Potential Economic Effects on the Philippines of the Trans-Pacific Partnership (TPP)[*]

Caesar B. Cororaton and David Orden[**]

Revised February 2015

GII Working Paper No. 2014-1

Keywords: Trans-Pacific Partnership, Regional trade, Philippines, Global CGE

JEL Classification: C68, D58, F15

[*] Research funding provided by the Global Issues Initiative/ Institute for Society, Culture and Environment, Virginia Polytechnic Institute and State University.

[**]Caesar Cororaton (ccaesar@vt.edu) is Senior Research Fellow and David Orden (orden@vt.edu) is Director, at the Global Issues Initiative (GII), Institute for Society, Culture and Environment (ISCE), Virginia Polytechnic Institute and State University. 900 N. Glebe Road, Arlington Virginia, USA, 22203.

Abstract

The TPP is a potential economic block in Asia Pacific. If the negotiations are successful, the TPP can have important implications for the Philippines whether it decides to join or not because countries in TPP are important markets for Philippine exports and sources of imports, investments, and technology. The paper simulates a reduction in trade barriers within the TPP using a global CGE model. The results indicate trade creation within the TPP and trade diversion from the non-TPP. Philippine non-participation will generate small negative effects on the economy, but the economic opportunity cost of non-participation is larger. If the inflows of investments into the country improve with participation, the welfare gain is higher. While higher investments lead to real exchange rate appreciation, the majority of Philippine sectors benefit from the scale production effect of larger capital inflows.

I. Introduction

The goal of the twelve-nation Trans-Pacific Partnership (TPP) is to expand trade and investment across the Asia Pacific region through the elimination of tariffs and non-tariff barriers (NTBs), the harmonization of trade regulations, and the elimination of investment barriers. The TPP group includes Brunei, Chile, New Zealand, Singapore, United States, Japan, Canada, Mexico, Peru, Australia, Malaysia, and Vietnam. Together, this group is a huge economic block representing 40 percent of the world's gross domestic product (GDP) and 40 percent of world trade. In 2012, the TPP member countries had a combined population of 783.6 million and GDP of US$27.5 trillion. Although a TPP agreement is yet to be achieved with the members working to resolve many challenging and contentious issues, South Korea and Taiwan have already signified interest in joining because of the significance of the group as a major economic block[1]. The Philippines has yet to signify interest in joining TPP, but the government is in the process of evaluating a possible participation.

Based on the 10th November 2014 TPP Trade Minister's Report to Leaders, the negotiations among the participating countries are moving forward to finalize an agreement in several areas including: a comprehensive market access (duty-free access to goods within the TPP and lifting of restrictions on services, investment and financial services, temporary entry of business persons, and government procurement); a regional agreement (common rules of origin, trade facilitation, and elimination of non-tariff barriers); new trade issues (rules that ensure private sector businesses can compete with State-owned enterprises on a level playing field); and cross-cutting trade issues (promotion of small-and medium-sized enterprises, transparency and good

[1] See Krist (2013) for a discussion of the early negotiations and Fergusson and Vaughn (2010) for an overview of the TPP.

governance, strengthen anti-corruption efforts, improve opportunities for women and low-income individuals, capacity building in developing countries)[2].

Currently, several of the key TPP member countries are important markets for Philippine exports and sources of imports (Table 1), foreign direct investments (Table 2) and technology. With total merchandize exports 21.1 percent of GDP and imports 24.1 percent, external trade is a key component of the Philippine economy. Of the total exports, manufactures account for 86 percent, agriculture (including forestry) 7 percent and mining (including petro products) 5 percent. The leading export items of the Philippines are electronics and related products which accounted for an average share of 55 percent of total exports in 2010-2012. Raw materials and intermediate goods accounted for 51 percent of Philippine merchandise imports in 2010-2012. The other major import items are oil and fuel (19 percent), capital goods (17 percent), and consumer goods (12 percent). Thus, Philippine participation or non-participation in the TPP can affect its economy because it can expand or contract existing trade and investment linkages with partners participating in the group. Moreover, an important element in the TPP is the establishment of an institution that monitors the compliance of participating countries to the agreed rules and regulations and settles trade disputes. Should the Philippines decide to join the group, the institutional set-up in the TPP can provide discipline and therefore speed up trade reforms in agriculture, investments and corporate taxation.

The objective of this paper is to provide a quantitative analysis of the potential economic effects on the Philippine economy of a possible TPP and whether it is a member or not. In the analysis, a global computable general equilibrium (CGE) model (Robichaud, et al., 2011)

[2] http://www.ustr.gov/about-us/press-office/press-releases/2014/November/Trans-Pacific-Partnership-Trade-Ministers-Report-to-Leaders

calibrated to the GTAP 8 database[3] is used to simulate the possible effects on members, non-members and specifically the Philippine economy under three scenarios: Philippines not a TPP member; Philippine TPP participation with no additional foreign direct investment (FDI) inflow effects in the country; and Philippine TPP participation with additional FDI inflow effects in the country. In the analysis, a TPP agreement will involve a 10-year phased reduction in tariffs and NTBs among the participating parties.

There are a few quantitative assessment studies conducted that have used global CGE models to analyze the potential economic effects of the TPP agreement. Petri, Plummer, and Zhai (2012) calibrated the global CGE model of Zhai (2008) using a preliminary release version of the GTAP 8 database and analyzed trade liberalization within TPP in the context of other trade initiatives in Asia. In the analysis, changes in tariffs (including the reduction in preferential tariffs and the utilization rate of preferences) and non-tariff barriers were considered. Itakura and Lee (2012) used the dynamic GTAP model of Ianchovichina and Walmsley (2012) calibrated to the GTAP 7 database analyzed trade liberalization (reduction in tariffs and non-tariff barriers) within the TPP and within the current trade negotiations in the region. Both studies find steady and increasing gains over time among participating nations. Using the dynamic GTAP model calibrated to the GTAP 8 database, Cheong (2013) analyzed the potential effects of trade liberalization within the TPP and found that not all TPP member countries would benefit from the liberalization. Some countries would have negative GDP effects. Non-TPP countries will face economic losses from trade diversion.

To further develop these results, and with specific focus on the Philippines, the paper is organized as follows. The next section gives a brief discussion of the Philippines-TPP model, the

[3] GTAP refers to the Global Trade Analysis Project (https://www.gtap.agecon.purdue.edu/databases/).

tariff and NTB issues we assume TPP will address, and performance of the Philippines of attracting foreign investment. The simulation scenarios designed around these circumstances are described. The third section presents the simulation results including effects of a TPP on aggregate trade and welfare among members and non-members, effects of the scenarios on output in the Philippines disaggregate into 15 sectors and effects on factor returns for the Philippines. The final section is a brief summary and discussion of the results.

II. Framework of Analysis

Philippines-TPP CGE model. The Robichaud, et al. (2011) model was calibrated to the GTAP 8 database which consists of fifty seven sectors in one hundred and twenty nine countries/regions. The database includes two types of labor (skilled and unskilled), capital, land, and natural resources. However, to facilitate the computation of the model solution and the analysis of results, the database was aggregated to fifteen sectors in twenty countries/regions (Table 3)[4]. The fifteen sectors reflect the disaggregation of important sectors in the Philippine economy including the labor-intensive service sector, the electronic equipment sector which produces the country's key exports, the agricultural crops and food manufacturing sectors which have the highest trade barriers, and the labor-intensive textile and wearing apparel sectors which are among the list of industries in the export promotion program of the Philippine government.

In terms of the countries/regions, eleven of the included countries are the TPP members[5]. South Korea and Taiwan are included in the model because of their announced interest in the TPP. Indonesia and Thailand are included because they are important countries in the region, particularly in the ASEAN, and similarly to the Philippines, these countries are currently

[4] Appendix A presents a mapping of the 15 sectors and 20 countries/regions to the GTAP 8 database.
[5] Brunei was excluded in the model because it is not in the GTAP 8 database. The model's sectoral and regional aggregation compared to the GTAP 8 database is available from the authors.

performing due diligence on the TPP to assess the potential benefits and the domestic policy adjustments required should they decide to join in the coming years. In addition, other main geographic regions are aggregated into the EU25, Latin America (excluding Chile, Mexico and Peru), Africa and a remaining Rest of the World.

Model Structure. The detailed specification of the model is given in Appendix A. Important features of the model include: (a) a three-level production structure where value added and intermediate inputs are used in fixed proportion to produce output and the second and third levels are constant elasticity of substitution (CES) functions of various disaggregated factor inputs; (b) a linear expenditure system demand structure; (c) domestically produced and imported goods are imperfect substitutes and modeled using CES function; (d) imports of each commodity are disaggregated using another CES function to the various sources of imports, which implies product differentiation among imports from the various origins; (e) exports of each commodity are disaggregated using constant elasticity of transformation (CET) function to the various export destinations, which also implies imperfect substitutability among exports to the destinations; and (f) the system of prices in the model reflects the cost of production plus a series of mark-ups which consists of layers of taxes and international transport margins.

Trade Barriers. The sectoral tariff rates applied by each country/region on imports from each of the import origins were calibrated from the GTAP 8 database. Over the past couple of decades the series of tariff reduction programs implemented globally under the World Trade Organization (WTO), regionally under the various regional trading agreements or unilaterally have lowered quite considerably the level of tariff rates across countries. However, despite the trade reform programs, tariff rates in a few commodities remain high, especially those goods that fall under the special product categories. Furthermore, there are various NTBs which continue to

affect the flow of commodities across borders. In the international market for food for example, although most of the production, processing, and distribution of food is done by the private sector, the market is affected by various forms of government regulation. The economic justifications for a government role in food markets stem from both the public goods aspects of disease and pest control and the opportunities to reduce market transactions cost for firms and consumers, but NTMs can also serve protectionist purposes (Josling, Roberts, and Orden, 2004). To factor in some of these features in international trade into the analysis, and in an effort to capture the overall level of protection imposed by countries on imports, the calibrated import tariff rates were augmented to include estimates of NTBs effects available in the literature.

Modeling NTBs within a CGE framework is complex because NTBs have both demand-shifting and supply-shifting effects which may affect both the demand and supply elasticities which are difficult to implement in a CGE framework (Fugazza and Maur, 2008)[6]. Setting aside these challenging modeling issues on NTBs, the analysis includes the estimates of NTB effects of Kee, Nicita, and Olarreaga (2006) added to the calibrated sectoral tariff rates to come up with the estimates of the overall level of protection. That is, following Kee, Nicita, and Olarreaga (2006), the overall protection is $T_{i,z} = AVE_{i,z} + t_{i,z}$ where $T_{i,z}$ is the overall protection that country z imposes on commodity imports i; $AVE_{i,z}$ is the tariff ad-valorem equivalent (AVE) of NTBs that country z imposes on imports i; and $t_{i,z}$ is the applied tariff. The estimates of the AVE protection used in the analysis are given in Table 4 for three aggregates of sectors. As shown, the AVE of NTBs generally exceed the simple average tariffs reported by Kee, Nicita, and Olarreaga (2006). In the simulations, estimates of the AVE of NTBs for agriculture in each of the

[6] For example, requirements to provide information to consumers (e.g., labelling) may affect supply by changing the costs of production and distribution but also affect consumer behavior and therefore consumer demand. Similarly, preventing the sale of products that have hazardous effects on health or creating standards to increase compatibility can affect both supply and demand.

countries/regions was applied to crops and other agriculture sectors in the model, and the manufacturing rate to all manufacturing sectors, i.e., from food manufacturing to all other manufacturing sectors. The estimates of the AVE of NTBs for mining was applied to the mining sector in the model.

