armington structure. Bilateral changes in tariffs at the sector level are calculated based on the reference group method using the same information at the tariff line as in PL_TL; this scenario is currently the main method used in trade analysis. The fourth

TABLE 3 Composition of EU-Canada state of trade and related tariffs

	EU bilateral import (%)		Canada bilateral import (%)	
	Sectoral share	**Tariff rate**	**Sectoral share**	**Tariff rate**
All sectors	100	0.86	100	0.96
Agri-food	6.60	6.45	5.36	1.71
Paddy rice (PDR)	0.00	0.00	0.00	0.00
Wheat (WHT)	25.78	5.00	0.21	0.48
Cereal grains nec (GRO)	8.35	0.07	0.44	0.04
Vegetables, fruit, nuts (V_F)	8.35	0.46	3.70	1.63
Oil seeds (OSD)	13.57	0.00	0.15	0.00
Sugar cane, sugar beet (C_B)	0.00	0.00	0.00	0.00
Plant-based fibers (PBF)	0.00	0.00	0.00	0.00
Crops nec (OCR)	1.10	2.19	2.03	1.98
Cattle, sheep, goats, horses (CTL)	0.78	0.16	0.48	0.00
Animal products nec (OAP)	4.44	0.57	7.90	0.01
Raw milk (RMK)	0.03	0.00	0.00	0.00
Wool, silk-worm cocoons WOL)	0.00	0.00	0.36	0.00
Meat: cattle, sheep, goats, horse (CMT)	1.23	19.28	0.25	0.11
Meat products nec (OMT)	0.27	16.99	2.17	0.90
Vegetable oils and fats (VOL)	1.20	2.85	3.97	0.96
Dairy products (MIL)	0.56	38.69	3.89	1.69
Processed rice (PCR)	0.05	8.55	0.08	0.00
Sugar (SGR)	1.90	4.21	0.19	2.81
Food products nec (OFD)	30.20	16.08	29.25	4.41
Beverages and tobacco products (B_T)	2.20	2.17	44.99	0.49
Extraction	9.04	0.14	0.27	0.07
Manufacturing	46.33	0.95	53.60	1.64
Services	37.67	–	40.77	–

Source: GTAP database (GTAP 10, 2014 reference year).

TABLE 4 Scenario specifications

	PL_TL	FL_TL	PL_SL	FL_SL
Model layout	Tariff line for all sectors except services Standard structure for services sectors		Standard Armington	Tariffs aggregated according to Taste
Shock	Changes in tariffs at tariff line according to FTA agreement	Full bilateral liberalisation (difference only relevant for Agri-food)	Changes in tariffs at tariff line according to FTA agreement	Full bilateral liberalisation (difference only relevant for Agri-food)

scenario, full tariff line scenario sectoral level (FL_SL), uses the structure of the standard GTAP model but assumes full tariff liberalisation.[11]

The difference between the results of PL_TL and FL_TL provides information on the sensitivity of results with regard to exclusion/inclusion of sensitive products from trade liberalisation. Tables 5 and 6, respectively, show the status of tariffs after CETA[12] for sensitive products where tariffs are only partially removed, or they stay unchanged (note that agri-food accounts for all tariff lines exempted). The difference between PL_TL and PL_SL provides information on the importance of aggregation bias that arises from assuming full bilateral liberalisation (hereafter, 'Bias from an oversimplified shock

[11] The GTAP data base does not report tariffs for services – but these are not subject to liberalisation in any of the scenarios. Accordingly, we do not break-down service sectors at the tariff line in the _TL variants.

[12] Note that like any other trade agreement, CETA negotiated changes in current bound rates, which might exceed currently applied ones. Wherever post-agreement-AVEs of bound rates are higher than applied tariff rates, we report the level of applied tariffs. If post-agreement-AVEs of bound rates are lower than applied tariff rates, we use the new bounds rates.

TABLE 5 EU tariff on sensitive products

HS*	Corresponding GTAP sector	Initial tax rate (%)	Final tax rate (%)	Tariff reduction at sector level (%)**	Reference group trade share in GTAP sector (%)	Actual bilateral trade share in GTAP sector (%)
020130	Ruminant meat (CMT)	54	54	28	67.48	1.90
020230		64	64		3.16	0.49
020120		41	41		1.24	0.39
020629		275	275		0.06	0.00
020610		112	112		0.04	0.00
020220		81	81		0.04	0.00
020110		136	136		0.01	0.00
020210		13	13		0.00	0.39
010599	Other animal (OAP)	57	57	99.9	0.00	0.00
200580	Other food (OFD)	18	18	99	0.06	0.00
040811		15	15		0.03	0.00
040899		170	170		0.00	0.00
040819		24	24		0.00	0.00
021099	Other meat (OMT)	42	15	49	25.03	0.00
020329		36	36		7.51	0.00
020714		9	9		6.91	0.00
020727		570	570		4.54	0.00
021020		15	15		2.88	0.00
020319		46	46		2.63	0.00
020312		284	284		0.76	0.00
020322		34	34		0.62	0.00
020713		103	103		0.30	0.00
021011		12	12		0.10	0.00
020712		75	75		0.06	0.00
020711		147	147		0.02	0.00
020726		378	378		0.01	0.00
020724		210	210		0.00	0.00
020725		296	296		0.00	0.00

Note: Initial tax rates are based on MAcMap database for the year 2017, final rates are based on the text of agreement, and the share are based on UN–Comtrade Database for the average of years 2015–2017.

*See Table A1. for the HS descriptions.

**Calculated based on MAcMap reference group method.

definition') and/or from the tariff aggregation bias. Tariffs levels on different tariff lines within some aggregated GTAP sectors can be quite dispersed. Considering a weighted average, only, flattens this dispersion and implicitly assumes that all tariff lines within a sector are subject to an identical reduction in tariff.

Tables 5 and 6 shows the percentage reduction of tariffs for some sectors that are not fully liberalised in CETA. The tariffs for all other tariff lines, and sectors that are not shown in Table 5 and 6 are reduced to zero across all liberalisation scenarios in _TL and _SL variants. As shown in Table 5, the two sectors with the lowest tariffs cuts for the EU, ruminant meat (CMT) and other meat (OMT) are liberalised by about 28% and 49%.

