# Ponder the Difference between the Trade Specifications in a CGE Model: the AKME module and Import Sourcing

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## 1 Introduction

Computable General Equilibrium (CGE) models have been widely used for quantifying economic impacts of free trade agreements and economic partnership agreements. Trans-Pacific Partnership (TPP) Agreement is the recent case as it reached the final agreement in October 2015 among the twelve countries.[1] Even when US withdrew from the TPP after the 2017 presidential election, CGE models were also used to assess potential effects of the abrupt policy change. Prior to the final agreement of the TPP, for example, Cabinet Secretariat (2013) in Japan estimated that the TPP would increase Japanese real GDP by 0.66 percent. Pacific Economic Cooperation Council (2012)[2] also estimated that the TPP would raise Japanese real GDP by 2.24 percent higher by 2025. These estimates were based on simulation results obtained from global CGE models; the former utilized the standard GTAP model (Hertel (1997), and McDougall (2003)) while the latter developed their own model (Zhai (2008), and Petri et al. (2012)). Differences in their estimated economic effects are not small, but it is not surprising because the components of trade liberalization taken into their TPP simulations are different. Petri et al. (2012) considered exhaustive com-

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[1] United States, Japan, Singapore, Brunei, Malaysia, Vietnam, Australia, New Zealand, Canada, Mexico, Chile, and Peru.

[2] Referring to the economic effects of "TPP track" which was based on the negotiating eleven countries plus Japan and Korea in 2012 (Chapter 3, p 40).

ponents of liberalization, such as removing tariffs, reducing non-tariff barriers, liberalizing trade in services and foreign direct investment. On the other hand, Cabinet Secretariat (2013) estimated only the tariff removing effect, as a result of that their estimates were smaller than Petri et al. (2012). More recently, Cabinet Secretariat (2015) updated their estimate by expanding the liberalization components of the TPP simulation, and the real GDP of Japan was estimated to increase by 2.6 percent. Also, the World Bank (2016) reported that, because of the TPP, Japanese real GDP would be 2.7 percent higher by 2030, drawing from the recent work of Petri and Plummer (2016).

Beside their differences in simulation components, it is more interesting for us to ponder the difference in international trade specification used in their global CGE models. Zhai (2008) and Petri et al. (2012) defined their trade specification based on Melitz (2003) which features firm-level product differentiation, while the GTAP model has been adopting the conventional specification of trade by Armington (1969) that assumes the product differentiation at country level. Thus, we are interested in comparing different trade specifications and its resulting estimates of economic impacts of trade liberalization in global CGE model.

Dixon and Rimmer (2011) proposes an encompassing model of different trade specifications, overarching Armington (1969), Krugman (1980), and Melitz (2003), hereinafter referred to as the AKME module. Stimulated by their work, Oyamada (2013) developes a prototype global CGE model incorporating the AKME module, to explain how the necessary parameters for the AKME module can be calibrated. More recently, Dixon et al. (2016) conducts thorough analysis on their AKME module. One of their important findings is that it is possible to have equivalent economic effects of liberalization on trade and welfare both in the Armington- and in the Melitz-type specifications, once the substitution elasticity satisfies certain condition. Oyamada (2014) investigates properties in a global CGE model with the AKME module by running a set of simulations, targeting at preference parameter on product variety. Oyamada (2014) identifies that the preference parameter significantly influences the welfare effect of trade liberalization. Depending on the value of the preference parameter, welfare gains from trade liberalization can be larger in the Melitz-type specification than in the Krugman-type, or vice versa. Dixon et al. (2016) and Oyamada (2014) are among a few studies comparing Armington, Krugman, and Melitz trade specifications in CGE model, except for the pioneering work by Balistreri et al. (2011) and Balistreri and Rutherford (2012) which inspires Dixon and Rimmer (2011), and the GTAP-HET model by Akgul et al. (2016). Akgul (2017) reviews different approaches in CGE modeling of the Armington-, Krugman-, and Melitz-type trade specification, focusing on whether the welfare gains from trade liberalization are equivalent across the different specifications.

This paper introduces the AKME module to the standard GTAP model (Hertel (1997), and McDougall (2003)), following the modeling strategy in Dixon and Rimmer (2011), Dixon et al. (2016) and Oyamada (2013). Sources of imports are determined either at the national border or by the economic agents. Our primary interest is in comparing simulation results and their implications for trade policies, obtained from different trade specifications. Taking the TPP and the TPP sans US as example, we run experimental simulations to draw comparisons between the Armington-type, Krugman-type, and Melitz-type. We also examine how the simulation results are affected by varying key parameters, such as import substitution elasticities and sunk costs. Since there exits only a handful of attempts to compare the simulation results with different trade specifications, we believe it would be informative and useful in exploring the CGE analysis of trade policy.