Foreign Investments. One of the benefits of participating in trade agreements is the expected increase in the volume of trade flows among the participating parties as trade barriers are minimized. Another benefit that normally goes with higher volume of trade is higher investment flows and active transfer of technology among the participating parties. The Philippines is located in a dynamic zone in Asia where a rapid increase in inflows of FDI has been observed. Unfortunately, the inflows of FDI into the Philippines have been low; the country has been underperforming in terms of attracting FDI. Using a concept called global FDI frontier, Petri, Plummer, and Zhai (2012) have shown that the stock of FDI inflows as of 2006 into the Philippines were significantly below the global FDI frontier by about US$30 – 40 billion (Table 5). The Philippines has a large absorptive capacity for higher inflows of FDI given its large and young population base and educated work force and its rich natural resources. Thus, the country may be able to improve its FDI performance as it seeks deeper integration with its trading partners in the TPP, especially with the United States and Japan, the two major sources of FDI in the Philippines.

Definition of Simulations. To analyze the potential economic effects on the Philippines of a possible TPP participation, four simulations were conducted:

A. Baseline. The global CGE was simulated until 2024 using actual real GDP and population growth from 2007 to 2013, and projected GDP growth of the World Bank and the population projection of the United Nations until 2024. A calibrated (pre-solved) multifactor

productivity in each country/region was used to ensure that the model replicates exactly the real GDP used, both actual and projected, in the baseline.

B. TPP without Philippine Participation ('TPP'). In this simulation, the trade barriers among the TPP members were reduced starting in 2015 until 2024; a phased reduction over a 10-year period. The negotiations among the original TPP members are still ongoing and no definite agreements have been reached as of December 2014. For this reason, an assumed adjustment is hypothesized to occur as follows. The applied tariffs in the TPP countries were reduced from the current levels by 90 percent over the 10-year period. Tariffs were reduced using a geometric growth formula and no exceptions were provided for special products. Issues related to NTBs are sometimes contentious, their negotiations are quiet involved, and their resolution often protracted. Thus, the reduction in NTBs is expected to be much lower compared to the reduction in tariff rates over the 10-year period. In the analysis, the AVE of NTBs among TPP participating countries was reduced by 20 percent[7]. The AVEs were reduced using a geometric growth formula over the 10-year period. Both tariffs and NTBs in the non-TPP (including the Philippines) were retained during the simulation period.

C. TPP including the Philippines ('TPP+Philippines'). In this simulation, the trade barriers (tariffs and NTBs) in the TPP plus the Philippines were reduced using the same method in B. In this simulation the non-TPP excludes the Philippines.

D. TPP including the Philippines with Enhanced FDI Inflows ('TPP+Philippines+FDI'). This is similar to C, except that FDI inflows into the Philippines increase yearly by US$1 billion over the 10-year period. Given the relatively low level of FDI stock in the Philippines in the estimates of Petri, Plummer, and Zhai (2012), the additional US$10

[7] Additional simulation results involving a 40 percent reduction in the AVE of NTBs are available from the authors.

billion FDI over the 10-year period results in a stock of FDI stock that is still well below the global FDI frontier. An improvement in FDI inflow increases foreign savings in the Philippines, which in turn increases total investments in the country. In addition, this will have general equilibrium impacts on tradables and non-tradables through the effects on the Philippine real exchange rate.

III. Simulation Results

In this section the effects of the reduction in trade barriers within the TPP are evaluated on the members, non-members, and on the Philippines depending on whether the country participates or not. The trade creation, trade diversion and welfare effects are discussed as well as the effects on Philippine sector output and factor returns. The results presented are for the years 2015, 2020 and 2024[8], essentially immediate, medium-term and long-term impacts as the reductions in trade barriers are phased in and economic adjustments occur.

Trade Effects. The trade effects on the TPP countries under the 'TPP' scenario are presented in Table 6. In the table, the 'Total' column is the sum of the 'Within TPP' and 'To Non-TPP' columns. The table includes the baseline values in 2014 and the yearly value difference from the baseline expressed in US$ billion at 2007 prices. The percent difference is also included for 2024.

The combined exports of the TPP countries increases annually starting by US$8.3 billion in 2015 and increasing to US$71.7 billion in 2024. The effects of the reduction in tariffs dominate the effects of the reduction in NTBs[9]. These results are consistent with the earlier CGE studies of

[8] The series of annual results from 2015 to 2024 are available from the authors upon request.

[9] It is only in the 9th year (in 2023) that the NTB reduction effects start to exceed the tariff reduction effects. However, the simulations involving a 40 percent reduction in the AVE of NTBs indicates that the effects of the reduction in NTBs dominate the effects of a 90 percent drop in tariffs throughout the 10-year period.

Petri, Plummer, and Zhai (2012) and Itakura and Lee (2012) which find that the TPP will result in steady and increasing gains over time among participating nations.

In 2024, the United States shows an increase in exports of US$18.1 billion over the baseline. It is followed by Japan with an increase of US$15.3 billion. But as a percent of the 2024 baseline export value, Viet Nam has the highest improvement in exports of 4.8 percent, followed by New Zealand with export increase of 2.5 percent.

The TPP creates trade among the member countries. The trade creation effect increases the total exports of the TPP annually starting by US$10.1 billion in 2015 and increasing to US$ 87.4 billion in 2024. Among the TPP members, Viet Nam benefits the most in percentage terms with the highest increase in exports of 12.3 percent in 2024.

The TPP diverts trade from the non-TPP. The trade diversion decreases exports of the TPP to the non-TPP annually starting by US$ 1.8 billion and decreasing further to US$ 15.7 billion in 2024. Among the TPP countries, New Zealand has the highest trade diversion of -1.8 percent relative to the 2024 baseline exports.

Table 7 presents the trade effects on the non-TPP countries/regions under the ‘TPP’ scenario. The combined exports of the non-TPP declines annually starting by US$1.6 billion in 2015 and decreasing by US$16.1 billion in 2024. This decline is due to the steady drop in exports to the TPP countries from US$ 2.2 billion in 2015 to US$ 19.6 billion in 2024. Exports within the non-TPP increase but not enough to offset the drop in exports to the TPP. Similar pattern of trade effects on the Philippines is observed. Philippine exports decline annually starting by US$ 0.01 billion in 2015 and declining by US$ 0.4 billion in 2024. Philippine exports within the non-TPP increase, but only marginally and not enough to offset the decline in exports to the TPP.

If the Philippines joins the TPP under the 'TPP+Philippines' scenario, the positive trade effects are higher for the expanded group relative to results in Table 6. The expanded group's total exports improves annually starting by US$ 8.9 billion in 2015 and increasing to US$ 77.6 billion in 2024. Table 8 shows that Philippine participation in the TPP leads to higher exports. The total exports of the Philippines improve annually starting by US$ 0.25 billion in 2015 and increasing to US$ 3.0 billion in 2024. These effects are consistent with the results of Petri, Plummer and Zhai (2013) in their analysis of the possible South Korean participation in the TPP. Their results indicate similar small trade diversion effects for South Korea if the country decides to stay outside of the TPP. Likewise, the export effects are considerably larger if South Korea joins the TPP.

The trade creation among the members of the expanded TPP group is also higher. The total exports within the expanded 'TPP+Philippines' group increases annually starting by US$ 10.8 billion and increasing to US$ 95 billion in 2014. Philippine exports within the expanded group is also higher with an export improvement of 6.3 percent in 2024. Conversely, the trade diversion effect of the expanded TPP on the non-TPP is relatively larger. The total exports of the expanded TPP to non-TPP (excluding the Philippines) declines annually starting by US$ 2 billion in 2015 and decreasing further to US$ 17.3 billion in 2024. Philippine exports to the non-TPP also declines.

Table 8 also includes the results for the Philippines under TPP participation with enhanced FDI inflow into the country, the 'TPP+Philippines+FDI' scenario. The results indicate that additional inflows of foreign capital will result in Philippine real exchange rate appreciation starting by 0.1 percent in 2015 and increasing to 0.5 percent in 2024. The appreciation of the real exchange reduces the effects on Philippine exports. However, as shown below the additional inflows of FDI generate scale production effect which improve output of key sectors in the Philippines.

Philippine Sectoral Effects. Table 9 presents the sectoral output effects in the Philippines. The first column in the table shows the 2014 baseline values of sectoral production. Services, excluding public administration, has the largest share of 27.5 percent, followed by the export-focused electronic equipment sector with an output share of 15.3 percent. The second column shows the yearly percent change difference of sectoral value of production from the baseline under the 'TPP' scenario, while the third and the fourth columns show the percent change difference under the 'TPP+Philippines' and the 'TPP+Philippines+FDI' scenarios respectively.

The small negative export effects on the Philippines under the 'TPP' scenario lead to small negative effects on sectoral output. In 2024, the total production in the Philippines declines by 0.1 percent. The effects vary across sectors. The service sector declines relative to the baseline annually starting by 0.01 percent in 2015 and declining further by 0.16 percent in 2024. The output of the second major sector, electronic equipment, starts to decline in 2019. In 2024 its output is 0.12 percent lower than the baseline. Similar pattern is observed in the transport and machinery equipment sector. Its output starts to decline in 2017, and in 2024 the sector's output is 0.15 percent lower than the baseline. The relatively smaller sectors such as other agriculture, textile and wearing apparel, petroleum products, chemicals, metal products, utilities and construction also decline relative to the baseline over time. There are ten sectors which are negatively affected under Philippine non-participation in the TPP. However, food manufacturing, another major sector, improves. The crops sector which supplies inputs to the food manufacturing sector improves as well.

The positive effects on Philippine exports under the 'TPP+Philippines' scenario lead to higher production. Total output improves annually starting by 0.01 percent in 2015 and increasing to 0.31 percent in 2024. Two key sectors, service and electronic equipment, show increasing

output growth relative to the baseline throughout the 10-year period. Smaller sector such as textile and wearing apparel, shows notable improvement in output growth. However, there are also negatively affected sectors. The output of the construction sector, which is non-tradable, drops. The output of the relatively protected food manufacturing and the crops sectors decline under TPP participation. The output of the transport and machinery equipment sector is lower. There are eight sectors which are negatively affected under the 'TPP+Philippines' scenario.

The real exchange rate appreciation from additional inflows of FDI in the 'TPP+Philippines+FDI' scenario reduces the positive effects on its exports. However, additional inflows of FDI generate scale production effect. In 2024, total output improves by 0.70 percent with additional FDI inflows, which is relatively higher compared to the 0.31 percent increase under TPP participation without additional FDI inflows.

The scale production effect of higher FDI inflows varies across sectors. The decline in the output of crops and food manufacturing sectors is lower under the case with additional FDI inflows compared to the decrease under the scenario of no additional FDI inflows. In 2024, output of the crops sector declines by 0.23 percent under TPP with no additional FDI inflows as compared to 0.2 percent decline under TPP with additional FDI. The scale production effect is also evident in the service sector. The negative effect on the construction sector from the reduction in trade barriers is partly offset by the additional inflows of FDI. Overall, a positive scale production effect is observed in all sectors, except for textile and wearing apparel and electronic equipment. The improvement in the output of these two sectors relative to the baseline is lower under the scenario with additional FDI inflows as the real exchange rate effect dominates the scale production effect in these sectors. In the scenario with additional FDI inflows, there are seven sectors with reduced

negative output effect, four sectors with higher positive output growth effect, one sector which changes from negative to positive output effect, and two sectors with lower positive output effect.

Table 10 presents the effects on factor returns in the Philippines. The results were adjusted for the change in the GDP deflator. Wages of skilled and unskilled workers in the Philippines decline if the country decides to remain outside of the TPP. The returns to capital decline in the initially years, but improve in the latter years. The returns to land improve throughout the 10-year period under the 'TPP' scenario.

Philippine participation with no change in the FDI inflows will result in a sustained improvement in the wages of skilled and unskilled workers and in the returns to capital. The returns to land declines. The 'TPP+Philippines+FDI' scenario will result in higher wages relative to the case with no additional FDI inflows. The increase in the returns to capital and the decline in the returns to land are both lower under the case with additional FDI inflows into the Philippines.