In Canada (Table 6), more sectors are exempted from full liberalisation. Here the Dairy (MIL), OMT and OFD show the lowest tariff reductions with 6%,[13] 55% and 75%, respectively. In comparing PT_TL and PT_SL, we do not separate the two sources of aggregation bias as these are linked together. To do so, we compare the result of FL_TL and FL_SL to filter out the bias from the tariff aggregation, and provide information on the importance of the bias from an oversimplified shock

[13] High protection in Canada's dairy program is one reason why partners seek better access (Cardwell et al., 2015).

TABLE 6 Canada tariff on sensitive products

HS*	Corresponding GTAP sector	Initial tax rate (%)	Final tax rate (%)	Tariff reduction at sector level (%)**	Reference group share in GTAP sector (%)	Bilateral share in GTAP sector (%)
220290	Beverages and tobacco (B_T)	256	256	99.9	7.27	0.00
020990	Ruminant meat (CMT)	207	207	99.9	0.00	0.37
040690	Dairy (MIL)	123	123	6	53.96	78.15
040510		299	299		9.13	6.19
040410		110	104		6.49	0.19
040640		123	123		5.16	6.29
210500		277	277		4.40	0.06
040630		123	123		2.76	2.42
040620		123	123		2.34	0.91
040490		270	270		1.88	0.08
040310		238	238		1.47	0.02
040210		202	202		1.22	0.21
040610		123	123		1.16	0.56
040120		241	241		1.16	0.09
040221		269	269		0.99	0.00
040390		212	212		0.92	0.00
040590		314	314		0.57	0.00
040299		255	255		0.15	0.00
040291		259	259		0.14	0.04
040110		241	241		0.04	0.00
040229		269	269		0.00	0.00
040140		293	293		0.00	0.00
040150		293	293		0.00	1.23
040520		275	275		0.00	0.00
010511	Other animal (OAP)	238	238	95	4.89	1.22
010594		238	238		0.00	0.00
010599		155	155		0.00	0.00
040711		201	201		0.00	0.00
040721		164	164		0.00	0.00
040790		164	164		0.00	0.00
210690	Other food (OFD)	135	135	74	9.48	6.97
180690		265	265		9.01	10.71
230990		206	206		2.91	2.54
190120		245	245		1.63	1.03
190190		259	259		1.36	0.37
180620		265	265		1.31	2.02
040899		94	94		0.04	0.00
350211		68	68		0.01	0.00
020713	Other meat (OMT)	249	249	55	25.43	0.00
160100		196	196		12.73	8.41
160232		251	251		2.05	3.99
160231		167	167		1.47	0.00
020714		245	245		0.83	5.09

(Continues)

TABLE 6 (Continued)

HS*	Corresponding GTAP sector	Initial tax rate (%)	Final tax rate (%)	Tariff reduction at sector level (%)**	Reference group share in GTAP sector (%)	Bilateral share in GTAP sector (%)
020726		165	165		0.60	0.04
020711		238	238		0.56	0.00
160220		196	196		0.43	0.40
020727		162	162		0.28	0.00
020724		155	155		0.21	0.00
021099		207	207		0.13	0.00
020712		238	238		0.03	0.00
020725		155	155		0.00	0.00
151790	Vegetable oil and fats (VOL)	218	218	99.9	12.06	0.00
151710		103	103		1.36	0.00

Note: Initial tax rate are based on MAcMap for the year 2017, Final rates are based on the text of agreement, and the share are based on UN–Comtrade Database for the average of years 2015–2017.
*See Table A1 for the HS descriptions.
**Calculated based on MAcMap reference group method.

definition. Jointly, the four scenarios shed light on the differences (based on trade and welfare impacts) resulting from different implementations of trade in the model structure and from different shock definitions.

5.2 | Simulation results

5.2.1 | Trade and welfare impacts of PL_TL

Bilateral trade impacts for an aggregate of all commodities, an aggregate agri-food sector and for individual agri-food sectors for the EU and Canada are presented in Tables 7 and 8. Following the reduction of tariffs on imports by the EU and Canada at the tariff line level, their total bilateral imports increase by 2.3% and 3.4%, while agri-food imports increase by 15.5% and 1.2%. Despite its less than 7% share in bilateral trade at the benchmark, agri-food products account for 44.9% of the increase in bilateral imports of the EU from Canada. Therefore, the agri-food sector is a key driver of the expansion of imports, particularly for the EU.

Hejazi and Francois (2008) simulated a significantly larger expansion in bilateral trade (+24.3% for EU imports and 36.6% Canadian imports), but they assumed larger tariff cuts (full tariff elimination) combined with additional reductions in trade costs due to lowered non-tariff measures. The trade impacts in their study are largely driven by the processed food sector, increasing by +326% for Canadian imports and +142% for EU imports. The simulated trade impacts in European Commission (2017) also exceed our PL_TL scenario results (+8.0% for Canadian imports and +8.1% for EU imports), but they are close to the impacts in the PL_SL scenario. This suggests that the PL_SL approach corresponds to the state-of-the-art CGE modelling approach (followed in European Commission, 2017); and the smaller impacts in PL_TL suggests that the tariff aggregation bias might overestimate impacts in most CGE-based CETA studies.

The largest contributor to the bilateral import increase of agri-food trade in the EU is the OFD sector, which accounts for 30% of agri-food imports from Canada and was subjected to a 16% bilateral import tax at the benchmark (Table 3). The contribution of other sectors to the overall increase is negligible. Still, in terms of relative changes, larger impacts can be observed for the MIL (270%), reflecting a high initial average tariff of 39%. Note that this large relative increase relates to a quite small initial import share which leaves the total expanded traded volumes still relatively small.