# 2 Model

Following Dixon and Rimmer (2011), Dixon et al. (2016), and Oyamada (2013), we develop a CGE model of global trade with heterogeneous firms. The salient features in the model are the treatment of domestic market and the agent based import sourcing.

## 2.1 AKME Module

We briefly describe the AKME module implemented in a CGE model. By the term "module," we mean that a module is a part of the entire system of equations in a CGE model. In region $s$ the good $X_s$ is an aggregate of domestically supplied good $\widetilde{N_s}D_s$ and imported good $\widetilde{N_{rs}}Q_{rs}$ from region $r$. Number of firms suppling domestically produced goods in region $s$ is $\widetilde{N_s}$, and number of firms exporting goods from region $r$ to $s$ is $\widetilde{N_{rs}}$. Average quantity of $D_s$ and $Q_{rs}$ are per firm supply. As shown in Equation (1), constant elasticity of substitution (CES) function is used for the aggregation, with substitution elasticity $\sigma > 1$, scaling parameter $\theta_s$, and the CES weight $\delta_s$ for the domestic good and $\delta_{rs}$ for the imported good. Price index dual to the CES aggregate of good $X_s$ is defined as $P_s$ in Equation (2), where price $p_s$ corresponds to the domestic good and import tariff-inclusive price $(1 - \tau_{rs})p_{rs}$ for the imported good with the bilateral tariffs $\tau_{rs}$. Demands for a variety in the domestic and the imported goods are expressed as follows.

$$D_s = \left(\frac{p_s}{\delta_s P_s}\right)^{\sigma} \frac{X_s}{\theta_s}$$
$$Q_{rs} = \left(\frac{(1-\tau_{rs})p_{rs}}{\delta_{rs} P_s}\right)^{\sigma} \frac{X_s}{\theta_s}$$

Each firm produces a different variety of the goods by using primary factor inputs and intermediate inputs. Composite price of the inputs is $\mathbf{p}_r$. Firms set the profit maximizing markup price $p_r$ for domestic market and $p_{rs}$ for foreign markets, given their productivity $\varphi$ and the price of the composite input $\mathbf{p}_r$. Equation (3)(4) show the pricing rules, where $\eta = -1/\sigma$. Goods supplied to the domestic and the foreign markets are the gross output $Z_r$ net of sunk costs, as shown in Equation (5). Firms need to bear the sunk cost to set up the business in region $r$, $H_r$, the sunk cost to sell product to the domestic market $r$, $F_r$, and the sunk cost to export, $F_{rs}$, serving foreign market $s$. Proportion of the firms in region $r$ supplying to the domestic market $E_r$ and to the foreign market $E_{rs}$ are related to the average productivities of the firms in corresponding markets, respectively $\varphi_r$ and $\varphi_{rs}$ (Equation (6)(7)). Each firm's productivity level is drawn from the Pareto distribution with the shape parameter $\gamma$. Firms' products supplied to domestic $D_r$ and/or abroad $Q_{rs}$ relative to the corresponding sunk cost $F_r$ or $F_{rs}$ are associated with the average productivities (Equation (8)(9)). The number of firms $N_r$ is determined in Equation (10), equating the total value of sunk costs to the total value of products adjusted by substitution elasticity.

For the Melitz-type trade specification, we set $\eta = -\frac{1}{\sigma}$, $\widetilde{N_r} = E_r N_r$, and $\widetilde{N_{rs}} = E_{rs} N_r$. As for the Krugman-type trade specification, the sunk cost to domestic and foreign markets sales are absent, $F_r = F_{rs} = 0$, so that the average productivities are set to be unity, $\varphi_r = \varphi_{rs} = 1$. This implies that all firms serves in both domestic and foreign markets, $E_r = E_{rs} = 1$, and $\widetilde{N_r} = \widetilde{N_{rs}} = N_r$. The equations from (6) to (9) are dropped for the Krugman-type and the Armington-type specifications. Also the Armington-type excludes the equation (10). The sunk costs and markups are not existing in the Armington-type, $F_r = F_{rs} = H_r = 0, \eta = 0, \varphi_r = \varphi_{rs} = 1$, and the number of firms is one.

The system of equations to be incorporated into a CGE model is summarized as follows;

$$X_s = \theta_s \left( \delta_s \widetilde{N_s} D_s^{\frac{\sigma-1}{\sigma}} + \sum_r \delta_{rs} \widetilde{N_{rs}} Q_{rs}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

$$P_s = \left( \delta_s^{\sigma} \widetilde{N_s} p_s^{1-\sigma} + \sum_r \delta_{rs}^{\sigma} \widetilde{N_{rs}} \left\{ (1+\tau_{rs})\, p_{rs} \right\}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{2}$$

$$p_r = \left( \frac{1}{1+\eta} \right) \frac{\mathbf{p}_r}{\varphi_r} \tag{3}$$

$$p_{rs} = \left( \frac{1}{1+\eta} \right) \frac{\mathbf{p}_r}{\varphi_{rs}} \tag{4}$$