Welfare Effects. The measure of welfare used in the analysis is equivalent variation (EV). Table 11 presents EV results as a percent of GDP. If the Philippines decides to remain outside of the TPP, the decline in its exports will result in lower output and a loss in welfare. In 2024, the welfare loss is 0.2 percent of GDP. Philippine participation will result in sustained welfare gain. In 2024 the gain is 1.2 percent of GDP. If the inflows of FDI improve with participation, the welfare gain is relatively higher, representing 1.5 percent of GDP in 2024. The economic opportunity cost to the Philippines of remaining outside of the TPP, computed as the sum of the welfare loss due to non-participation and the potential welfare gain from participation with FDI inflows, is higher. In 2024, the economic opportunity cost is 1.7 percent of GDP.

Among other countries/regions, the welfare effects vary across TPP participating countries. In 2024, Viet Nam benefits the most from the TPP with a welfare gain representing 2.7 percent of

GDP. It is followed by Malaysia. If the Philippines joins the TPP, the welfare gain across participating countries is relatively higher, except for Mexico and Peru where the increase in welfare is slightly lower. All non-TPP countries/regions show welfare losses. Thailand has the highest welfare loss followed by Taiwan.

IV. Summary and Conclusions

The Philippines has a sizeable share of external trade in GDP. The members in the TPP are key markets for Philippine exports as well as sources of imports, foreign investments and technology. If the ongoing negotiations within the TPP are successful, participation or non-participation in the TPP will affect the Philippine economy.

The negotiations cover several elements. One important component is the reduction in the trade barriers within TPP. The analysis in the paper considers a 90 percent drop in tariff rates and a 20 percent decline in the AVE of NTBs. The reduction in the trade barriers was phased over a 10-year period from 2015 to 2024 and simulated using a global CGE model.

The reduction in the trade barriers within the TPP (with or without Philippine participation) results in trade creation within the TPP and trade diversion from the non-TPP. If the Philippines remains outside of the TPP, the trade diversion effect is small. If the Philippines decides to join the TPP, the trade creation effect is higher and will benefit not only the country but all members of the expanded TPP group as well. If the inflows of FDI to the Philippines improve with participation, the economy will benefit from the scale production effect of higher capital inflows. Although the real exchange rate appreciates with higher FDI which reduces slightly the positive effects of participation on exports, the appreciation effect is offset by the scale production effect. Thus, total output is higher. Philippine participation in the TPP will lead to higher wages for both

skilled and unskilled labor and returns to capital will improve. The increase in wages is relatively higher if the inflow of capital improves with participation.

The output effects vary across sectors. Two of the key sectors of the economy, the service and the electronic equipment, will improve if the Philippines decides to join the TPP. The output of the textile and wearing apparel sector, which is part of the government's list of industries for export promotion, will improve notably. The output of the sectors with high trade barriers, crops and food manufacturing, will decline and land prices will fall. These adjustments may be worth bearing. Food prices in the Philippines are high because of trade barriers in agriculture and food manufacturing. Rice imports are still controlled by quantitative restrictions. Tariffs on import sugar are still prohibitively high. Philippine participation in the TPP can provide discipline and can speed up the trade reform process in agriculture and food sectors, which is critical in reducing food prices and in alleviating poverty.

The model results show that TPP participation will lead to an overall welfare gain for the Philippines. But the gain can potentially be higher. The analysis in the paper only considers additional yearly FDI inflows of US$1 billion over a 10-year period. While these inflows will improve the economy's position relative to the FDI frontier estimated by Petri, P., M. Plummer, and F. Zhai (2012), this new position is still well below the frontier. The Philippines has large absorptive capacity for foreign capital. The country has a huge gap in infrastructure. It requires significant amount of investment to improve its infrastructure, which is currently inadequate to sustain the economy's present growth trajectory. The country has large amounts of untapped natural (mineral) resources. It has a large young labor force with high level of education which can benefit from higher wages as a result of a TPP participation. However, significant reforms in investment and corporate taxation are required to make the Philippines an attractive destination

for foreign investments. At present, the negative list for foreign investment is long. Corporate taxes are high relative to those in the region. Again, TPP participation could help stimulate beneficial reforms of domestic policies.

References:

Cheong, I. 2013. Negotiations for the Trans-Pacific Partnership Agreement: Evaluation and Implications for East Asian Regionalism. ADBI Working Paper Series No. 428. Asian Development Bank Institute: Tokyo, Japan.

Fergusson, I., and B. Vaughn. 2010. The Trans-Pacific Partnership. Congressional Research Service 7-5700. Washington D.C.

Fugazza, M., and J. Maur. 2008. Non-Tariff Barriers in Computable General Equilibrium Modeling. Policy Issues in International Trade and Commodities Study Series N. 38. United Nations Conference on Trade and Development.

Ianchovichina, E. and T. Walmsley. 2012. *GDyn Book: Dynamic Modeling and Applications in Global Economic Analysis*. Cambridge University Press: Cambridge, U.K.

Itakura, K, and H. Lee. 2012. Welfare Changes and Sectoral Adjustments of Asia-Pacific Countries under Alternative Sequencings of Free Trade Agreements. Osaka School of International Public Policy Discussion Paper DP-2012-E-005.

Josling, T., D. Roberts, and D. Orden. 2004. *Food Regulation and Trade: Toward a Safe and Open Global System*. Institute for International Economics: Washington, D.C.

Kee, H., A. Nicita, and M. Olarreaga. 2006. Estimating Trade Restrictiveness Indices. World Bank Policy Research Working Paper 3840. World Bank: Washington, D.C.

Krist, W. 2013. The Trans-Pacific Partnership Negotiations: Getting to an Agreement. Program on America and the Global Economy. Woodrow Wilson International Center for Scholars: Washington, D.C. Available from URL: www.wilsoncenter.org/page.

Petri, P., M. Plummer, and F. Zhai. 2012. The Trans-Pacific Partnership and Asia-Pacific Integration: A Quantitative Assessment. *98 Policy Analyses in International Economics*. November. Peterson Institute for International Economics: Washington, D.C.

Petri, P., M. Plummer, and F. Zhai. 2013. Adding Japan and Korea to the TPP. March 7. Available from URL: http://asiapacifictrade.org/wp-content/uploads/2013/05/Adding-Japan-and-Korea-to-TPP.pdf

Petri, P., M. Plummer, and F. Zhai. 2012. "The ASEAN Economic Community: A General Equilibrium Analysis". *Asian Economic Journal*. Vol. 26. Issue 2. Pages 93-118.

Robichaud, V., A. Lemelin, H. Maisonnave and B. Decaluwe. 2011. The PEP Standard Multi-Region, Recursive Dynamic World Model, PEP Global Model (PEP-w-t_v1_4.gms). Available from URL: www.pep-net.org.

Zhai, F. 2008. Armington Meets Meltiz: Introducing Firm Heterogeneity in a Global CGE Model of Trade. *Journal of Economic Integration* 23(3), September, pp. 575-604.

Table 1. Philippine Trade with Partners

	Exports, 2010-2013			Imports, 2010-2013	
Countries	Annual Average, US $mil.	Average Share,%	Countries	Annual Average, US $mil.	Average Share,%
Japan	9,507	18.5	USA	6,558	11.0
USA	7,474	14.5	European Union	6,363	10.6
European Union	6,363	12.4	China	6,357	10.6
China	6,178	12.0	Japan	6,229	10.4
Singapore	5,120	9.9	Singapore	4,680	7.8
Hong Kong	4,308	8.4	Taiwan	4,405	7.4
South Korea	2,622	5.1	South Korea	4,395	7.3
Thailand	2,018	3.9	Thailand	3,544	5.9
Taiwan	1,872	3.6	Indonesia	2,558	4.3
Malaysia	1,203	2.3	Malaysia	2,487	4.2
Indonesia	680	1.3	Hong Kong	1,436	2.4
Canada	451	0.9	Australia	1,058	1.8
Australia	485	0.9	Canada	451	0.8
New Zealand	44	0.1	New Zealand	466	0.8
Others	3,147	6.1	Others	8,863	14.8
Total	51,470	100.0	Total	59,847	100.0
% of GDP	22.9		% of GDP	26.6	

Source: Bangko Sentral ng Pilipinas

Table 2. Net Foreign Direct Investments in the Philippines (US$ million)

	2009	2010	2011	2012	2013	Total 2009-2013	Percent Share, %
Total	1,731	-396	558	2,006	563	4,462	100.0
United States	719	229	225	554	-653	1,073	24.0
Japan	626	247	367	146	438	1,823	40.9
European Union 25	-13	-1,411	-292	369	61	-1,286	-28.8
ASEAN /1/	19	44	43	-62	-42	3	0.1
ANIEs /2/	424	240	132	659	-80	1,375	30.8
South Korea	14	7	21	4	2	49	1.1
Hong Kong	408	216	100	655	-86	1,292	29.0
Taiwan	1	17	11	0	4	34	0.8
Others	-43	254	83	339	840	1,473	33.0

/1/ Association of South East Asian Nations

/2/ Asian Newly Industrializing Economies

Source: Bangk Sentral ng Pilipinas

Table 3. Sectors and Regions in the Philippines-TPP CGE Model

Sectors	Countries/Regions	
Crops	TPP Countries	
All other agriculture	Australia	Canada
Mining	New Zealand	United States
Food manufacturing	Japan	Mexico
Textile and wearing apparel	Malaysia	Chile
Petroleum products	Singapore	Peru
Chemical, rubber, plastic & others	Viet Nam	
Metal products	Non-TPP	
Transport & machinery equipment	South Korea	European Union 25
Electronic equipment	Taiwan	Latin America
All other manufacturing	Philippines	Africa
Utilities	Indonesia	Rest of the World
Construction	Thailand	
Services		
Public administration		

Table 4. Estimates of Tariff and Non-Tariff Barriers for Aggregations of Sectors

	Simple Average Tariffs			AVE of Non-Tariff Barriers /1/	
	Agriculture	Mining	Manufacturing	Agriculture	Manufacturing
Australia	0.003	0.013	0.031	0.210	0.052
New Zealand	0.001	0.016	0.023	0.254	0.084
Japan	0.050	0.003	0.031	0.345	0.043
Korea	0.540	0.028	0.065	0.262	0.040
Taiwan	0.097	0.026	0.048	0.262	0.040
Malaysia	0.069	0.037	0.052	0.423	0.181
Philippines	0.049	0.036	0.045	0.398	0.177
Singapore	0.000	0.000	0.000	0.262	0.040
Viet Nam	0.083	0.067	0.104	0.306	0.197
Indonesia	0.024	0.029	0.042	0.146	0.026
Thailand	0.124	0.037	0.096	0.087	0.017
Canada	0.008	0.007	0.033	0.127	0.021
United States	0.018	0.008	0.018	0.138	0.046
Mexico	0.068	0.091	0.090	0.266	0.126
Chile	0.027	0.030	0.035	0.113	0.038
Peru	0.052	0.073	0.079	0.146	0.055
European Union	0.029	0.008	0.026	0.345	0.057
Latin America	0.055	0.051	0.083	0.149	0.066
Africa	0.090	0.064	0.104	0.146	0.093
Rest of the World	0.084	0.053	0.096	0.430	0.040

Sources: GTAP 8 database; Kee, Nicita, and Olarreaga (2006); and Fugazza and Maur (2008)

/1/ AVE refers to ad valorem equivalent

Table 5. Alternative Foreign Direct Investment Scenarios (US$ millions)

	Actual FDI	Alternative estimated stocks (2006)		
	stock (2006)	Top 3 years	75th percentile	1/2 to 90th
ASEAN	420,025	536,993	648,178	643,649
Brunei	9,861	19,057	15,312	15,312
Cambodia	2,954	3,245	3,481	3,969
Indonesia	19,056	77,545	178,794	134,655
Lao	856	1,209	1,686	1,599
Malaysia	53,575	90,704	73,067	78,074
Myanmar	5,005	7,165	6,378	7,280
Philippines	17,120	17,849	57,364	48,757
Singapore	210,089	211,070	210,521	210,521
Thailand	68,068	68,928	101,180	104,599
Vietnam	33,451	40,221	36,395	38,883

Source: Petri, Plummer, and Zhai (2011).