Other sectors are not affected as much (in terms of absolute values), because either their initial trade volume or average tariff was small. Impacts partly reflect the intra-industry relations as well, when, for instance, increased export demand drives up prices which in turn lets domestic firms substitute away from domestic supply. Similarly, increased imports of processed products crowd out domestic production, reducing intermediate import demand from sectors where output drops. For example, in our analysis, EU's OFD imports from Canada increase. Related inter-sectoral linkages reduce the

TABLE 7 Impacts on the imports of the EU from Canada

	Baseline(Million USD)	PL_TL (%)	FL_TL (%)	PL_SL (%)	FL_SL (%)
All sectors	56.617	2.3	2.4	4.8	5.5
Agri-food	3.735	15.5	17.6	31.1	44.9
Paddy rice (PDR)	0.00	−0.4	−0.5	−3.0	−3.6
Wheat (WHT)	0.963	−0.3	−0.3	43.3	42.9
Cereal grains nec (GRO)	0.312	0.1	0.1	−0.3	−0.4
Vegetables, fruit, nuts (V_F)	0.312	0.8	0.8	0.9	0.7
Oil seeds (OSD)	0.507	−0.2	−0.2	−0.9	−1.1
Crops nec (OCR)	0.041	8.1	8.1	13.6	13.2
Cattle, sheep, goats, horses (CTL)	0.029	0.3	0.3	−0.3	−0.4
Animal products nec (OAP)	0.166	0.7	0.9	0.9	0.8
Raw milk (RMK)	0.001	−0.1	−0.1	−1.6	−2.3
Meat: cattle, sheep, goats, horse (CMT)	0.046	0.02	155.3	282.1	281.0
Meat products nec (OMT)	0.01	35.0	129.1	105.5	290.2
Vegetable oils and fats (VOL)	0.045	11.2	11.2	16.3	19.0
Dairy products (MIL)	0.021	269.8	269.6	11.9	968.1
Processed rice (PCR)	0.002	25.5	25.5	51.7	51.4
Sugar (SGR)	0.071	13.1	13.0	24.1	23.9
Food products nec (OFD)	1.128	45.3	45.6	53.3	79.8
Beverages and tobacco products (B_T)	0.082	2.8	2.7	4.4	4.7
Extraction	5.324	0.1	0.1	0.2	0.2
Manufacturing	26.228	3.2	3.2	3.9	3.8
Services	21.33	−0.2	−0.2	−0.2	−0.2

Source: Simulation results.

EU's import demand for the WHT sector. The importance of such a sectoral-linkage effect also suggests that reducing the sectoral resolution of the database by aggregating can bias results by removing information on sectoral relationships. Keeping the resolution of the data base and instead aggregating the results post model is therefore recommended by Britz and Van der Mensbrugghe (2016).

The change in Canadian bilateral imports is mostly due to the increase in OFD imports, which has a 29% share of the total bilateral agri-food imports and an average bilateral import tariff of 4.4% at the benchmark. As opposed to the EU case, MIL Canadian imports increase only marginally (+0.23%). This is due to the combination of small tariff reductions, a low share of bilateral agri-food imports (4%) and a low initial tariff (1.7%). This contrast to the results of Philippidis and Kitou (2012), who identify dairy as the driver of the expansion in Canadian agri-food imports (at 40 percent) under a full liberalisation scenario (i.e., they assume the removal of the prohibitive Canadian dairy TRQs). Regarding other sectors, they are subject to relatively low tariffs and/or have small bilateral trade weights, which implies limited impacts overall.

We report welfare impacts based on the equivalent variation (EV) criterion, that is, the amount of income to be added to the regional household's benchmark income at benchmark prices to reach the same utility as under simulated income and prices. At the global level, an increase in welfare of 0.03 USD per capita (Figure 4) is not much different from the EU's gain of 0.7 USD per capita. Canada shows a larger gain of 6.6 USD per capita. The significantly larger per capita welfare gains in Canada are in line with previous studies (e.g., Philippidis and Kitou (2012) report a 10 times larger impacts for Canada).

5.2.2 | Exclusion of sensitive products

We now shed light on the importance of exemptions for sensitive products by using the same model layout, but liberalizing tariffs fully at the tariff line level. We compare the results generated from PL_TL with FL_TL and focus on the sectors that

TABLE 8 Impacts on the imports of Canada from the EU

	Baseline(Million USD)	PL_TL (%)	FL_TL (%)	PL_SL (%)	FL_SL (%)
All sectors	89.242	3.38	3.57	6.5	6.5
Agri-food	4.786	1.20	4.65	6.9	7.2
Wheat (WHT)	0.01	0.85	0.93	7.5	7.9
Cereal grains nec (GRO)	0.021	0.61	0.66	0.6	1.0
Vegetables, fruit, nuts (V_F)	0.177	3.90	3.92	6.2	6.3
Oil seeds (OSD)	0.007	0.25	0.27	0.2	0.4
Sugar cane, sugar beet (C_B)	0.000	0.29	0.29	0.3	0.4
OCR (Crops nec)	0.097	7.98	8.00	13.1	13.2
Cattle, sheep, goats, horses (CTL)	0.023	0.16	0.43	0.8	0.9
Animal products nec (OAP)	0.378	0.44	0.49	0.6	0.9
Wool, silk-worm cocoons (WOL)	0.017	0.58	0.62	0.5	0.9
Meat: cattle, sheep, goats, horse (CMT)	0.012	0.69	0.71	0.8	1.7
Meat products nec (OMT)	0.104	1.80	4.97	4.4	8.8
Vegetable oils and fats (VOL)	0.19	4.18	4.38	6.3	6.6
Dairy products (MIL)	0.186	0.23	8.10	11.5	12.0
Processed rice (PCR)	0.004	0.20	0.22	0.4	0.5
Sugar (SGR)	0.009	9.51	9.55	16.5	16.7
Food products nec (OFD)	1.4	1.70	11.55	17.8	18.1
Beverages and tobacco products (B_T)	2.153	0.31	0.89	1.0	1.0
Extraction	0.241	0.07	0.07	0.0	0.0
Manufacturing	47.834	6.22	6.22	6.5	6.5
Services	36.381	0.13	0.14	6.9	7.2

Source: Simulation results.