$$\widetilde{N_r} \frac{D_r}{\varphi_r} + \sum_s \widetilde{N_{rs}} \frac{Q_{rs}}{\varphi_{rs}} = Z_r - \widetilde{N_r} F_r - \sum_s \widetilde{N_{rs}} F_{rs} - N_r H_r \tag{5}$$

$$E_r = \left( \frac{\gamma}{\gamma - \sigma + 1} \right)^{\frac{\gamma}{\sigma-1}} \varphi_r^{-\gamma} \tag{6}$$

$$E_{rs} = \left( \frac{\gamma}{\gamma - \sigma + 1} \right)^{\frac{\gamma}{\sigma-1}} \varphi_{rs}^{-\gamma} \tag{7}$$

$$\varphi_r = \frac{\gamma - \sigma + 1}{\gamma\,(\sigma - 1)} \left( \frac{D_r}{F_r} \right) \tag{8}$$

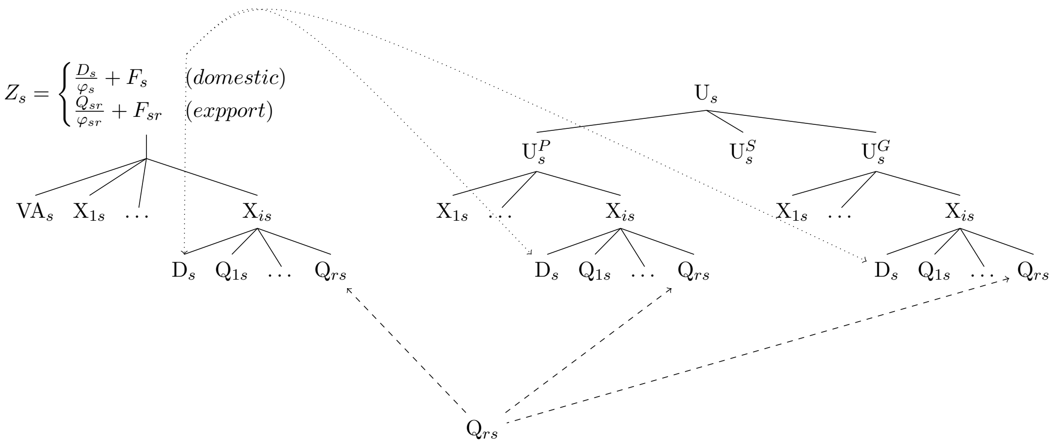
$$\varphi_{rs} = \frac{\gamma - \sigma + 1}{\gamma\,(\sigma - 1)} \left( \frac{Q_{rs}}{F_{rs}} \right) \tag{9}$$

$$\mathbf{p}_r \left( \widetilde{N_r} F_r + \sum_s \widetilde{N_{rs}} F_{rs} + N_r H_r \right) = -\eta \left( \widetilde{N_r} p_r D_r + \sum_s \widetilde{N_{rs}} p_{rs} Q_{rs} \right) \tag{10}$$

## 2.2 Structure of the CGE model

The AKME module is incorporated into a CGE model of global trade, namely the standard GTAP model (Hertel (1997), and McDougall (2003)). Figure 1 summarizes the structure of the CGE model. Tree at the lefthand side is the nested production structure. To produce gross output $Z_s$, the value added composite $VA_s$ and intermediate inputs $X_{is}$ form a input composite by the Leontief production function, where $i$ for the traded goods. The value added composite is aggregated by the CES function, and the composite is made up of skilled and unskilled labor, capital and specific factors such as land and natural resources. All of the primary factor inputs are exogenously given.

Domestically produced good $D_s$ is supplied to producers for intermediate input use,




Source: Author.

Figure 1: Schematic View of the Model Structure

to private household for consumption, and to government household for public expenditure. Recall from Equation (1), the domestically supplied good $D_s$ is aggregated with the imported goods $Q_{rs}$ to form the composite good $X_{is}$.

In the righthand tree, the representative household's utility $U_s$, welfare measure used in our simulation experiments, is derived from the sub-utilities of private household $U_s^P$, government household $U_s^G$ and savings $U_s^S$, via the Cobb-Douglas-type function. The private household's utility is, then, determined by the constant difference elasticity function of the composite goods $X_{is}$, whereas for the government household utility by the CES function. Because of the non-homotheticity in the private household's utility, adjustment to sift distribution parameters of expenditure is introduced, following McDougall (2003).