Table 6. Trade Effects on TPP Countries of Reduction in Trade Barriers within TPP /1/

	Total					Within TPP					To Non-TPP				
	2014	2015	2020	2024		2014	2015	2020	2024		2014	2015	2020	2024	
	US$ Billion 2007 prices				%	US$ Billion 2007 prices					US$ Billion 2007 prices				
	Baseline	Difference from baseline /1/			Diff. /2/	Baseline	Difference from baseline			% Diff.	Baseline	Difference from baseline			% Diff.
Combined exports /3/		8.32	45.06	71.71											
Due to tariff ch. alone		5.25	24.06	32.84											
Due to NTB ch. alone		3.05	20.37	37.51											
Total Exports:	3,697	8.32	45.06	71.71	1.44	1,587	10.13	54.80	87.38	4.17	2,110	-1.80	-9.74	-15.67	-0.55
Australia	175	0.57	2.89	4.14	1.80	58	0.83	4.34	6.46	8.80	117	-0.25	-1.45	-2.33	-1.49
New Zealand	34	0.15	0.79	1.16	2.51	14	0.22	1.14	1.67	9.12	20	-0.07	-0.35	-0.50	-1.80
Japan	745	2.25	10.80	15.32	1.75	215	2.81	13.10	18.46	7.33	530	-0.56	-2.30	-3.14	-0.50
Malaysia	240	0.59	3.60	6.67	1.51	91	0.65	4.02	7.29	4.60	149	-0.06	-0.42	-0.62	-0.22
Singapore	253	0.39	2.76	5.48	1.40	79	0.54	3.61	6.96	5.33	174	-0.14	-0.85	-1.48	-0.57
Viet Nam	64	0.58	3.41	5.67	4.84	29	0.72	4.02	6.52	12.25	35	-0.13	-0.61	-0.86	-1.35
Canada	421	0.86	4.64	7.31	1.40	320	0.94	5.22	8.40	2.17	101	-0.08	-0.57	-1.09	-0.80
United States	1,370	2.11	11.43	18.10	1.01	515	2.49	13.78	22.15	3.36	854	-0.38	-2.35	-4.05	-0.36
Mexico	279	0.58	3.51	6.03	1.56	226	0.60	3.69	6.45	2.09	52	-0.02	-0.18	-0.42	-0.55
Chile	79	0.10	0.52	0.80	0.68	25	0.18	1.03	1.69	4.95	54	-0.08	-0.51	-0.89	-1.09
Peru	36	0.13	0.69	1.05	1.85	14	0.15	0.84	1.33	6.38	22	-0.02	-0.15	-0.28	-0.77

Source: Authors' calculations

/1/ Total = (Within TPP) + (To Non-TPP) for yearly values, but not for 2024 % difference because baseline values are different

/2/ % difference from baseline in 2024

/3/ ch. means change. The effects of simulating changes in tariffs and NTBs separately may not be equal to the combined effects of simulating them together due to model nonlinearity

Table 7. Trade Effects on Non-TPP (including the Philippines) of Reduction in Trade Barriers within TPP

	Total					Within Non-TPP					To TPP				
	2014	2015	2020	2024		2014	2015	2020	2024		2014	2015	2020	2024	
	US$ Billion 2007 prices				%	US$ Billion 2007 prices					US$ Billion 2007 prices				
	Baseline	Difference from baseline /1/			Diff. /2/	Baseline	Difference from baseline			% Diff.	Baseline	Difference from baseline			% Diff.
Total exports	11,803	-1.56	-9.36	-16.13	-0.10	9,140	0.67	2.78	3.46	0.03	2,663	-2.23	-12.15	-19.59	-0.57
Korea	471	-0.11	-0.70	-1.20	-0.19	341	0.04	0.14	0.11	0.02	130	-0.16	-0.84	-1.31	-0.83
Taiwan	335	-0.04	-0.31	-0.57	-0.12	240	0.05	0.19	0.22	0.06	95	-0.09	-0.50	-0.79	-0.66
Indonesia	168	-0.07	-0.47	-0.86	-0.29	96	0.04	0.20	0.32	0.18	72	-0.10	-0.67	-1.18	-0.99
Thailand	210	-0.08	-0.53	-0.95	-0.28	130	0.06	0.26	0.34	0.16	80	-0.14	-0.79	-1.29	-1.08
European Union 25	5,242	-0.35	-1.70	-2.51	-0.04	4,544	0.11	0.37	0.39	0.01	698	-0.47	-2.07	-2.90	-0.38
Latin America	504	-0.11	-0.62	-1.01	-0.14	320	0.07	0.34	0.53	0.11	185	-0.18	-0.96	-1.54	-0.64
Africa	526	-0.06	-0.32	-0.54	-0.07	380	0.04	0.20	0.32	0.06	146	-0.09	-0.53	-0.87	-0.45
Rest of the World	4,255	-0.73	-4.57	-8.13	-0.13	3,031	0.25	1.03	1.20	0.03	1,225	-0.98	-5.60	-9.34	-0.55
Philippines	*91*	*-0.01*	*-0.16*	*-0.35*	*-0.25*	*59*	*0.02*	0.05	*0.02*	*0.02*	*32*	*-0.03*	*-0.20*	*-0.37*	*-0.80*

Source: Authors' calculations

/1/Total = (Within Non-TPP) + (To TPP) for yearly values, but not for 2024 % difference because of different baseline values

/2/ % difference from baseline in 2024

Table 8. Trade Effects in the Philippines (difference from baseline, US$ billion 2007 prices)

	2015	2020	2024	2015	2020	2024	2015	2020	2024
	Scenario: TPP			TPP+Philippines			TPP+Philippines+FDI		
Total Exports	-0.01	-0.16	-0.35	0.25	1.64	3.00	0.19	1.36	2.61
To TPP	-0.03	-0.20	-0.37	0.29	1.79	3.14	0.26	1.70	3.04
To Non-TPP	0.02	0.05	0.02	-0.03	-0.15	-0.14	-0.08	-0.34	-0.43
FOREX appreciation /1/							-0.11	-0.37	-0.54

Source: Authors' calculations

/1/ Appreciation in the real exchange rate in the Philippines

Table 9. Sectoral Production Effects in the Philippines

	2014 baseline		% Change from the baseline								
	US$ billion	Output	2015	2020	2024	2015	2020	2024	2015	2020	2024
	2007 prices	share, %	Scenario: TPP			TPP+Philippines			TPP+Philippines+FDI		
Crops	13.13	3.51	0.01	0.02	0.02	-0.04	-0.18	-0.23	-0.04	-0.17	-0.20
All other agriculture	14.28	3.82	0.00	-0.01	-0.02	-0.02	-0.19	-0.24	-0.01	-0.03	0.04
Mining	8.45	2.26	0.00	0.04	0.06	-0.03	-1.31	-2.30	-0.04	-1.09	-1.61
Food manufacturing	32.00	8.56	0.01	0.03	0.02	-0.06	-0.40	-0.52	-0.08	-0.39	-0.47
Textile and wearing apparel	9.75	2.61	-0.02	-0.31	-0.55	0.97	8.75	14.28	0.90	8.57	14.18
Petroleum products	8.23	2.20	-0.02	-0.16	-0.27	0.15	0.70	1.06	0.14	0.85	1.45
Chemical, rubber, & others	10.55	2.82	0.00	-0.05	-0.10	0.02	0.37	0.62	0.01	0.52	1.03
Metal products	14.96	4.00	0.00	-0.06	-0.13	-0.18	-1.66	-2.56	-0.21	-1.40	-1.78
Transport & machinery equip.	32.98	8.82	0.01	-0.06	-0.15	-0.20	-1.86	-3.00	-0.20	-1.27	-1.60
Electronic equip.	57.20	15.30	0.01	-0.03	-0.12	0.04	0.54	1.15	-0.04	0.13	0.53
All other manufacturing	11.64	3.11	0.02	0.07	0.08	-0.07	-0.40	-0.50	-0.11	-0.27	-0.07
Utilities	12.20	3.26	-0.01	-0.08	-0.15	0.08	0.41	0.65	0.07	0.63	1.18
Construction	20.73	5.54	0.00	-0.09	-0.20	-0.52	-2.98	-4.52	-0.26	-0.83	-0.58
Services /1/	102.71	27.47	-0.01	-0.09	-0.16	0.08	0.48	0.80	0.07	0.74	1.40
Weighted total output change			0.00	-0.05	-0.11	0.01	0.13	0.31	0.00	0.29	0.70

Source: Authors' calculations

/1/ The share of public administration is 6.72%; its output is held fixed

Table 10. Factor Return Effects in the Philippines /1/

	2015	2020	2024	2015	2020	2024	2015	2020	2024
	Scenario: TPP			TPP+Philippines			TPP+Philippines+FDI		
Skilled wages	-0.01	-0.09	-0.16	0.07	0.51	0.95	0.09	0.74	1.36
Unskilled wages	-0.01	-0.08	-0.15	0.01	0.29	0.64	0.04	0.58	1.16
Returns to capital	-0.01	0.01	0.04	0.11	0.53	0.78	0.09	0.18	0.05
Returns to land	0.05	0.11	0.08	-0.41	-1.94	-2.65	-0.41	-1.37	-1.45

Source: Authors' calculations

/1/ % change in factor returns less % change in GDP deflator

Table 11. Welfare Effects (equivalent variation % of GDP)

	2015	2020	2024	2015	2020	2024
	Scenario: TPP			TPP+Philippines		
Philippines	-0.023	-0.100	-0.193	0.170	0.829	1.220
with FDI				0.175	0.942	1.461
Total /1/				0.198	1.042	1.654
TPP members:						
Australia	0.039	0.160	0.185	0.039	0.162	0.188
New Zealand	0.054	0.228	0.276	0.055	0.232	0.282
Japan	0.040	0.173	0.230	0.041	0.177	0.237
Malaysia	0.282	1.238	1.738	0.288	1.277	1.803
Singapore	0.064	0.289	0.455	0.069	0.308	0.481
Viet Nam	0.481	2.028	2.713	0.535	2.310	3.117
Canada	0.046	0.205	0.276	0.046	0.206	0.278
United States	0.009	0.039	0.052	0.009	0.041	0.055
Mexico	0.048	0.218	0.294	0.048	0.217	0.291
Chile	0.043	0.179	0.224	0.045	0.195	0.252
Peru	0.073	0.276	0.337	0.073	0.276	0.335
Non-TPP:						
South Korea	-0.011	-0.052	-0.079	-0.012	-0.052	-0.091
Taiwan	-0.014	-0.069	-0.104	-0.016	-0.069	-0.125
Indonesia	-0.014	-0.077	-0.123	-0.016	-0.077	-0.146
Thailand	-0.022	-0.099	-0.139	-0.025	-0.099	-0.164
European Union 25	-0.001	-0.005	-0.007	-0.001	-0.005	-0.008
Latin America	-0.004	-0.018	-0.028	-0.004	-0.018	-0.030
Africa	-0.004	-0.016	-0.023	-0.004	-0.016	-0.025
Rest of the World	-0.004	-0.018	-0.026	-0.005	-0.018	-0.029

Source: Authors' calculations

/1/ The sum of the opportunity cost of non-participation and the estimated effects of participation with FDI effects

Appendix A: Mapping to GTAP 8 and Specification of a Global CGE Model

A.1. Mapping to GTAP 8 Database

The GTAP 8 database contains information for 57 sectors in 129 countries/regions. To facilitate the computation of the model solution and analysis of results, the database was aggregated to 15 sectors in 20 countries/regions and used to calibrate the global CGE model. Table A1 presents the mapping of the 15 sectors in the model to 57 sectors the GTAP 8, while Table A2 the mapping of the 20 countries/regions to the 129 countries/regions in the database.