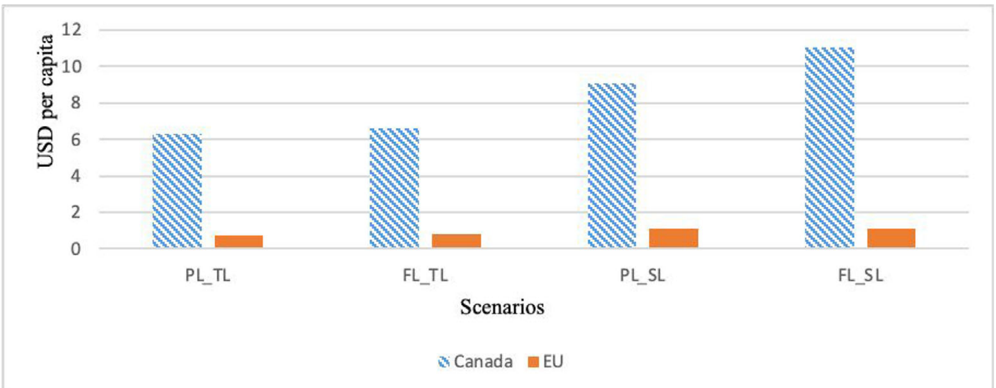

FIGURE 4 Welfare impacts [USD per capita]
Source: Simulation results

comprise the sensitive products. The FL_TL scenarios projects an increase of agri-food bilateral imports of 17.6% for the EU and 4.65% for Canada (compared to 15.5% and 1.2% under the PL_TL scenario).

As indicated in Table 5, sensitive products in the EU are found in the CMT, OMT, OFD and other animal product (OAP) sectors. There are eight HS6 categories noted as sensitive in the CMT sector (accounting for 2.5% of bilateral trade), but liberalisation of these products increases the bilateral import of the sector to 155% in FT_TL (PL_TL simulated an increase of 0.02%). Similarly, for OMT there are 15 HS6 lines considered sensitive. Their share is almost zero, but they feature tariffs ranging from 9 to 570%, thus full liberalisation more than triples the trade effect from 35% to 129%. There is a total of four

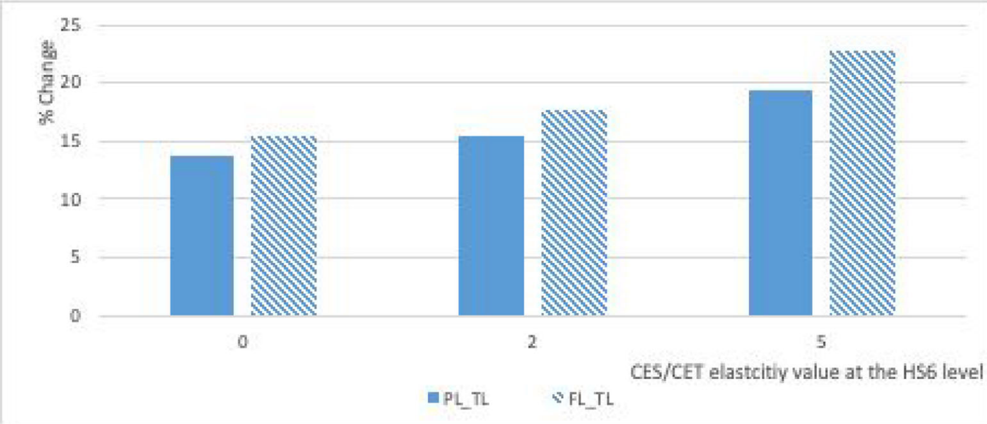

FIGURE 5 Impacts on the agricultural import of the EU from Canada
Source: Simulation results

HS6 categories for OFD and one for OAP that are sensitive; their weight in the bilateral trade of respected GTAP sectors is almost zero. The bilateral tariff removal results in an increase in their bilateral trade 45.3 % and 0.07% in PL_TL to 45.6 % and 0.9% and in FL_TL.

The OFD sector in Canada, which accounts for 9% of total imports from EU, has high protection (68–265%) across HS6 lines. FT_TL considers tariff removal for all HS6 lines, while PT_TL keeps tariffs on sensitive tariff lines unchanged (Table 6). Due to the higher tariff cuts, FL_TL projects an increase of bilateral imports by 11.55% compared to a 1.7% increase from PT_TL. Similar to the EU case, MIL Canadian imports increase significantly by 8.1% in FL_TL, compared to a 0.23% increase in PT_TL. The other sector that experiences significant bilateral import growth is OMT with an increase ranging from 1.8% in PT_TL to 4.97% in FL_TL. The same occurs for the B_T sector, where simulated impacts are tripled between the two scenarios: from 0.31% to 0.89%. Also, other sensitive sectors, experience increases in imports, namely OAP, CMT and VOL (Vegetable oils). The systematically higher simulated impacts under the full liberalisation scenario are in line with the findings of the literature review in Section 2, with authors often noting that follow-up analysis could consider exemptions for sensitive products (e.g., Cameron & Loukine, 2001).

To assess the robustness of the simulated impact on trade, we also perform a sensitivity analysis on the size of transformation and substitution elasticities in the CET and CES functions at the tariff line. We randomly draw a sample for the transformation and substitution elasticities from a truncated normal distribution within the interval of 0 and 5 and perform 100 model runs. Simulated impacts are found to change only marginally (not reported here) for different elasticities. Significant, but still small, changes are observed when the substitution elasticities are from the tails of the distribution. We report the simulated results for the upper and the lower bound of the distribution interval, comparing those to the results with the benchmark elasticity of 2. The detailed results are presented in Appendix A Tables A2 and A3, and confirm the pattern described above. Increasing the substitution and transformation elasticities tends to increase the simulated impacts on bilateral trade (Figure 5 and 6). A zero elasticity (lower bound for our sensitivity analysis) corresponds to the standard (fix) trade weighted tariff aggregator. The simulated impacts under different elasticity values suggest that trade liberalisation impacts strongly depend on the dispersion of tariff changes, and on the attached trade weights.

Overall, our result shows that neglecting exemptions for sensitive products can lead to sizeable overestimation of trade generated effects. Welfare gains also tend to be overestimated when sensitive products are neglected, but to a smaller degree (compare results for Figure 4 under the same model layout). The sensitivity analysis identifies a positive correlation between simulated bilateral trade impacts and the size of the substitution elasticities in the modelling framework.