## 3 Data and Simulation Experiments

We rely on the database, Global Trade Analysis Project (GTAP) Data Base version 9.2 (Aguiar et al., 2016), to compute the sunk costs as well as to curry out simulation experiments. The GTAP Database stores vast economic information covering 57 industrial sectors for 141 regions. Because the focus of this study is on the TPP countries and for our experimental purpose, we aggregate the database to 3 sectors and 23 regions (Table 5 and 6). We assume that producers in primary sector (Prim) and services sector (Srvc) are under the perfect competition and their production technologies are constant returns to scale. Primary sector employs the specific factors of production such as land and natural resources. We also assume that firms in manufacturing sector (Mnfc) are operating under the imperfect competition, and the AKME module is applied to this sector. Key parameters used in the AKME module are substitution elasticity $\sigma$ and Pareto distribution $\gamma$, and they are set at 3.4 and 5.0 for all regions, taken from Aguiar et al. (2016) and Balistreri et al. (2011). The value of extensive margin is set at 0.6, following Zhai (2008), and the number of firms in each region is normalized to be unity for the calibration.

Table 1: Average Applied Import Tariff Rates on Merchandise Trade (%)

| | TPP | | TPP sans US | |
|---|---|---|---|---|
| | Prim | Mnfc | Prim | Mnfc |
| Japan | 4.3 | 3.0 | 6.1 | 5.6 |
| Singapore | 9.6 | 1.2 | 10.9 | 1.6 |
| Brunei | 0.0 | 0.8 | 0.0 | 0.2 |
| Malaysia | 0.8 | 0.8 | 0.8 | 0.6 |
| VietNam | 2.3 | 5.8 | 2.9 | 2.2 |
| Australia | 2.8 | 0.5 | 2.8 | 0.7 |
| NewZealand | 6.6 | 0.6 | 7.6 | 0.6 |
| USA | 9.0 | 0.3 | 9.0 | 0.3 |
| Canada | 1.4 | 0.0 | 8.8 | 0.7 |
| Mexico | 0.5 | 0.0 | 7.2 | 0.5 |
| Chile | 1.6 | 0.4 | 2.0 | 0.2 |
| Peru | 0.4 | 0.3 | 0.4 | 0.5 |

Source: Calculated from Aguiar et al. (2016).

Table 1 lists the average applied import tariff rates for the TPP member countries. Japanese imports of primary goods from the TPP member countries are subject to 4.3 percent tariffs on average, while 3.0 percent is applied to manufactured goods. The rates excluding US are higher both the primary and the manufactured goods in Japan, 6.1 and 5.6 percent respectively. This means that the US exports face lower tariff rates in Japan when compared to other TPP member countries. For our simulation experiments, the import tariffs are removed for the TPP member counties (Simulation 1), or for the TPP members without US (Simulation 2).

**Simulation Experiments**

**S1** Simulation 1. Import tariff removal for the TPP member countries

> **S1A** Armington-type with the substitution parameter $\sigma \in [2.0, 11.9]$
>
> **S1K** Krugman-type with the substitution parameter $\sigma \in [2.0, 11.9]$
>
> **S1M** Melitz-type with the substitution parameter $\sigma \in [2.0, 5.8]$

**S2** Simulation 2. Import tariff removal for the TPP sans US

Under the Simulation 1, we repeated the simulation of the TPP tariff removal, with a range of substitution parameter value for the Armington-type, the Krugman-type, and the Melitz-type trade specification. The default value of the substitution elasticity is $\sigma = 3.4$ and country-generic, and the value varies over the specified range. For the Armington-type and the Krugman-type, we increase the value from 2.0 to 11.9 which is 3.5 times larger than the default value. Because the Melitz-type has a restriction on the parameter value, $\gamma > \sigma - 1$, we run the experiments up to 5.8 that is about 1.7 times the default value. By this experimental setting, we can observe the sensitivity of each type of specifications. Also, we are able to see whether or not there exists the equivalent value of welfare result across the specifications.

For the Melitz-type trade specification, we compute three different kinds of sunk costs by calibrating the CGE model with heterogeneous firms. They are the sunk cost to entry ($H_r$), the sunk cost to domestic sales ($F_r$), and the sunk cost to exports ($F_{rs}$). All firms bear the first sunk cost for starting up their business to enter the market. Some firms are productive enough to make profit in the domestic market, or foreign markets. Thus, given the sunk costs and their productivity level, not all the firms are able to sell domestically or internationally.

Table 2 shows the estimated share of sunk costs in total cost. Given the region-generic parameter value of the substitution elasticity ($\sigma = 3.4$), there are not much variations in the calibrated share of sunk cost to entry ($H_r$). On average, it is about 14 percent in the total cost for average firm to set up business or start operating. Having established the business, a firm may incur further sunk cost to supply domestically ($F_r$), which ranges from 4.0 percent in Singapore to 13.2 percent in Peru. Or a firm may run up 24-35% sunk cost to exports ($F_{rs}$), if it serves all foreign markets. These sunk costs to domestic and foreign markets are affected by the data aggregation, because the size of market depends on how to group the countries in the database.