Table A1. Mapping of Global CGE Sectors to GTAP 8 Database Sectors

Global CGE Sectors			GTAP 8 Database Sectors	
Sector No.	Code	Description	Code	Description
1	1crops	Crops	pdr	Paddy rice
			wht	Wheat
			gro	Cereal grains nec
			v_f	Vegetables-fruit-nuts
			osd	Oil seeds
			c_b	Sugar cane-sugar beet
			pfb	Plant-based fibers
			ocr	Crops nec
2	1oagri	All other agriculture	ctl	Cattle-sheep-goats-horses
			oap	Animal products nec
			rmk	Raw milk
			wol	Wool-silk-worm cocoons
			frs	Forestry
			fsh	Fishing
3	1mng	Mining	coa	Coal
			oil	Oil
			gas	Gas
			omn	Minerals nec
			nmm	Mineral products nec
4	1food	Food	cmt	Meat-cattle-sheep-goats-horse
			omt	Meat products nec
			vol	Vegetable oils-fats
			mil	Dairy products
			pcr	Processed rice
			sgr	Sugar
			ofd	Food products nec
			b_t	Beverages-tobacco products

5	1texwap	Textile and wearing apparel	tex	Textiles
			wap	Wearing apparel
6	1petro	Petroleum products	p_c	Petroleum-coal products
7	1crp	Chemical, rubber, and plastic prods	crp	Chemical-rubber-plastic prods
8	1metal	Metal products	i_s	Ferrous metals
			nfm	Metals nec
			fmp	Metal products
9	1trnpmac	Transp_Machinery equipment	mvh	Motor vehicles-parts
			otn	Transport equipment nec
			ome	Machinery-equipment nec
10	1ele	Electronic equipment	ele	Electronic equipment
11	1omanf	All other manufacturing	lea	Leather products
			lum	Wood products
			ppp	Paper products-publishing
			omf	Manufactures nec
12	1util	Utilities	ely	Electricity
			gdt	Gas manufacture-distribution
			wtr	Water
13	1cns	Construction	cns	Construction
14	1serv	Services	trd	Trade
			otp	Transport nec
			wtp	Sea transport
			atp	Air transport
			cmn	Communication
			ofi	Financial services nec
			isr	Insurance
			obs	Business services nec
			ros	Recreation-other services
			dwe	Dwellings
15	1osg	Public administration	osg	PubAdmin-Defense-Health-Education

Table A2. Mapping of Global CGE Countries/Regions to GTAP 8 Countries/Regions

Global CGE Countries/Regions			GTAP 8 Database Countries/Regions	
No.	Code	Description	Code	Description
1	1AUS	Australia	AUS	Australia
2	1NZL	New Zealand	NZL	New Zealand
3	1JPN	Japan	JPN	Japan
4	1KOR	Korea	KOR	Korea
5	1TWN	Taiwan	TWN	Taiwan
6	1MYS	Malaysia	MYS	Malaysia
7	1PHL	Philippines	PHL	Philippines
8	1SGP	Singapore	SGP	Singapore
9	1VNM	Viet Nam	VNM	Viet Nam
10	1IDN	Indonesia	IDN	Indonesia
11	1THA	Thailand	THA	Thailand
12	1CAN	Canada	CAN	Canada
13	1USA	United States of America	USA	United States of America
14	1MEX	Mexico	MEX	Mexico
15	1CHL	Chile	CHL	Chile
16	1PER	Peru	PER	Peru
17	1EU25	European Union 25	AUT	Austria
			BEL	Belgium
			CYP	Cyprus
			CZE	Czech Republic
			DNK	Denmark
			EST	Estonia
			FIN	Finland
			FRA	France
			DEU	Germany
			GRC	Greece
			HUN	Hungary
			IRL	Ireland
			ITA	Italy
			LVA	Latvia
			LTU	Lithuania
			LUX	Luxembourg
			MLT	Malta
			POL	Poland
			PRT	Portugal
			SVK	Slovakia
			SVN	Slovenia
			ESP	Spain
			SWE	Sweden

			GBR	United Kingdom
18	1LTN	Latin America	ARG	Argentina
			BOL	Bolivia
			BRA	Brazil
			COL	Colombia
			ECU	Ecuador
			PRY	Paraguay
			URY	Uruguay
			VEN	Venezuela
			XSM	Rest of South America
			CRI	Costa Rica
			GTM	Guatemala
			HND	Honduras
			NIC	Nicaragua
			PAN	Panama
			SLV	El Salvador
			XCA	Rest of Central America
			XCB	Caribbean
19	1AFR	Africa	EGY	Egypt
			MAR	Morocco
			TUN	Tunisia
			XNF	Rest of North Africa
			CMR	Cameroon
			CIV	Cote d_Ivoire
			GHA	Ghana
			NGA	Nigeria
			SEN	Senegal
			XWF	Rest of Western Africa
			XCF	Central Africa
			XAC	South Central Africa
			ETH	Ethiopia
			KEN	Kenya
			MDG	Madagascar
			MWI	Malawi
			MUS	Mauritius
			MOZ	Mozambique
			TZA	Tanzania
			UGA	Uganda
			ZMB	Zambia
			ZWE	Zimbabwe
			XEC	Rest of Eastern Africa
			BWA	Botswana
			NAM	Namibia

			ZAF	South Africa
			XSC	Rest of South African Custom
20	1ROW	Rest of the World	XOC	Rest of Oceania
			CHN	China
			HKG	Hong Kong
			MNG	Mongolia
			XEA	Rest of East Asia
			KHM	Cambodia
			LAO	Lao Peoples Democratic Rep
			XSE	Rest of Southeast Asia
			BGD	Bangladesh
			IND	India
			NPL	Nepal
			PAK	Pakistan
			LKA	Sri Lanka
			XSA	Rest of South Asia
			XNA	Rest of North America
			CHE	Switzerland
			NOR	Norway
			XEF	Rest of EFTA
			ALB	Albania
			BGR	Bulgaria
			BLR	Belarus
			HRV	Croatia
			ROU	Romania
			RUS	Russian Federation
			UKR	Ukraine
			XEE	Rest of Eastern Europe
			XER	Rest of Europe
			KAZ	Kazakhstan
			KGZ	Kyrgyzstan
			XSU	Rest of Former Soviet Union
			ARM	Armenia
			AZE	Azerbaijan
			GEO	Georgia
			BHR	Bahrain
			IRN	Iran Islamic Republic of
			ISR	Israel
			KWT	Kuwait
			OMN	Oman
			QAT	Qatar
			SAU	Saudi Arabia
			TUR	Turkey

ARE	United Arab Emirates
XWS	Rest of Western Asia
XTW	Rest of the World

A.2. Specification of a Global CGE Model[10]

Indices

The following are the indices used in the variables of the model

(*i, j, ij*):	sectors
(*m*):	imported commodities
(*nm*):	non-imported, domestically produced commodities
(*x*):	exports
(*nx*):	domestically produced sold to the domestic market only
(*z, zj*):	countries or regions
(*k*):	capital type
(*l*):	labor type
(*t*):	period

Production

Sectoral value added ($VA_{j,z,t}$) is a fixed proportion of sectoral output ($XS_{j,z,t}$)

(1) $VA_{j,z,t} = v_{j,z} XS_{j,z,t}$

where ($v_{j,z}$) is a set of fixed value added coefficients.

Sectoral intermediate consumption is also a fixed proportion of sectoral output

(2) $CI_{j,z,t} = io_{j,z} XS_{j,z,t}$

where ($io_{j,z}$) is a set of fixed intermediate consumption coefficients.

[10] The structure of the model follows closely the PEP-w-t model (Robichaud, et al. 2011), but some equations were modified to facilitate the coding of the model.

Sectoral value added is a CES function of composite labor and composite capital. The breakdown of these composite factor inputs is discussed below. Cost minimization by firms yields the following first order conditions (Rutherford, 2002): the demand functions for the composite labor ($LDC_{j,z,t}$) and the composite capital ($KDC_{j,z,t}$), and a unit cost function of value added ($PVA_{j,z,t}$).

The demand for the composite labor is

$$(3) \qquad LDC_{j,z,t} = \beta_{LDC,j,z}^{\sigma_{VA,j,z}} \left(\delta_{LDC,j,z}\alpha_{VA,j,z}\right)^{\sigma_{VA,j,z}-1} \left(\frac{PVA_{j,z,t}}{WC_{j,z,t}}\right)^{\sigma_{VA,j,z}} VA_{j,z,t}$$

where ($\beta_{LDC,j.Z}$) is the composite labor share parameter, ($\alpha_{VA,j,z}$) the scale parameter in the CES function, ($\delta_{LDC,j,z}$) the composite labor productivity factor, ($\sigma_{VA,j,z}$) the elasticity of substitution between the composite labor and the composite capital, ($WC_{j,z,t}$) the composite wage, and ($VA_{j,z,t}$) the value added.

The demand for the composite capital is

$$(4) \qquad KDC_{j,z,t} = \beta_{KDC,j,z}^{\sigma_{VA,j,z}} \left(\delta_{KDC,j,z}\alpha_{VA,j,z}\right)^{\sigma_{VA,j,z}-1} \left(\frac{PVA_{j,z,t}}{RC_{j,z,t}}\right)^{\sigma_{VA,j,z}} VA_{j,z,t}$$

where ($\beta_{KDC,j.Z}$) is the composite capital share parameter, ($\delta_{KDC,j,z}$) the composite capital productivity factor, and ($RC_{j,z,t}$) the composite rental rate of capital.

The unit cost function of value added is

$$(5) \qquad PVA_{j,z,t} = \left(\frac{1}{\alpha_{VA,j,z}}\right)\left(\beta_{LDC,j,z}\left(\frac{WC_{j,z,t}}{\delta_{LDC,j,z}}\right)^{1-\sigma_{VA,j,z}} + \beta_{KDC,j,z}\left(\frac{RC_{j,z,t}}{\delta_{KDC,j,z}}\right)^{1-\sigma_{VA,j,z}}\right)^{\frac{1}{1-\sigma_{VA,j,z}}}$$

where ($PVA_{j,z,t}$) is the CES dual price; it is the aggregate price of the CES components: the prices of composite labor and composite capital.

The composite labor is a CES function of two types of labor: (l) = skilled and unskilled labor. Cost minimization by firms will yield the following first order conditions: the demand functions for each type of labor, and a unit cost function of the composite labor.

The demand for type *l* labor is

$$(6) \qquad LD_{l,j,z,t} = \beta_{l,j,z}^{\sigma_{LD,j,z}} \left(\delta_{l,j,z}\alpha_{LD,j,z}\right)^{\sigma_{LD,j,z}-1} \left(\frac{WC_{j,z,t}}{WTI_{l,j,z,t}}\right)^{\sigma_{LD,j,z}} LDC_{j,z,t}$$

where ($\beta_{l,j.Z}$) is the share parameter of type *l* labor, ($\delta_{l,j,z}$t) the productivity factor of type *l* labor, ($\alpha_{LD,j,z}$) the scale parameter in the CES function, ($\sigma_{LD,j,z}$) the elasticity of substitution between the two types of labor, and ($WTI_{l,j,z,t}$) the wage rate of type *l* labor including payroll tax.

The unit cost function of the composite labor is

$$(7) \qquad WC_{j,z,t} = \left(\frac{1}{\alpha_{LD,j,z}}\right)\left(\quad \sum_l \beta_{l,j,z} \left(\frac{WTI_{l,j,z,t}}{\delta_{l,j,z}}\right)^{1-\sigma_{LD,j,z}}\right)^{\frac{1}{1-\sigma_{LD,j,z}}}$$

This is a CES dual price.

The composite capital is a CES function of two types of capital: (*k*) = physical capital and land (which includes natural resources). However, land is only used in agriculture and mining while physical capital in all sectors.

The demand for type *k* capital is

$$(8) \qquad KD_{k,j,z,t} = \beta_{k,j,z}^{\sigma_{KD,j,z}} \left(\delta_{k,j,z}\alpha_{KD,j,z}\right)^{\sigma_{KD,j,z}-1} \left(\frac{RC_{j,z,t}}{RTI_{k,j,z,t}}\right)^{\sigma_{KD,z}} KDC_{j,z,t}$$

where ($\beta_{k,j.Z}$) is the share parameter of type *k* capital, ($\delta_{k,j,z}$t) the productivity factor of type *k* capital, ($\alpha_{KD,j,z}$) the scale parameter in the CES function, ($\sigma_{KD,j,z}$) the elasticity of substitution between the two types of capital, and ($RTI_{k,j,z,t}$) the rental rate of type *k* capital including factor tax on capital.