5.2.3 | Aggregation bias

This section compares the results of PL_TL and PL_SL, that is, the same shock considering exemptions for sensitive products implemented in the different model structures. PL_SL, using the GTAP standard trade representation, requires pre-aggregating tariff changes; while PL_TL tries to reduce the aggregation bias by moving the tariff aggregator into the model

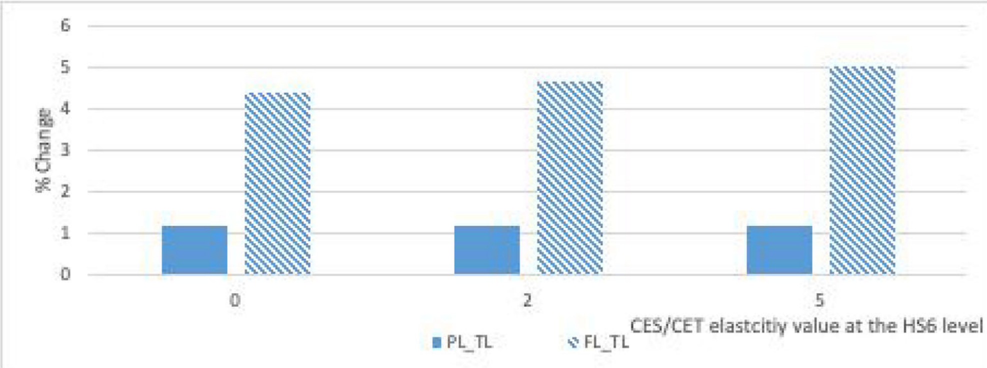

FIGURE 6 Impacts on the agricultural import of Canada from the EU
Source: Simulation results

itself such that aggregation weights adjust endogenously. Differences in outcomes relate to the workings of a CES/CET nesting over multiple bilateral tariff lines compared to one using (implicitly) fixed shares. From the demand side, the CES will adjust the shares according to changes in CIF price relations. Tariff lines that experience a (CIF) price drop above the average will increase their value share. This can, however, decrease quantity if their benchmark (CIF) price is well above the average, implying higher per unit utility. Size and direction of these effects also reflect the assumed substitution and transformation elasticities.

In the EU, the bilateral imports of all products except the MIL are projected to be higher under the current GTAP standard plus TASTE (PL_SL) method. On average, bilateral imports of agri-food products increase from 15.5% % to 31.1%, stemming mostly from OFD which increases from 45.3% to 53.3%. The drop in the simulated increase of dairy products from 269% to 11.9% reflects the unchanged trade shares which adjust quite strongly in PL_TL. Similarly, the Canadian bilateral import of agri-food products increases from 1.2% to 6.9%. This increase is largely associated with the increase of OFD from 1.70% to 17.8%. The highest relative change in bilateral imports is found for the MIL sector which expands 11.5% compared to 0.23% in the PL_TL setup. As a response to higher simulated trade, the welfare gain in the EU increases from 6.6 to 9.1 USD per capita and in Canada from 0.7 to 1 USD per capita (Figure 4). The results are also in line with the literature reviewed in Section 2, suggesting that adding more sectoral details (and ultimately moving to the tariff line level) tends to decrease simulated trade impacts.[14]

To shed further light on the differences between model structures, we compare results of FL_TL and FL_SL where identical shocks are imposed and the final average protection rate of each sector at bilateral level is zero, independent from the tariff aggregator. As can be seen from Tables 7 and 8, the trade impact tends to decrease with the tariff line extension for all sectors.

Overall, we find that the bias from neglecting tariff cut exemptions (full liberalisation assumptions) is likely bigger than the bias from neglecting the substitution effect between tariff lines in the tariff aggregation (pre-model aggregators). Interestingly, the pre-model aggregation provoked stronger trade generation effects and welfare gains than the tariff line aggregator. The different simulated impacts highlight the need for considering the substitution between tariff lines, in particular, if tariff dispersion and the variability in trade weights are large. Furthermore, the impacts with the pre-model aggregation are systematically higher, even if the substitution and transformation elasticities are reduced to zero. This suggests that the endogenous aggregation keeps the average protection rate higher than the pre-model approach, even if we reduce the flexibility for substituting away from exempted tariff lines by decreasing elasticities.

6 | IMPORT RESPONSE OF THE MODEL

To verify our model extension, we calculate import demand elasticities based on the results of the sensitivity analysis

[14] To show that the results are mainly driven by the dispersion of tariffs across tariff lines within each aggregated sector and their attached weights, we again compare the results of PL_TL with zero substitution and transformation elasticities across tariff lines (Table A1 and A2), and show that the impacts are significantly higher in PL_SL.

TABLE 9 Import quantity changes for a 10% reduction in CIF price between Canada and the EU, with and without a CET transformation approach

		% Change in bilateral imports (from the EU/Canada to its CETA partner)		% Change in total imports (to all trade partners)	
		CET	Standard GTAP	CET	Standard GTAP
Canada	wht	80.83	162.01	2.65	6.01
	gro	28.19	33.64	0.07	0.14
	v_f	50.49	62.80	0.12	0.21
	osd	57.16	80.27	0.43	0.89
	pfb			0.02	0.03
	ocr	62.83	96.09	0.88	1.12
	ctl	39.74	51.68	2.14	2.51
	oap	24.32	28.67	1.92	2.10
	wol			0.00	
	frs	53.55	75.24	0.47	0.60
	fsh	34.36	39.75	0.51	0.59
	vol	58.58	91.22	3.40	4.92
	meat	71.56	129.42	0.57	0.92
	mil	12.77	18.18	3.23	3.97
	pcr	61.65	86.80	0.05	0.05
	sgr	44.67	64.24	0.72	1.23
	ofd	32.44	41.65	1.51	1.78
	b_t	19.69	22.40	4.06	4.35
EU	wht	71.94	120.18	2.21	2.92
	gro	27.72	32.85	0.20	0.22
	v_f	37.86	48.29	0.04	0.05
	osd	46.46	63.21	0.66	0.78
	pfb	47.82	69.17	0.01	0.01
	ocr	60.87	97.25	0.02	0.04
	ctl	39.20	52.01	0.11	0.13
	oap	25.58	30.65	0.10	0.11
	wol			0.00	
	frs	49.95	71.02	0.06	0.07
	fsh	22.49	26.56	0.06	0.06
	vol	61.91	98.66	0.12	0.16
	meat	66.12	120.09	0.04	0.06
	mil	33.16	53.47	0.01	0.02
	pcr	43.66	63.30	0.00	0.00
	sgr	48.95	72.77	0.10	0.01
	ofd	33.60	44.38	0.07	0.09
	b_t	23.34	27.52	0.01	0.02

Source: Simulation results.

and compare them to those derived with the standard GTAP model. We do not consider the third level of the Armington nesting in the analysis below, since it simply acts as a tariff aggregator in this context, that is, it does not impact demand. We run a stylised policy shock with a 10% import tariff reduction at the aggregated commodity level, and for bilateral trade between the EU and Canada. The shock of the sensitivity analysis is run with two different model configurations: with a CET formulation, which is required for the tariff line module and without CET, as in the standard GTAP. The transformation elasticity of the CET is set to 15 across export flows and set to 10 between total exports and domestic sales.