Table 2: Share of Sunk Costs (%)

| | $H_r$ | $F_r$ | $\sum_s F_{rs}$ |
|---|---|---|---|
| Japan | 14.7 | 12.1 | 35.9 |
| China | 14.1 | 12.6 | 31.9 |
| Korea | 14.1 | 9.9 | 35.8 |
| Taiwan | 14.2 | 6.9 | 33.4 |
| Singapore | 14.0 | 4.0 | 30.5 |
| Brunei | 14.1 | 10.4 | 32.5 |
| Indonesia | 14.1 | 11.9 | 33.4 |
| Malaysia | 14.1 | 7.6 | 37.0 |
| Philippines | 14.1 | 8.0 | 34.4 |
| Thailand | 14.1 | 8.0 | 38.4 |
| Viet Nam | 14.2 | 6.9 | 34.1 |
| RoASEAN | 14.1 | 6.4 | 30.1 |
| India | 14.1 | 12.6 | 26.9 |
| Australia | 14.2 | 12.3 | 34.9 |
| New Zealand | 14.2 | 11.0 | 32.6 |
| USA | 14.3 | 12.6 | 32.2 |
| Canada | 14.2 | 9.5 | 26.5 |
| Mexico | 14.2 | 8.4 | 24.9 |
| Chile | 14.2 | 8.4 | 31.5 |
| Peru | 14.6 | 13.2 | 24.1 |
| Russia | 14.1 | 12.0 | 24.1 |
| EU28 | 14.2 | 7.6 | 28.7 |
| ROW | 14.2 | 11.1 | 32.5 |

Source: Author's computation.

Once the sunk costs are obtained, we are able to conduct the second set of simulation experiments, by asking what if the sunk costs to entry, domestic sales, and exports are lowered, on top of the TPP tariff removal.

**S3** Simulation 3. Import tariff removal and sunk cost reduction for the TPP members

**S3-1** Chage in sunk costs over the range of [-20, 20]

**S4** Simulation 4. Import tariff removal and sunk cost reduction for the TPP sans US

We assume 20 percent for the sunk cost reduction for the TPP members in the Simulation 3 and without US in the Simulation 4, while removing the same import tariffs as used in the Simulation 1 and 2. All the simulations are implemented by using the GEMAPCK economic modeling software (Harrison and Pearson, 1996).

## 4 Simulation Results

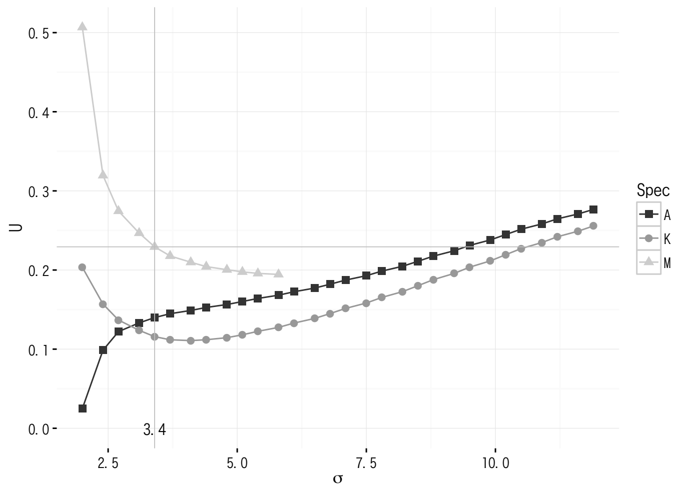
Table 3 reports the results of Simulation 1 and 2, the effect of the import tariff removal on welfare, for the Armington-type, the Krugman-type, and the Melitz-type trade specification. In general, the welfare results are small in percent change, except for the case of Viet Nam under the TPP. For the TPP without US, even the Vietnamese results become less than one percent, similar to other countries. These small effects on welfare are not surprising because the tariff rates are very low for the manufactured goods, and for some relatively high tariff rates of the primary goods their imports account tiny fraction of the total trade, thereby resulted in the small effects.

Beside the magnitude in percent change, we are interested in comparing the results across the different trade specifications. For the purpose of comparison, we carried out the same tariff removal experiments by the standard GTAP model. One distinctive difference in the standard GTAP model from the AKME module is the nesting structure of the demands. The GTAP model has the double-nest structure, where the bottom nest aggregates imports and the upper nest aggregates domestic goods with the composite of imports via the CES functions. Before the experiments, we expected that welfare effect of the Melitz-type might be the largest, followed by the Krugman-type, and then the Armington-type to be the least. However, against our anticipation, we don't observe such clear ranking of the specification. Instead, it seems to be country specific and to be influenced by the experiments.