The unit cost function of the composite capital is

$$(9) \qquad RC_{j,z,t} = \left(\frac{1}{\alpha_{KD,j,z}}\right)\left(\quad \sum_k \beta_{k,j,z} \left(\frac{RTI_{k,j,z,t}}{\delta_{k,j,z}}\right)^{1-\sigma_{KD,j,z}}\right)^{\frac{1}{1-\sigma_{KD,j,z}}}$$

This is a CES dual price.

Income and Savings

In each region there is a single household and a government. Household income ($YH_{z,t}$) is composed of labor ($YHL_{z,t}$) and capital income ($YHK_{z,t}$).

(10) $YH_{z,t} = YHL_{z,t} + YHK_{z,t}$

Labor income is the sum of labor earnings from the two types of labor, while capital income is the sum of rentals paid for the two types of capital less depreciation. That is,

(11) $YHL_{z,t} = \sum_{l,j} W_{l,z,t} LD_{l,j,z,t}$

(12) $YHK_{z,t} = \sum_{k,j} R_{k,j,z,t} KD_{k,j,z,t} - Dep_{z,t}$

where ($W_{l,z,t}$) is the wage rate of type *l* labor before payroll tax, ($R_{k,j,z,t}$) the sectoral rental rate of type *k* capital before rental tax, and ($Dep_{z,t}$) the amount of depreciation (capital consumption allowance).

The household disposable income ($YDH_{z,t}$), the household consumption budget ($CTH_{z,t}$), and the household savings ($SH_{z,t}$) are

(13) $YDH_{z,t} = YH_{z,t} - TDH_{z,t}$

(14) $CTH_{z,t} = YDH_{z,t} - SH_{z,t}$

(15) $SH_{z,t} = PIXCON_{z,t}^{\eta} sh0_{z,t} + sh1_z YDH_{z,t}$

where ($TDH_{z,t}$) is the household income tax, ($PIXCON_{z,t}$) the consumer price index, ($sh0_{z,t}$) the intercept in the savings function in *t*, ($sh1_z$) the slope of the savings function, and (η) the price-elasticity of indexed transfers and parameters.

Government

The revenue of the government ($YG_{z,t}$) comes from three sources: household income tax ($TDH_{z,t}$), production-related taxes ($TPRODN_{z,t}$), and products and imports taxes ($TPRCT_{z,t}$).

(16) $YG_{z,t} = TDH_{z,t} + TPRODN_{z,t} + TPRCT_{z,t}$

Income taxes paid by households are a linear function of total income, i.e.,

(17) $TDH_{z,t} = PIXCON_{z,t}^{\eta} ttdh0_{z,t} + ttdh0_{z,t} YH_{z,t}$

The production-related taxes are: the taxes on payroll ($TIWT_{z,t}$), the taxes on the use capital ($TIKT_{z,t}$), and the taxes on production ($TIPT_{z,t}$).

(18) $TPRODN_{z,t} = TIWT_{z,t} + TIKT_{z,t} + TIPT_{z,t}$

The tax on payroll is

(19) $TIWT_{z,t} = \sum_{l,j} TIW_{l,j,z,t} = \sum_{l,j} ttiw_{l,j,z,t} W_{l,z,t} LD_{l,j,z,t}$

where ($TIW_{l,j,z,t}$) is the revenue from payroll tax on type *l* labor, and ($ttiw_{l,j,z,t}$) the rate of payroll tax.

Similarly, the tax on the use of capital is

(20) $TIKT_{z,t} = \sum_{k,j} TIK_{k,j,z,t} = \sum_{k,j} ttik_{k,j,z,t} R_{k,j,z,t} KD_{k,j,z,t}$

where ($TIK_{k,j,z,t}$) is the revenue from the tax on the use of type *k* capital, and ($ttik_{k,j,z,t}$) the tax rate on the use of capital.

The production tax is

(21) $TIPT_{z,t} = \sum_{j} TIP_{j,z,t} = \sum_{j} ttip_{j,z,t} PP_{j,z,t} XS_{j,z,t}$

where ($TIP_{j,z,t}$) is the revenue from the tax on production, ($ttiP_{j,z,t}$) the tax rate on the use of capital, and ($PP_{j,z,t}$) the unit cost of sector *j*.

The taxes on products and imports are: the indirect taxes on commodities ($TICT_{z,t}$), the duties levied on imports ($TIMT_{z,t}$), and the export taxes ($TIXT_{z,t}$).

(22) $TPRCTS_{z,t} = TICT_{z,t} + TIMT_{z,t} + TIXT_{z,t}$

The indirect tax on commodities is

(23) $TICT_{z,t} = \sum_i TIC_{i,z,t}$

where ($TIC_{i,z,t}$) is the revenue from indirect tax. Since commodities available in the domestic market are composed of domestically produced goods and imports, ($TIC_{i,z,t}$) has two components: ($TIC_{nm,z,t}$) the indirect tax on non-imported commodities, and ($TIC_{m,z,t}$) the indirect tax on imported commodities.

The indirect tax on non-imported commodities is

(24) $TIC_{nm,z,t} = ttic_{nm,z,t} PL_{nm,z,t} DD_{nm,z,t}$

where ($ttic_{nm,z,t}$) is the indirect tax rate on non-imported commodities, ($PL_{nm,z,t}$) the price of locally produced commodities excluding taxes, and ($DD_{nm,z,t}$) the domestic demand for commodity *nm*.

Import duties are levied on commodities that enter the border. When these commodities are moved beyond the border into the various domestic markets, similar to the domestically produced goods, they are charged with indirect taxes as well. Moreover, the border price of imports includes trade margins. Taking all these factors together, the indirect tax on imported commodities ($TIC_{m,z,t}$) is

(25) $TIC_{m,z,t} = ttic_{m,z,t}\{PL_{m,z,t} DD_{m,z,t} \sum_{zj}[(1 + ttim_{m,zj,z,t})(PWM_{m,zj,z,t} + \sum_{ij} PWMG_{ij,t} tmrg_{ij,m,zj,z,t}) e_{z,t} IM_{m,zj,z,t}]\}$

where ($ttic_{m,z,t}$) the indirect tax rate on imports, ($ttim_{m,zj,z,t}$) the rate of import duties, ($PWM_{m,zj,z,t}$) the world price of m imported from country/region *zj* by country/region *z* in international currency, ($PWMG_{ij,t}$) the world price of trade margins in international currency, ($tmrg_{ij,m,zj,z,t}$) the rate of international transport margin services, ($e_{z,t}$) the exchange rate, and ($IM_{m,zj,z,t}$) imports.

The total government revenue ($TIMT_{z,t}$) from duties on imports is given as

(26) $TIMT_{z,t} = \sum_{m,zj} TIM_{m,zj,z,t} = \sum_{m,zj} ttim_{m,zj,z,t}\left(PWM_{m,zj,z,t} + PWM_{m,zj,z,t}\right)e_{z,t}IM_{m,zj,z,t}$

The total government revenue ($TIXT_{z,t}$) from export taxes is defined as

(27) $TIXT_{z,t} = \sum_{x,zj} TIX_{x,z,zj,t} = \sum_{x,zj} ttix_{x,z,zj,t}PE_{x,z,zj,t}EX_{x,z,zj,t}$

where ($TIX_{x,z,zj,t}$) is the revenue from taxes on export by country/region *z* to country/region *zj*, ($ttix_{x,z,zj,t}$) the rate of export taxes, ($PE_{x,z,zj,t}$) the price of exports excluding export taxes, and ($EX_{x,z,zj,t}$) exports.

Government savings ($SG_{z,t}$) is total government revenue net of total current government expenditure ($G_{z,t}$).

(28) $SG_{z,t} = YG_{z,t} - G_{z,t}$

Domestic Demand

Household demand ($C_{i,z,t}$) is derived by utility maximization subject to a budget constraint. This process will yield the following consumption function[11]

(29) $C_{i,z,t}PC_{i,z,t} = C_{i,z,t}^{MIN}PC_{i,z,t} + \gamma_{i,z}^{LES}\left(CTH_{z,t} - \sum_{ij} C_{ij,z,t}^{MIN}\right)$

where ($C_{i,z,t}^{MIN}$) is the minimum consumption of commodity, ($PC_{i,z,t}$) the purchaser price of commodity, and ($\gamma_{i,z}^{LES}$) the marginal share of commodity in the household consumption budget.

The volume of government expenditure on commodities ($CG_{i,z,t}$) is given by

(30) $CG_{i,z,t}PC_{i,z,t} = \gamma_{i,z}^{GVT}G_{z,t}$

[11] This is a linear expenditure system (LES).

where ($\gamma_{i,z}^{GVT}$) is the share of expenditure on commodities in the total current government expenditure. The total current government expenditure is equal to the total real government expenditure ($RG_{z,t}$) multiplied by a public (government) expenditure price index ($PIXGVT_{z,t}$), i.e.,

(31) $$G_{z,t} = RG_{z,t} PIXGVT_{z,t}$$

The public expenditure price index is defined later. The equation (31) allows for alternative model closures in the sense that government expenditure can either be fixed in real or in nominal terms.

The total investment in each country/region is determined by the savings-investment equilibrium constraint which is be defined later. The total available investment ($IT_{z,t}$) is distributed across sectors using a set of fixed shares

(32) $$INV_{i,z,t} PC_{i,z,t} = \gamma_{i,z}^{INV} IT_{z,t}$$

where ($INV_{i,z,t}$) is the final demand for commodity for investment purposes (or the gross fixed capital formation), and ($\gamma_{i,z}^{INV}$) the share of commodity in the total investment expenditures[12].

The total intermediate demand ($DIT_{i,z,t}$) for each commodity is the sum of the industry demands for production inputs ($DI_{i,j,z,t}$), i.e.,

(33) $$DIT_{i,z,t} = \sum_j DI_{i,j,z,t}$$

Supplies and International Trade

The supply of produced output in each country/region is represented by two-level nested CET functions: (a) in the first nest, each sectoral output produced ($XS_{j,z,t}$) is allocated to three outlets: domestic demand ($DS_{j,z,t}$), exports ($EXT_{j,z,t}$), and international transport margin services ($MRGN_{j,z,t}$); and (b) in the second nest, the total export of each country/region is distributed to the various export market destinations. However, not all output produced are exportable. Some goods are only sold in the domestic market. Thus, the commodities are grouped in two sets: (*x*) for output

[12]As pointed out in Robichaud, et al (2011), this specification implies that the production of new capital is Cobb-Douglas. Thus, the quantity demanded for each commodity for investment purposes under a given amount of investment expenditure is inversely related to its price.

sold in both exports and the domestic markets, and (*nx*) for output sold in the domestic market only.

Producers allocate output to the three outlets in order to maximize revenue given product prices in each of the outlets. Assuming imperfect substitutability among the three outlets, the product is supplied to each outlet based on a CET function. The first order conditions yield supply of exports, domestic demand, and international transport margin services.

The supply of exports is

$$(34) \quad EXT_{x,z,t} = \beta_{x,z}^{EXT} \alpha 1_{x,z}^{-(1+\sigma 1_{x,z})} \left(\frac{P_{x,z,t}}{PET_{x,z,t}}\right)^{-\sigma 1_{x,z}} XS_{x,z,t}$$

where ($\beta_{x,z}^{EXT}$) is the share parameter in the CET function for exports, ($\alpha 1_{x,z}$) the scale parameter in the CET function in the first nest, ($\sigma 1_{x,z}$) the elasticity of transformation in the first nest, ($P_{x,z,t}$) the basic price of commodities, and ($PET_{x,z,t}$) the border price of exports excluding export taxes.