Consequently, the 10% shock we introduce decreases the CIF price on the bilateral trade links between EU and Canada by 10%.[15]

Bilateral trade flows react quite elastically to a 10% drop in the CIF price (Table 9), as we would expect, reflecting the lower level Armington elasticities in GTAP that are quite elastic. These observations are also in line with Hertel et al. (2007), Kee et al. (2008), and Fontagne et al. (2019) who show the import price elasticity is above one. Relative differences in simulated impacts among products reflect differences in the respective Armington elasticities (taken from GTAP database). Simulated impacts on bilateral trade with and without the CET can differ up to a factor of two. These differences are somewhat surprising, given the large transformation elasticities applied in the CET function. Still, the bilateral trade response remains quite elastic with the CET specification. The smallest simulated demand elasticity is around 1.2 in the case of Canadian EU imports, for MIL, and around 2.3 for EU imports from Canada, for (B_T). The largest demand elasticities are found for wheat trade, with around 16 for Canada and 12 for the EU imports.

Total import changes are clearly more muted and reflect additionally the original import share of the partner country, as well as smaller elasticities at the top Armington level (again taking the elasticities from the GTAP database). The relative differences in total import changes with and without the CET structure are quite similar to the ones we found on the bilateral trade link. The median total import change in Canada is around 1%, far bigger than the 0.07% we find for the EU, which reflects the different market sizes and the strong integration[16] between EU countries (EU single market).

7 | SUMMARY AND CONCLUSION

Sensitive products, those with high rates of protection, are often exempted from trade liberalisation, but many CGE analyses ignore these exemptions. Doing so likely overestimates trade impacts. In addition, some CGE analyses preform pre-model tariff aggregation, but this is prone to bias due to neglecting how importers substitute tariff line-level goods. Recent developments (e.g., GTAP-HS) attempt to mitigate these problems by extending the GTAP structure to HS lines by disaggregating trade, consumption and production data for one (or a few) sectors. However, this approach requires a substantial amount of data from different sources, causing data harmonisation problems (subsectors classifications might differ from one dataset to the other). Moreover, this approach increases overall model size considerably, which renders it computationally challenging to disaggregate sectors comprising many tariff lines, while at the same time considering regional detail.

The approach proposed in this paper, instead, solely extends the two-stage CES/CET trade structures, found in many global CGE models, to the tariff line for selected trade links. This module acts as an endogenous tariff aggregator across tariff lines, allowing for substitution of commodities across tariff lines, reducing data needs and the computational burden. To test the framework, we generate four scenarios to quantify CETA impacts, which jointly allow for a systematic comparison of the aggregation bias in state-of-the-art approaches for modelling trade liberalisation in the CGE framework. Our simulation results confirm that neglecting sensitive products in CGE-based FTA analysis overestimates trade generation and welfare gains. In cases where sensitive products are included in the analysis, the proposed approach resulted in significantly lower simulated trade and welfare impacts compared to standard pre-model tariff aggregation approaches. Consequently, we find that the state-of-the-art reference group method for tariff aggregation implies potentially overestimated trade dynamics.

We conclude that our approach, based on open-source and open-access code, provides a relatively easy to employ alternative to pre-model tariff aggregation and can be valuable for policy makers who conduct trade policy discussions at the HS level. Our CETA analysis demonstrates that it is computationally feasible to even disaggregate all GTAP sectors to over 5,000 HS6 tariff lines for one specific bilateral link, based on the proposed extension of the CES/CET nests depicting bilateral trade. Such an approach is especially suitable to analyse FTAs between two (or few) trading partners where typically detailed data on bilateral policy instruments and their changes are readily available.

Nevertheless, reduced computational burden and easy implementation comes at a price. Some limitations are as follows: the proposed model extension does not capture changes in production and domestic supply as well as consumption and demand for domestically produced good at the tariff line level. Substitution and transformation elasticities across tariff

[15] Actual simulated (FOB) price changes will slightly deviate from the shock on CIF prices due to endogeneity of the trade margins.

[16] Note here that the EU in our model is one aggregate region over the 28 individual EU Member States (pre-Brexit status). Imports between the Member States are aggregated to an EU–EU bilateral trade flow in the data base used for benchmarking. Accordingly, domestic sales for the EU model region are an aggregate of the domestic sales of the individual EU member countries.

lines should be backed up by empirical estimates (commodity and country specific), which are currently not available in the literature, in contrast to the approach of the explicit representation of the tariff line commodities where trade elasticity estimates are available (e.g., Fontagné et al., 2019). Our approach does not reduce the data needed by much for such multilateral trade policies, compared to other existing approaches in the literature. Commodity aggregation is extended to the tariff line only for the FTA partners, but not for third country trade relations. This makes sense when considering the extension as an endogenous non-linear tariff aggregator. As long as tariffs on a trade link do not change, either exogenously due to the shock, or endogenously due to, for instance, TRQs, there is no need to integrate a tariff aggregator in the model itself. However, keeping commodities highly aggregated for non-FTA partners might distort simulated trade diversion effects. The high level of details on sensitive products potentially limits trade creation between FTA partners, compared to standard (more aggregated) CGE modelling exercises. In theory, small (or no) trade creation for sensitive tariff lines also limits trade diversion, including the impact on trade of these sensitive products with third countries. Our approach is biased in terms of this indirect effect on third countries, because tariff lines that are declared sensitive for intra-FTA trade are aggregated to broader commodity definitions in extra-FTA trade relations.

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CONFLICT OF INTEREST

The paper has not been published previously and it is not under consideration for publication elsewhere. All authors approve this publication and if the paper accepted, it will not be published elsewhere in the same form.