Table 3: Effect of Import Tariff Removal on Welfare (%)

| | TPP | | | | TPP sans US | | | |
|---|---|---|---|---|---|---|---|---|
| | A | K | M | G | A | K | M | G |
| Japan | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| China | -0.1 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Korea | -0.1 | 0.0 | 0.0 | -0.2 | 0.0 | 0.0 | 0.0 | -0.1 |
| Taiwan | -0.1 | 0.0 | 0.0 | -0.1 | -0.1 | 0.0 | 0.0 | -0.1 |
| Singapore | 0.3 | 0.3 | 0.8 | 0.3 | 0.3 | 0.3 | 0.8 | 0.4 |
| Brunei | 0.0 | 0.1 | -0.2 | 0.2 | 0.2 | 0.2 | -0.2 | 0.5 |
| Indonesia | -0.1 | 0.0 | 0.0 | -0.2 | 0.0 | 0.0 | 0.0 | -0.1 |
| Malaysia | -0.1 | 0.1 | -0.4 | 0.0 | -0.1 | 0.0 | -0.4 | 0.1 |
| Philippines | -0.1 | 0.0 | 0.0 | -0.1 | -0.1 | 0.0 | 0.0 | -0.1 |
| Thailand | -0.2 | -0.1 | 0.0 | -0.3 | -0.1 | -0.1 | 0.0 | -0.2 |
| Viet Nam | 3.2 | 2.1 | 2.6 | 3.1 | 0.6 | 0.4 | 0.0 | 0.8 |
| RoASEAN | -0.1 | -0.1 | 0.0 | -0.2 | 0.0 | 0.0 | 0.0 | -0.1 |
| India | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Australia | 0.0 | 0.0 | -0.1 | 0.0 | 0.1 | 0.0 | -0.1 | 0.1 |
| New Zealand | 0.4 | 0.2 | -0.1 | 0.7 | 0.4 | 0.2 | -0.1 | 0.8 |
| USA | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Canada | -0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 |
| Mexico | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Chile | 0.0 | 0.0 | 0.0 | -0.1 | 0.1 | 0.0 | 0.0 | 0.1 |
| Peru | -0.1 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Russia | -0.1 | 0.0 | 0.0 | -0.2 | 0.0 | 0.0 | 0.0 | -0.1 |
| EU28 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ROW | -0.1 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | 0.0 |

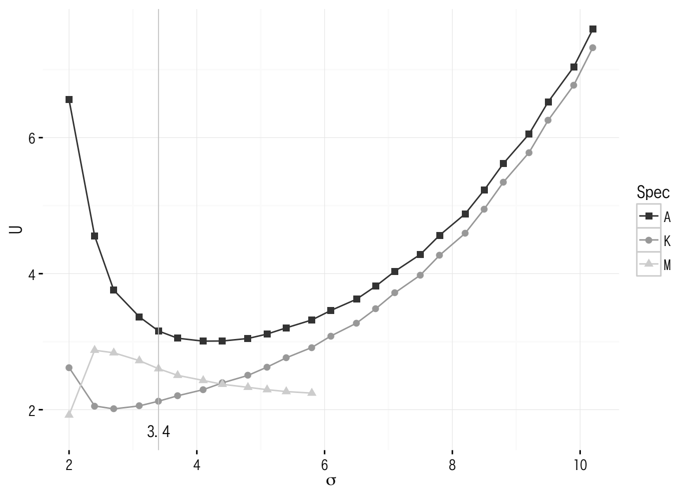
A: Armington-type, K: Krugman-type, M: Melitz-type, G: std. GTAP
Source: Author's simulation results




Note: $\sigma \in [2.0, 11.9]$

Source: Author's simulation results.

Figure 2: Effect of TPP Tariff Removal on Welfare in Japan (%)




Note: $\sigma \in [2.0, 10.2]$ for plotting.

Source: Author's simulation results.

Figure 3: Effect of TPP Tariff Removal on Welfare in Viet Nam (%)