The supply of goods sold in the domestic market is

$$(35) \quad DS_{x,z,t} = \beta_{x,z}^{DS} \alpha 1_{x,z}^{-(1+\sigma 1_{x,z})} \left(\frac{P_{x,z,t}}{PL_{x,z,t}}\right)^{-\sigma 1_{x,z}} XS_{x,z,t}$$

where ($\beta_{x,z}^{DS}$) is the share parameter in the CET function for domestic demand, and ($PL_{x,z,t}$) the price of locally produced commodities excluding indirect taxes.

The supply of international transport margin services is

$$(36) \quad MRGN_{x,z,t} = \beta_{x,z}^{MRGN} \alpha 1_{x,z}^{-(1+\sigma 1_{x,z})} \left(\frac{P_{x,z,t}}{e_{z,t} PWMG_{x,z,t}}\right)^{-\sigma 1_{x,z}} XS_{x,z,t}$$

where ($\beta_{x,z}^{MRGN}$) is the share parameter in the CET function for domestic demand, and ($PWMG_{x,z,t}$) the world price of imports of international transport margin services in international currency.

The basic price is the CET dual price which is an aggregate price of the CET components. It is given by

(37) $$P_{x,z,t} = \left(\frac{1}{\alpha 1_{x,z}}\right)\left(\beta_{x,z}^{EXT}\left(PET_{x,z,t}\right)^{1+\sigma 1_{x,z}} + \beta_{x,z}^{DS}\left(PL_{x,z,t}\right)^{1+\sigma 1_{x,z}} + \beta_{x,z}^{MRGN}\left(e_{z,t}PWNG_{x,z,t}\right)^{1+\sigma 1_{x,z}}\right)^{\frac{1}{1+\sigma 1_{x,z}}}$$

The total exports of each country/region is disaggregated to the various export destinations using a second nest CET function. The first order conditions for revenue maximization yield the supply of exports of country/region *z* in export destination *zj*

(38) $$EX_{x,z,zj,t} = \beta_{x,z,zj}\alpha 2_{x,z}^{-(1+\sigma 2_{x,z})}\left(\frac{PET_{x,z,t}}{PE_{x,z,zj,t}}\right)^{-\sigma 2_{x,z}} EXT_{x,z,t}$$

where ($\beta_{x,z,zj}$) is the share parameter in the CET function, ($\alpha 2_{x,z}$) the scale parameter in the CET function in the second nest, ($\sigma 2_{x,z}$) the elasticity of transformation in the second nest, and ($PE_{x,z,t}$) the price of exports excluding export taxes.

The dual CET price is

(39) $$PET_{x,z,t} = \left(\frac{1}{\alpha 2_{x,z}}\right)\left(\sum_{zj}\beta_{x,z,zj}\,PE_{x,z,zj,t}^{1+\sigma 2_{x,z}}\right)^{\frac{1}{1+\sigma 2_{x,z}}}$$

For commodities which are not exported their output prices are

(40) $$P_{nx,z,t} = PL_{nx,z,t}$$

The supply of each commodity in the domestic market of each country/region is represented by two-level nested CES function: (a) in the first level is an Armington composite good consisting of domestically produced commodities and composite imports; and (2) in the second level is a disaggregation of imports from various countries/regions of origin. Also, since not all commodities have competing imports, commodities are grouped in two sets: (*m*) for commodities with competing imports, and (*nm*) for commodities supplied by domestically produced goods only.

The first order conditions for cost minimization will yield the demand for domestically produced goods, and the demand for the composite imports, and a composite import price. The demand for domestically produced goods ($DD_{m,z,t}$) is

(41) $$DD_{m,z,t} = \beta_{DD,m,z}^{\sigma 1_{m,z}} \left(\alpha 1_{m,z}\right)^{\sigma 1_{m,z}-1} \left(\frac{PC_{m,z,t}}{PD_{m,z,t}}\right)^{\sigma 1_{m,z}} Q_{m,z,t}$$

where ($\beta_{DD,m,z}$) is the share parameter for domestically produced goods, ($\alpha 1_{m,z}$) the scale parameter in the CES function in the first nest, ($\sigma 1_{m,z}$) the elasticity of substitution in the first nest, ($PC_{m,z,t}$) the purchaser price of commodity, ($PD_{m,z,t}$) the price of locally produced goods sold in the domestic market including taxes, and ($Q_{m,z,t}$) the Armington composite good.

The demand for the composite imports ($IMT_{m,z,t}$) is given by

(42) $$IMT_{m,z,t} = \beta_{IMT,m,z}^{\sigma 1_{m,z}} \left(\alpha 1_{m,z}\right)^{\sigma 1_{m,z}-1} \left(\frac{PC_{m,z,t}}{PMT_{m,z,t}}\right)^{\sigma 1_{m,z}} Q_{m,z,t}$$

where ($\beta_{IMT,m,z}$) is the share parameter for the composite imports, and ($PMT_{m,z,t}$) the price of the composite imports.

The CES dual price is the composite price of ($PD_{m,z,t}$) and ($PMT_{m,z,t}$), i.e.,

(43) $$PC_{m,z,t} = \left(\frac{1}{\alpha 1_{m,z}}\right)\left(\beta_{DD,m,z}\left(PD_{m,z,t}\right)^{1-\sigma 1_{m,z}} + \beta_{IMT,m,z}\left(PMT_{m,z,t}\right)^{1-\sigma 1_{m,z}}\right)^{\frac{1}{1-\sigma 1_{m,z}}}$$

The total imports of each commodity in each country/region is disaggregated into imports from various countries/regions of origin using a second CES nest. The first order conditions for cost minimization yields the import demand for imports by *z* from *zj*

(44) $$IM_{m,zj,z,t} = \beta_{m,zj,z}^{\sigma 2_{m,z}} \left(\alpha 2_{m,z}\right)^{\sigma 2_{m,z}-1} \left(\frac{PMT_{m,z,t}}{PM_{m,zj,z,t}}\right)^{\sigma 2_{m,z}} IMT_{m,z,t}$$

where ($\beta_{m,zj,z}$) is the share parameter for imports from origin *zj*, ($\sigma 2_{m,z}$) the elasticity of substitution in the second nest, ($\alpha 2_{m,z}$) the scale parameter in the CES function in the second nest, and ($PM_{m,zj,z,t}$) the price of imports inclusive of taxes, duties and trade margins.

The CES dual price is

(45) $$PMT_{m,z,t} = \left(\frac{1}{\alpha 2_{m,z}}\right)\left(\sum_{zj} \beta_{m,zj,z}\left(PM_{m,zj,z,t}\right)^{1-\sigma 2_{m,z}}\right)^{\frac{1}{1-\sigma 2_{m,z}}}$$

For commodities without competing imports their purchasing prices are given by

(46) $PC_{nm,z,t} = PD_{nm,z,t}$

External Account

In the GTAP 8 database, information is available on the amount of trade margin in each sector *i* associated with each bilateral trade flows between countries/regions *z* and *zj*. However, there is no information available matching the producers of the international transport margin services ($MRGN_{j,z,t}$) to the individual bilateral trade flows. Therefore, the disaggregating international transport margin services similar to the breaking down of exports of goods and services to the various export destination cannot be done because there are no information available in the GTAP 8 database needed to calibrate this nest. Thus similar to the PEP-w-t- model, the present model has the supply of $MRGN_{x,z,t}$ in each country/region pooled in a sector called 'external account' (EA)' and its production is shared among suppliers in each country/region through a competitive process.

The EA receives payments ($YEA_{z,t}$) for the value imports of the country/region including international transport margin services, i.e.,

(47) $YEA_{z,t} = e_{z,t} \sum_{m,zj} \{IM_{m,zj,t} (PWM_{m,zj,z,t} + \sum_i PWMG_{i,t} tmrg_{i,m,zj,z})\}$

The saving in the EA ($SEA_{z,t}$) is the difference between total receipts and spending which is given by

(48) $SEA_{z,t} = YEA_{z,t} - e_{z,t} \sum_{x,zj} PWX_{x,z,zj,t} EX_{x,z,zj,t} - e_{z,t} \sum_m PWMG_{m,t} MRGN_{m,z,t}$

where ($PWX_{x,z,zj,t}$) is the world price of *x* exported by country/region *z* to *zj* in international currency.

The current account balance ($CAB_{z,t}$) of each country/region is the negative of ($SEA_{z,t}$), i.e.,

(49) $CAB_{z,t} = -SEA_{z,t}$

Prices

The unit cost of a sector's output (including taxes related to the use of capital and labor, but excluding other production taxes) is given by

(50) $$PP_{j,z,t} = \frac{PVA_{j,z,t}VA_{j,z,t}+PCI_{j,z,t}CI_{j,z,t}}{XS_{j,z,t}}$$

where ($PCI_{j,z,t}$) is the price of intermediate consumption which is given as

(51) $$PCI_{j,z,t} = \frac{\sum_i PC_{i,z,t}DI_{i,j,z,t}}{CI_{j,z,t}}$$

There are various forms of taxes that appear in the model. The relationship between prices before and after taxes are defined below. The basic price of production in (37) is the unit cost in (50) plus production taxes, excluding taxes on the use of labor and capital which have already been included in the unit cost. That is,

(52) $$P_{j,z,t} = \left(1 + ttip_{j,z,t}\right)PP_{j,z,t}$$

where ($ttip_{j,z,t}$) is the production tax rate.

The wage rate of type *l* labor including payroll tax in (6) and (7) is

(53) $$WTI_{l,j,z,t} = \left(1 + ttiw_{l,j,z,t}\right)W_{l,z,t}$$

where ($ttiw_{l,j,z,t}$) is the payroll tax rate, and ($W_{l,z,t}$) is the wage rate of type *l* labor.

Similarly, the rental rate of type *k* capital including the rental tax rate on the use of capital in (8) and (9) is

(54) $$RTI_{k,j,z,t} = \left(1 + ttik_{k,j,z,t}\right)R_{k,j,z,t}$$

where ($ttik_{k,j,z,t}$) is the rental tax rate, and ($R_{k,j,z,t}$) is the rental rate of type *k* capital in sector *j*.

The price of locally produced commodities in (41) and (46) is

(55) $PD_{i,z,t} = \left(1 + ttic_{i,z,t}\right) PL_{i,z,t}$

where ($ttic_{i,z,t}$) is the indirect tax rate.

The relationship between the export price and the world price of exports is

(56) $PE_{x,z,zj,t}\left(1 + ttix_{x,z,zj,t}\right) = e_{z,t} PWX_{x,z,zj,t}$

where ($ttix_{x,z,zj,t}$) is the export tax rate, and ($PWX_{x,z,zj,t}$) is the world price of exports in international currency.

The local price of imports is

(57) $PM_{m,zj,z,t} = e_{z,t}\left(1 + ttic_{m,z,t}\right)\left(PWM_{m,zj,t} + \sum_i PWMG_{i,r} tmrg_{i,m,zj,z}\right)\left(1 + ttim_{m,zj,z,t}\right)$

where ($PWM_{m,zj,t}$) is the world price of imports, and ($ttim_{m,zj,z,t}$) is the import tariff rate.

The world price of exports and imports are the same

(58) $PWX_{x,z,zj,t} = PWM_{m,z,zj,t} \qquad \forall\, x = m$

The consumer price index is a Laspeyres index defined as

(59) $PIXCON_{z,t} = \frac{\sum_i PC_{i,z,t} C^0_{i,z}}{\sum_{ij} PC^0_{ij,z} C^0_{ij,z}}$

where ($C^0_{i,z}$) is household demand at the base value, and ($PC^0_{ij,z}$) is consumer price at the base value.

The investment price index is

(60) $PIXINV_{z,t} = \prod_i \left(\frac{PC_{i,z,t}}{PC^0_{ij,z}}\right)^{\gamma^{INV}_{i,z}}$

This price index is the dual price of a Cobb-Douglas function which describes the commodity demand for investment purposes in (32).