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APPENDIX A

TABLE A1 HS descriptions

HS	Descriptions
010511	Poultry: live, fowls of the species *Gallus domesticus*, weighing not more than 185 g
010594	Poultry: live, fowls of the species *Gallus domesticus*, weighing more than 185 g
010599	Poultry: live, ducks, geese, turkeys and guinea fowls, weighing more than 185 g
010599	Poultry: live, ducks, geese, turkeys and guinea fowls, weighing more than 185 g
020110	Meat: of bovine animals, carcasses and half-carcasses, fresh or chilled
020120	Meat: of bovine animals, cuts with bone in (excluding carcasses and half-carcasses), fresh or chilled
020130	Meat: of bovine animals, boneless cuts, fresh or chilled
020210	Meat: of bovine animals, carcasses and half-carcasses, frozen
020220	Meat: of bovine animals, cuts with bone in (excluding carcasses and half-carcasses), frozen

(Continues)

TABLE A1 (Continued)

HS	Descriptions
020230	Meat: of bovine animals, boneless cuts, frozen
020312	Meat: of swine, hams, shoulders and cuts thereof, with bone in, fresh or chilled
020319	Meat: of swine, nes. in item no. 0203.1, fresh or chilled
020322	Meat: of swine, hams, shoulders and cuts thereof, with bone in, frozen
020329	Meat: of swine, hams, shoulders and cuts thereof, with bone in, frozen
020610	Offal, edible: of bovine animals, fresh or chilled
020629	Offal, edible: of bovine animals, (other than tongues and livers), frozen
020711	Meat and edible offal: of the poultry of heading no. 0105, of fowls of the species *Gallus domesticus* (not cut in pieces), fresh or chilled
020711	Meat and edible offal: of fowls of the species *Gallus domesticus*, not cut in pieces, fresh or chilled
020712	Meat and edible offal: of the poultry of heading no. 0105, of fowls of the species *Gallus domesticus*, (not cut in pieces), frozen
020712	Meat and edible offal: of fowls of the species *Gallus domesticus*, not cut in pieces, frozen
020713	Meat and edible offal: of the poultry of heading no. 0105, of fowls of the species *Gallus domesticus*, cuts and offal, fresh or chilled
020713	Meat and edible offal: of fowls of the species *Gallus domesticus*, cuts and offal, fresh or chilled
020714	Meat and edible offal: of the poultry of heading no. 0105, of fowls of the species *Gallus domesticus*, cuts and offal, frozen
020714	Meat and edible offal: of fowls of the species *Gallus domesticus*, cuts and offal, frozen
020724	Meat and edible offal: of the poultry of heading no. 0105, of turkeys, (not cut in pieces), fresh or chilled
020724	Meat and edible offal: of turkeys, not cut in pieces, fresh or chilled
020725	Meat and edible offal: of the poultry of heading no. 0105, of turkeys, (not cut in pieces), frozen
020725	Meat and edible offal: of turkeys, not cut in pieces, frozen
020726	Meat and edible offal: of the poultry of heading no. 0105, of turkeys, cuts and offal, fresh or chilled
020726	Meat and edible offal: of turkeys, cuts and offal, fresh or chilled
020727	Meat and edible offal: of the poultry of heading no. 0105, of turkeys, cuts and offal, frozen
020727	Meat and edible offal: of turkeys, cuts and offal, frozen
020990	Fat: poultry fat, not rendered or otherwise extracted, fresh, chilled, frozen, salted, in brine, dried or smoked
021011	Meat, preserved: of swine, hams, shoulders and cuts thereof, with bone in, salted, in brine, dried or smoked
021020	Meat, preserved: of bovine animals, salted, in brine, dried or smoked
021099	Meat and edible meat offal: salted, in brine, dried or smoked and edible flours and meals of meat or meat offal, other than of primates, whales, dolphins, porpoises, manatees, dugongs, seals, sea lions, walruses, reptiles (including snakes and turtles)
021099	Meat and edible meat offal: salted, in brine, dried or smoked and edible flours and meals of meat or meat offal, other than of primates, whales, dolphins, porpoises, manatees, dugongs, seals, sea lions, walruses, reptiles (including snakes and turtles)
040110	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content not exceeding 1% (by weight)
040120	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content exceeding 1% but not exceeding 6% (by weight)
040140	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content, by weight, exceeding 6% but not exceeding 10%
040150	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content, by weight, exceeding 10%
040210	Dairy produce: milk and cream, concentrated or containing added sugar or other sweetening matter, in powder, granules or other solid forms, of a fat content not exceeding 1.5% (by weight)
040221	Dairy produce: milk and cream, concentrated, not containing added sugar or other sweetening matter, in powder, granules or other solid forms, of a fat content exceeding 1.5% (by weight)

(Continues)

TABLE A1 (Continued)