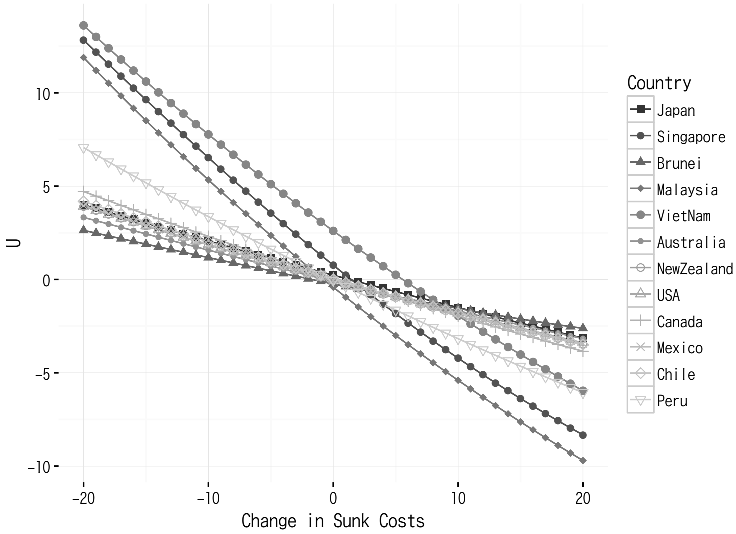
Close look at the results of Japan reveals that the Melitz-type specification is the highest (0.23), followed by the Armington-type (0.14) and the Krugman (0.12), under the substitution parameter value set at the default, $\sigma = 3.4$. We are interested in how sensitive this ranking is with respect to the parameter value. The simulation experiments of S1A, S1K, and S1M are implemented by changing the value from 2.0 ($0.6 \times \sigma$) to 11.9 ($3.5 \times \sigma$). Figure 2 draws the results for Japanese welfare gain. Welfare gain under the Melitz-type specification dominates other specifications. Because the restriction $\gamma > \sigma - 1$ limits the range of the substitution parameter value, there are fewer simulation results available than the Armington-type and the Krugman-type. At the lower substitution values, welfare gain in the Krugman-type is higher than the Armington-type, but it is quickly reversed as the parameter becomes larger, and the welfare gain eventually reaches to the 0.23 percent which is the Melitz-type's welfare gain at the default value. Thus, in Figure 2, there exits the parameter value for the Armington-type and the Krugman-type to be equivalent in welfare gain from the Melitz-type specification. Figure 3 for the Vietnamese results, however, does not show the equivalent value of substitution parameter between the Armington-type and the Melitz-type, at least for the simulated range. Following the discussion in Dixon et al. (2016) and Arkolakis et al. (2012), further investigation is warranted for the equivalence between the different trade specifications.

Table 4 reports the results from the simulations reducing the sunk costs by 20 percent for the TPP member countries, in addition to the tariff removal. If the TPP has liberalization components lowering the sunk cost of entry, domestic sales, and exports, then it may contribute to additional welfare gain from the liberalization. To highlight the potential gain, we simply assume the reduction is 20 percent. Large welfare gains are observed for the member countries both in the TPP and the TPP sans US, from 2.6 percent in Brunei to 14.5 percent in Singapore. Gains in the southeast Asian countries, Singapore, Malaysia, and Vietnam, are significantly large, while the high income counties also shows substantial gains in welfare. The logic to explain the welfare gains from lowering the sunk costs is following. The less a manufacturing firm incurs the sunk costs to enter, domestic sales, and export within the TPP, the more firms will enter into the markets. Although output per firm decreases because of the new entrants, aggregate sales and/or export volume increase. This indicates that more variety of goods becomes available and it contributes to higher sub-utilities, thereby leading to the overall welfare gain. It implies that the preference for variety dominates the price increase which is caused by the entry of firms with lower productivity.

Table 4: Effect of Import Tariff Removal and Sunk Costs Reduction on Welfare (%)

| | TPP | TPP sans US |
|---|---|---|
| Japan | 4.0 | 3.7 |
| China | -0.7 | -0.5 |
| Korea | -1.2 | -0.6 |
| Taiwan | -1.8 | -0.9 |
| Singapore | 12.8 | 14.5 |
| Brunei | 2.6 | 3.2 |
| Indonesia | -0.3 | -0.2 |
| Malaysia | 11.9 | 12.0 |
| Philippines | -0.7 | -0.5 |
| Thailand | -2.5 | -1.5 |
| Viet Nam | 13.6 | 9.7 |
| RoASEAN | -0.5 | -0.5 |
| India | -0.7 | -0.3 |
| Australia | 3.3 | 3.5 |
| New Zealand | 3.9 | 4.1 |
| USA | 3.9 | -0.2 |
| Canada | 4.7 | 4.2 |
| Mexico | 4.0 | 3.5 |
| Chile | 4.2 | 4.2 |
| Peru | 7.1 | 6.9 |
| Russia | -0.1 | 0.0 |
| EU28 | -0.3 | -0.1 |
| ROW | -0.5 | -0.2 |

Member countries reduce $H_r$, $F_r$, and $F_{rs}$ by 20 percent.
Source: Author's simulation results




Note: TPP member countries change $H_r$, $F_r$, and $F_{rs}$ by [-20, 20] percent.
Source: Author's simulation results.

Figure 4: Effect of Import Tariff Removal and Sunk Costs Reduction on Welfare (%)

Figure 4 shows the effect of import tariff removal and sunk costs reduction on welfare for the TPP member countries, by altering the change in sunk costs from -20 to 20 percent. Table 4 corresponds to the case of -20 percent change. As the change in sunk costs increases, welfare is monotonically diminishing for all countries.

## 5 Summary

This paper introduces the AKME module to a CGE model. Our primary interest is to compare the simulation results and their implications for trade policies. Taking the TPP and the TPP sans US as our example, we run experimental simulations to draw comparisons between the Armington-type, Krugman-tyep, and Melitz-type trade specifications. We also examine how the simulation results are affected by varying key parameters, such as import substitution elasticities and sunk costs.