Similarly, the public expenditure price index is

(61) $$PIXGVT_{z,t} = \prod_i \left(\frac{PC_{i,z,t}}{PC^0_{ij,z}}\right)^{\gamma^{GVT}_{i,z}}$$

which is also a dual price of a Cobb-Douglas function which describes the commodity demand for public consumption in (31).

The GDP price deflator is a Fisher index defined as

(62) $$PIXGDP_{z,t} = \sqrt{\frac{\sum_j (PVA_{j,z,t})\left(VA^0_{j,z}\right)\sum_j (PVA_{j,z,t})(VA_{j,z,t})}{\sum_j \left(PVA^0_{j,z}\right)\left(VA^0_{j,z}\right)\sum_j \left(PVA^0_{j,z}\right)(VA_{j,z,t})}}$$

Equilibrium

The equilibrium in the labor market is

(63) $$LS_{l,z,t} = \sum_j LD_{l,j,z,t}$$

where ($LS_{l,z,t}$) is the supply of type *l* labor. This will determine the value of the wage rate ($W_{l,z,t}$) in (53).

The equilibrium in the capital market is

(64) $$KS_{k,j,z,t} = \sum_j KD_{k,j,z,t}$$

where ($KS_{l,j,z,t}$) is the supply of type *k* capital in sector *j*. This will determine the value of the sectoral rental rate of type *k* capital ($R_{k,j,z,t}$) in (54).

Total investment expenditure is equal total savings plus the amount of depreciation. Total savings is the sum of household savings, government savings, and foreign savings (which is the negative of the current account balance in (49)).

(65) $$IT_{z,t} = SH_{z,t} + SG_{z,t} - CAB_{z,t} + DEP_{z,t}$$

The amount of depreciation is the sum of capital consumption allowances for all types of capital in all sectors, and the capital consumption allowance is a constant fraction of the replacement value of capital, i.e.,

(66) $DEP_{z,t} = PK_{z,t} \sum_{k,j} \delta_{k,j,z} KS_{k,j,z,t}$

where ($\delta_{k,j,z}$) is the depreciation rate of capital *k* in sector *j*, ($KS_{k,j,z,t}$) is the sectoral supply of type *k* capital, and ($PK_{z,t}$) is the price of new capital which is defined later in the section on dynamics.

The supply of commodity by local producers is equal to the domestic demand for that commodity produced locally, i.e.,

(67) $DS_{i,z,t} = DD_{i,z,t}$

The quantity of each commodity exported from *z* to *zj* is equal to the quantity imported from *z* by *zj*, i.e.,

(68) $EX_{x,z,zj,t} = IM_{m,z,zj,t} \qquad \forall\, x = m$

The supply of international transport margin services is equal to the sum of the demand associated with all bilateral (*z*,*zj*) trade flows in all *ij* commodities, i.e.,

(69) $\sum_z MRGN_{i,z,t} = \sum_{z,zj,ij} tmrg_{i,ij,zj,z} IM_{ij,zj,z,t}$

Note that because of (47), (48), (58), (68) and (69), the sum of $SROW_{z,t}$ expressed in common international currency across countries/regions is zero.

The product market equilibrium where supply is equal to demand for each commodity in the domestic market of each country/region is defined as

(70) $Q_{i-1,z,t} = C_{i-1,z,t} + CG_{i-1,z,t} + INV_{i-1,z,t} + DIT_{i-1,z,t}$

Note that because of Walras Law, one of the demand-supply product equilibrium conditions is redundant. Thus, (70) is over (*i*-1) only.

Gross Domestic Product

The gross domestic product at basic prices ($GDP_{z,t}^{BP}$) of each country/region is defined as the payments to factors plus taxes on production but excluding taxes on factors, i.e.,

(71) $GDP_{z,t}^{BP} = \sum_j PVA_{j,z,t} VA_{j,z,t} + TIPT_{z,t}$

GDP at market price ($GDP_{z,t}^{MP}$) is GDP at basic prices plus taxes on products and imports, i.e.,

(72) $GDP_{z,t}^{MP} = GDP_{z,t}^{BP} + TPRCTS_{z,t}$

Model Closure

The present global CGE model adopts the PEP-w-t model closure with the following features:

(a) The numeraire is the GDP deflator of the reference country/region ($PIXGDP_{zr,t}$), where *zr* is the reference country/region. In the present case, *zr* = Europe Union 25. In the PEP-w-t model *zr* = United States.

(b) Government expenditure in real terms ($RG_{z,t}$) in (31) is fixed in each period *t* in each country/region.

(c) Public capital investment ($IND_{k=capital,j=govrnment,z,t}$) is fixed in each period *t* in each country/region.

(d) The supply of type *l* labor ($LS_{l,z,t}$) in (63) is fixed in each period *t* in each country/region. This is however updated in the succeeding periods using the growth projections of the labor force.

(e) The supply of type *k* capital in each sector ($KS_{k,j,z,t}$) in (64) is fixed in each period *t* in each country/region. This is however updated in the succeeding periods using a dynamic equation discussed in the next section.

(f) The minimum consumption ($C_{i,z,t}^{MIN}$) in (29) is fixed in each period *t* in each country/region.

(g) The exchange rate ($e_{z,t}$) is fixed in each in each period *t* in each country/region.

The model has been tested for homogeneity wherein changing the value of the numeraire changes all price variables and the nominal values of the variables by the same proportion as the change in the numeraire, but retains the volume of the variables as they are not affected.

Dynamics

The supply of sectoral capital (*k=capital*) in each country/region in period *t+1* is equal to the stock in the preceding period, minus depreciation, and plus the volume of new capital investment in the preceding period. That is,

(73) $$KS_{k,j,z,t+1} = KS_{k,j,z,t}\left(1 - \delta_{k,j,z}\right) + IND_{k,j,z,t}$$

where ($IND_{k,j,z,t}$) is the volume of new capital investment of the private sector. The new capital investment of the government (for *j=government*) is fixed in model closure (c) above. There is no change in the supply of land (*k=land*) over time.

The total capital investment is constrained by the total investment in (65), i.e.,

(74) $$IT_{z,t} = PK_{z,t} \sum_{k,j} IND_{k,j,z,t}$$

where the price of new capital ($PK_{z,t}$) which is given by

(75) $$PK_{z,t} = \left(\frac{1}{A_z^K}\right) \prod_i \left(\frac{PC_{i,z,t}}{\gamma_{i,z}^{INV}}\right)^{\gamma_{i,z}^{INV}}$$

where (A_z^K) is a scale parameter.

Following Jung and Thorbecke (2001) the sectoral capital investment of the private sector (*j=private*) is patterned after the specification of the Tobin's *q*. That is,

(76) $$IND_{k,j,z,t} = \emptyset_{k,j,z} \left(\frac{R_{k,j,z,t}}{U_{k,j,z,t}}\right)^{\sigma_{k,j,z}^{INC}} KS_{k,j,z,t}$$

where ($U_{k,j,z,t}$) is user cost of type *k* capital in sector *j*, ($\sigma_{k,j,z}^{INC}$) is the elasticity of investment demand relative to Tobin's *q*. The user cost of capita is given as

(77) $U_{k,j,z,t} = PK_{z,t}\left(\delta_{k,j,z} + IR_{j,z,t}\right)$

where ($IR_{j,z,t}$) is the interest rate in *z* in period *t*. This interest rate is a rationing device that adjusts so as to satisfy the investment constraint in (74).

Baseline Scenario

The standard reference scenario is called the 'business as usual (BaU)' scenario. This scenario is generated using the individual countries/regions projections on population (from the population projections of the United Nations) and on GDP per capita (from the GDP growth projections of the World Bank). The growth of the per capita GDP ($gr_{z,t}^{GDP_{pc}}$) is

(78) $gr_{z,t}^{GDP_{pc}} = \frac{gr_{z,t}^{GDP}+1}{gr_{z,t}^{pop}+1} - 1$

where ($gr_{z,t}^{GDP}$) is the growth rate of GDP, and ($gr_{z,t}^{pop}$) is the growth rate of the population.

Following the PEP-w-t model, some variables and parameters are updated using an index that incorporates the growth projections of the population and GDP. This index is

(79) $gdpindex_{z,t} = \left(1 + gr_{z,t}^{pop}\right)\left(1 + \overline{gr_z^{GDP}}\right)gdpindex_{z,t-1},\ \ with\ gdpindex_{z,t=1} = 1$

where ($\overline{gr_z^{GDP}}$) is defined as

(80) $\overline{gr_z^{GDP}} = \left(\frac{1}{TT-t=1}\right)\left(\sum_{t=1}^{TT-1} gr_{z,t}^{GDP_{pc}}\right)$

where *t=1* is the first period and *TT* the last period. This index ($gdpindex_{z,t}$) is used to update the following variables: $C_{i,z,t}^{MIN}$ in (29), $LS_{l,z,t}$ in (63), $IND_{k=capital,j=govrnment,z,t}$ in item (c) of the model closure, $sh0_{z,t}$ in (15), $ttdh0_{z,t}$ in (17), and $RG_{z,t}$ in (31).

Similar to PEP-w-t, the model can be solved so the value of the GDP of each country/region align with the GDP projections of the World Bank. This is done by setting ($gr_{z,t}^{GDP}$) equal to the

World Bank projections and solving for a multifactor productivity factor ($A_{z,t}^{VA}$) for each country/region over the simulation period (from *t=1 to TT*). The solution of the model using these values of ($A_{z,t}^{VA}$) will generate the GDP growth projections of the World Bank.

Elasticity of Substitution

(a) Between Domestic Products and Imports, and Among Imports of Origin

The elasticity of substitution between domestically produced commodities and imports (in the first nest in the CES structure in (41), (42), and (43)) is

(81) $\sigma 1_{m,z} = \sum_i sh_{i,m,z}^{Q} \, ESUBD_i$

where ($ESUBD_i$) is the elasticity parameter in the GTAP model, and ($sh_{i,m,z}^{Q}$) is share of sector *i* in the base aggregate composite commodities ($\sum_m Q_{m,z}^{0}$) in each country/region. The value of the elasticity of substitution among imports from the different trading partners (in the second nest in the CES structure in (44) and (45)) is $\sigma 2_{m,z} = 2 * \sigma 1_{m,z}$.

(b) Between Factors of Production

The elasticity of substitution between the composite labor and composite capital (the first nest in the CES structure in (3), (4), and (5)) is

(82) $\sigma_{VA,j,z} = \sum_j sh_{j,z}^{VA} \, ESUBVA_j$

where ($ESUBVA_i$) is the elasticity parameter in the GTAP model, and ($sh_{j,z}^{VA}$) is share of sector *j* in the base aggregate value added ($\sum_j VA_{j,z}^{0}$) in each country/region. The value of the elasticity of substitution between the two types of labor (the second nest in the CES structure in (6) and (7)) is $\sigma_{LD,j,z} = 2 * \sigma_{VA,j,z}$. Similarly, the value of the elasticity of substitution between the two types of capital (the second nest in the CES structure in (8) and (9)) is $\sigma_{KD,j,z} = 2 * \sigma_{VA,j,z}$.

(c) Between Domestic Market and Exports, and Among Export Destination

The elasticity of transformation in the first nest of the CET structure i(34), (35), and (36) is $\sigma 1_{x,z} = 2$, while in the second nest in (38), and (39) is $\sigma 2_{x,z} = 3$.

Appendix B: Welfare Measure

The welfare measure used in the analysis is equivalent variation (EV). The global model used in the analysis utilizes a LES system whose demand functions are given in (29). Robichaud (2001) has shown that the EV corresponding to a demand system which is LES may be written as

(83) $$EV_{z,t} = \prod_i \left(\frac{PC^B_{i,z,t}}{PC^S_{i,z,t}}\right)^{gamma\_LES_{i,z}} \left(CTH^S_{z,t} - \sum_i CMIN^B_{i,z,t}\, PC^S_{i,z,t}\right) - \left(CTH^B_{z,t} - \sum_i CMIN^B_{i,z,t}\, PC^B_{i,z,t}\right)$$

where the superscript *B* refers to the baseline solution, while *S* to the simulation solution.