HS	Descriptions
040229	Dairy produce: milk and cream, containing added sugar or other sweetening matter, in powder, granules or other solid forms, of a fat content exceeding 1.5% (by weight)
040291	Dairy produce: milk and cream, concentrated, not containing added sugar or other sweetening matter, other than in powder, granules or other solid forms
040299	Dairy produce: milk and cream, containing added sugar or other sweetening matter, other than in powder, granules or other solid forms
040310	Dairy produce: yoghurt, whether or not concentrated or containing added sugar or other sweetening matter or flavoured or containing added fruit or cocoa
040390	Dairy produce: buttermilk, curdled milk or cream, kephir, fermented or acidified milk or cream, whether or not concentrated or containing added sweetening, flavouring, fruit or cocoa (excluding yoghurt)
040410	Dairy produce: whey, whether or not concentrated or containing added sugar or other sweetening matter
040490	Dairy produce: natural milk constituents (excluding whey), whether or not containing added sugar or other sweetening matter, nec. in chapter 04
040510	Dairy produce: derived from milk, butter
040520	Dairy produce: dairy spreads
040590	Dairy produce: fats and oils derived from milk (other than butter or dairy spreads)
040610	Dairy produce: fresh cheese (including whey cheese), not fermented, and curd
040620	Dairy produce: cheese of all kinds, grated or powdered
040630	Dairy produce: cheese, processed (not grated or powdered)
040640	Dairy produce: cheese, blue-veined and other cheese containing veins produced by Penicillium roqueforti (not grated, powdered or processed)
040690	Dairy produce: cheese (not grated, powdered or processed), nec. in heading no. 0406
040711	Birds' eggs, in shell: fresh, fertilised eggs for incubation, of fowls of the species Gallus domesticus (domestic hens)
040721	Birds' eggs, in shell: fresh, not for incubation, of fowls of the species Gallus domesticus (domestic hens)
040790	Birds' eggs, in shell: preserved or cooked
040811	Eggs: birds' eggs, yolks, dried, whether or not containing added sugar or other sweetening matter
040819	Eggs: birds' eggs, yolks, fresh, cooked by steaming or by boiling in water, moulded, frozen or otherwise preserved, whether or not containing added sugar or other sweetening matter
040899	Eggs: birds' eggs (not in shell, excluding yolks only), fresh, cooked by steaming or boiling in water, moulded, frozen, otherwise preserved, whether or not containing added sugar or other sweetening matter
040899	Eggs: birds' eggs (not in shell, excluding yolks only), fresh, cooked by steaming or boiling in water, moulded, frozen, otherwise preserved, whether or not containing added sugar or other sweetening matter
151710	Margarine: excluding liquid margarine
151790	Edible mixtures or preparations of animal or vegetable fats or oils or of fractions of different fats or oils of this chapter, other than edible fats or oils of heading no. 1516
160100	Meat preparations: sausages and similar products, of meat, meat offal or blood, and food preparations based on these products
160220	Meat preparations: of the prepared or preserved liver of any animal (excluding homogenised preparations)
160231	Meat preparations: of turkeys, prepared or preserved meat or meat offal (excluding livers and homogenised preparations)
160232	Meat preparations: of the poultry of heading no. 0105, (i.e., of fowls of the species Gallus domesticus)
180620	Chocolate & other food preparations containing cocoa; in blocks, slabs or bars weighing more than 2 kg or in liquid, paste, powder, granular or other bulk form in containers or immediate packings, content exceeding 2 kg
180690	Chocolate and other food preparations containing cocoa; nec. in chapter 18
190120	Food preparations; mixes and doughs for the preparation of bread, pastry, cakes, biscuits and other bakers' wares
190190	Food preparations; of flour, meal, starch, malt extract or milk products, for uses nec. in heading no. 1901
200580	Vegetable preparations; sweetcorn (*Zea mays* L. var. saccharata), prepared or preserved otherwise than by vinegar or acetic acid, not frozen

(Continues)

TABLE A1 (Continued)

HS	Descriptions
210500	Ice cream and other edible ice; whether or not containing cocoa
210690	Food preparations; nec. in item no. 2106.10
220290	Non-alcoholic beverages: nes. in item no. 2202.10, not including fruit or vegetable juices of heading no. 2009
230990	Dog or cat food: (not put up for retail sale), used in animal feeding
350211	Albumins: egg albumin, dried

TABLE A2 Impacts on the import of the EU from Canada (Sensitivity analysis)

	PL_TL (%)		FL_L (%)	
CES/CET substitution elasticities at the tariff line	0.0	5	0.0	5
All sectors	2.2	2.5	2.3	2.7
Agri-food	13.8	19.3	15.4	22.7
Paddy rice (PDR)	−0.4	−0.5	−0.5	−0.6
Wheat (WHT)	−0.3	−0.3	−0.3	−0.4
Cereal grains nec (GRO)	0.1	0.1	0.1	0.1
Vegetables, fruit, nuts (V_F)	0.8	0.8	0.8	0.8
Oil seeds (OSD)	−0.2	−0.2	−0.2	−0.2
Crops nec (OCR)	8.1	8.1	8.0	8.0
Cattle, sheep, goats, horses (CTL)	0.3	0.2	0.3	0.4
Animal products nec (OAP)	0.6	0.8	0.8	1.1
Raw milk (RMK)	−0.1	−0.1	−0.1	−0.1
Meat: cattle, sheep, goats, horse (CMT)	0.0	0.0	114.9	256.1
Meat products nec (OMT)	32.5	40.1	116.5	169.5
Vegetable oils and fats (VOL)	10.9	11.8	10.9	11.8
Dairy products (MIL)	264.4	277.2	264.2	277.0
Processed rice (PCR)	25.5	25.5	25.5	25.4
Sugar (SGR)	13.1	13.0	13.0	13.0
Food products nec (OFD)	39.5	58.3	39.8	58.6
Beverages and tobacco products (B_T)	2.7	2.8	2.7	2.8
Extraction	0.1	0.1	0.1	0.1
Manufacturing	0.1	0.1	0.1	0.1
Services	3.2	3.2	3.2	3.1

Source: Simulation results.

TABLE A3 . Impacts on the import of Canada from the EU (sensitivity analysis)

	PL_TL (%)		FL_TL (%)	
CES/CET substitution elasticities at the tariff line	0.0	5	0.0	5
All sectors	3.4	3.4	3.5	3.6
Agri-food	1.2	1.2	4.4	5.0
Wheat (WHT)	0.8	1.0	0.9	1.1
Cereal grains nec (GRO)	0.6	0.7	0.6	0.8
Vegetables, fruit, nuts (V_F)	3.8	4.1	3.8	4.1

(Continues)

TABLE A3 (Continued)

	PL_TL (%)		FL_TL (%)	
Oil seeds (OSD)	0.2	0.3	0.2	0.3
Sugar cane, sugar beet (C_B)	0.3	0.3	0.3	0.3
OCR (Crops nec)	7.9	8.1	7.9	8.1
Cattle, sheep, goats, horses (CTL)	0.1	0.2	0.4	0.6
Animal products nec (OAP)	0.4	0.5	0.5	0.6
Wool, silk-worm cocoons (WOL)	0.5	0.7	0.6	0.7
Meat: cattle, sheep, goats, horse (CMT)	0.7	0.7	0.7	0.7
Meat products nec (OMT)	1.8	1.8	4.9	5.1
Vegetable oils and fats (VOL)	4.1	4.3	4.3	4.5
Dairy products (MIL)	0.2	0.3	8.1	8.2
Processed rice (PCR)	0.2	0.2	0.2	0.3
Sugar (SGR)	9.3	9.9	9.3	10.0
Food products nec (OFD)	1.7	1.7	10.9	12.7
Beverages and tobacco products (B_T)	0.3	0.3	0.8	1.0
Extraction	0.1	0.1	0.1	0.1
Manufacturing	6.2	6.2	6.2	6.2
Services	0.1	0.1	0.1	0.2

Source: Simulation results.