The simulation results show that import tariff removal of the TPP and the TPP sans US leads to small welfare gains for the member countries. Given the low tariff rates to be abolished, it is not surprising to observe these small changes. However it is more interesting for us to see whether the ranking of welfare gain across the specification shows any clear results. Against our anticipation, we obtain the mixed results. For some countries, welfare gain in the Armington-type is higher than the Krugman-type and Melitz-type, and vice versa. Closer look into the simulation results reveals that by varying the substitution parameter value, we are able to find the equivalent welfare gain across the different trade specifications for Japan. However, we also find that this is not the case for Viet Nam. This implies that the welfare equivalence of trade specifications may be country specific, depending on the structure of economy reflected in the model.

For the Melitz-type trade specification, we compute three different kinds of sunk costs by calibrating the model. Given the region-generic value of the substitution elasticity, there are not much variations in the share of sunk cost to entry. On the other hand, the share of sunk cost to domestic sales and exports varies as the size of destination markets differs. We assume 20 percent reduction in the sunk costs on top of the import tariff removal for the TPP and the TPP sans US, and the results show profound welfare gains for the member countries. As the sunk costs increase, the welfare monotonically diminishes for the member countries.

Several limitations warrant further examination, not to mention the ongoing development and debugging in our CGE model with the AKME module.

Table 5: Sectoral aggregation

| No. | Setor | GTAP 57 sectors |
|---|---|---|
| 1 | Prim | Paddy rice; Wheat; Cereal grains nec; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Plant-based fibers; Crops nec; Cattle,sheep,goats,horses; Animal products nec; Raw milk; Wool, silk-worm cocoons; Forestry; Fishing; Coal; Oil; Gas; Minerals nec; Meat: cattle,sheep,goats,horse; Meat products nec; Vegetable oils and fats; Dairy products; Processed rice; Sugar; Food products nec; Beverages and tobacco products. |
| 2 | Mnfc | Textiles; Wearing apparel; Leather products; Wood products; Paper products, publishing; Petroleum, coal products; Chemical,rubber,plastic prods; Mineral products nec; Ferrous metals; Metals nec; Metal products; Motor vehicles and parts; Transport equipment nec; Electronic equipment; Machinery and equipment nec; Manufactures nec. |
| 3 | Srvc | Electricity; Gas manufacture, distribution; Water; Construction; Trade; Transport nec; Sea transport; Air transport; Communication; Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings. |

Source: Author's aggregation based on Aguiar et al. (2016)

Table 6: Regional aggregation

| No. | Country | GTAP 141 regions |
|---|---|---|
| 1 | Japan | Japan. |
| 2 | China | China; Hong Kong. |
| 3 | Korea | Korea. |
| 4 | Taiwan | Taiwan. |
| 5 | Singapore | Singapore. |
| 6 | Brunei | Brunei Darussalam. |
| 7 | Indonesia | Indonesia. |
| 8 | Malaysia | Malaysia. |
| 9 | Philippines | Philippines. |
| 10 | Thailand | Thailand. |
| 11 | Viet Nam | Viet Nam. |
| 12 | RoASEAN | Cambodia; Lao People's Democratic Republ; Rest of Southeast Asia. |
| 13 | India | India. |
| 14 | Australia | Australia. |
| 15 | New Zealand | New Zealand. |
| 16 | USA | United States of America. |
| 17 | Canada | Canada. |
| 18 | Mexico | Mexico. |
| 19 | Chile | Chile. |
| 20 | Peru | Peru. |
| 21 | Russia | Russian Federation. |
| 22 | EU28 | Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Bulgaria; Croatia; Romania. |
| 23 | ROW | Rest of Oceania; Mongolia; Rest of East Asia; Bangladesh; Nepal; Pakistan; Sri Lanka; Rest of South Asia; Rest of North America; Argentina; Bolivia; Brazil; Colombia; Ecuador; Paraguay; Uruguay; Venezuela; Rest of South America; Costa Rica; Guatemala; Honduras; Nicaragua; Panama; El Salvador; Rest of Central America; Dominican Republic; Jamaica; Puerto Rico; Trinidad and Tobago; Caribbean; Switzerland; Norway; Rest of EFTA; Albania; Belarus; Ukraine; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyzstan; Tajikistan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Bahrain; Iran Islamic Republic of; Israel; Jordan; Kuwait; Oman; Qatar; Saudi Arabia; Turkey; United Arab Emirates; Rest of Western Asia; Egypt; Morocco; Tunisia; Rest of North Africa; Benin; Burkina Faso; Cameroon; Cote d'Ivoire; Ghana; Guinea; Nigeria; Senegal; Togo; Rest of Western Africa; Central Africa; South Central Africa; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mozambique; Rwanda; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Namibia; South Africa; Rest of South African Customs ; Rest of the World. |

Source: Author's aggregation based on Aguiar et al. (2016)

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