Potential Effects of the Regional Comprehensive Economic Partnership (RCEP) on the Philippine Economy*

Submitted to the Philippine Institute for Development Studies

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October 6, 2015

Keywords: RCEP, ASEAN, Regional trade, Philippines, Global CGE

JEL Classification: C68, D58, F15

* Research funding provided by the Philippine Institute for Development Studies.

Abstract

Using a global CGE model, the paper analyzes the potential effects of RCEP on the Philippine economy. The analysis involves an 80-percent reduction in tariffs and 10 percent in non-tariff barriers within RCEP member countries over a 10-year period. The results indicate trade creation within RCEP. Exports of RCEP to non-member decline. Within RCEP, the improvement in exports of the 6 non-ASEAN members are relatively higher than ASEAN countries. Vietnam benefits the most among ASEAN countries. Exports of the rest of ASEAN increase as well, including the Philippines. The entry of cheaper rice in the Philippines benefits lower income households. The entry of cheaper textiles benefits the garments industry. On the whole, Philippine GDP improves by 3 percent and welfare by US$2 billion. Philippine Poverty declines from 24.9 percent to 23.3 percent.

Summary

The objective of the paper is to assess the potential effects of the reduction in trade barriers within RCEP on the Philippine economy using a global CGE model. The results indicate that RCEP exports within the area increase while exports to countries outside the region decline. Exports of non-RCEP countries exports to RCEP decline. With the area, the improvement in exports of 6 non-ASEAN RCEP members is higher than the increase in ASEAN exports.

The effects vary within ASEAN. Indonesia benefits the most in terms of higher exports within RCEP, but its exports to the rest of the world decline. Vietnam benefits both in terms of higher exports within RCEP and exports to the rest of the world. Although Cambodia benefits from higher exports within RCEP, this is offset by the reduction in its exports to the rest of the world. The net export effects in Malaysia and Thailand are smaller because of negative exports to the rest of the world. Philippine exports within RCEP improve. Initially, its exports to the rest of the world decline, but they recover over time.

The export effects of the 6 non-ASEAN RCEP vary as well. Japan benefits the most in terms of higher exports within RCEP. There are also notable improvements in exports of China, Australia, and New Zealand within RCEP. India benefits from higher exports within RCEP and as well as exports to the rest of the world.

In the Philippines, the entry of cheaper imported rice negatively affects domestic rice production, but benefits lower income households since rice is a major item in their food basket. The inflow of cheaper textile imports leads to lower textile production, but benefits the wearing apparel sector. The construction sector benefits from higher inflows of foreign investments. Output of transportation and machinery equipment sector improves along with the increase in the construction sector. There are notable positive output effects in the service sectors, particularly in the transportation sector which benefits from the improvement in agriculture and manufacturing. The returns to land and wages improve while the returns to capital decline. These effects are progressive in the sense that they favor lower income household groups. The effects decrease the poverty incidence in 10 years from 24.9 percent at present to 23.3 percent 2023. In addition, the effects lower the GINI coefficient, indicating favorable distributional effects. As a result of RCEP, Philippine real GDP is higher by 3 percent and welfare by US$2 billion in 2023.

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1. Introduction

The Regional Comprehensive Economic Partnership (RECP) is a free trade area (FTA) consisting of 10 members of the Association of South East Asian Nations, ASEAN (Brunei, Indonesia, Cambodia, Lao PDR, Myanmar, Malaysia, Philippines, Singapore, Thailand and Vietnam) and 6 non-ASEAN countries in Asia and Oceania (Australia, China, Japan, South Korea, New Zealand, and India). The economies covered in RCEP have a total gross domestic product (GDP) of $21 trillion in 2013, and a population of 3.4 billion. RCEP includes two of the world's largest nations (China and India), and the second and the third largest economies, China and Japan (Table 1). Within RCEP, ASEAN has combined GDP of US$2.6 trillion and a population of 622 million, while the 6 non-ASEAN countries ("+6" from here on) have a population of 2.8 billion and a total GDP of US$19 trillion.

Several rounds of negotiations, based on ASEAN's centrality, have taken place since its initial launch during the East Asia Summit in November 2012, and more negotiations are expected in the years ahead before its conclusion. The overriding goals of the on-going negotiations include:

(a) To "achieve a model, comprehensive, high-quality and mutually beneficial economic partnership agreement establishing an open trade and investment environment in the region to facilitate the expansion of regional trade and investment and contribute to global economic growth and development; and

(b) To boost economic growth and equitable economic development, advance economic cooperation and broaden and deepen integration in the region through the RCEP, which will build upon existing linkages"[2].

[2] http://www.asean.org/news/asean-statement-communiques/item/regional-comprehensive-economic-partnership-rcep-joint-statement-the-first-meeting-of-trade-negotiating-committee

Table 1. RCEP Countries: Population and Gross Domestic Product

	2013 Population, million	2013 GDP, US$ billion*
ASEAN		
Brunei	0.4	16.1
Cambodia	15.0	15.2
Indonesia	248.8	868.3
Lao	6.7	10.6
Malaysia	29.9	312.4
Myanmar	61.6	80.7
Philippines	97.4	272.1
Singapore	5.4	297.9
Thailand	66.8	416.1
Vietnam	89.7	171.2
Total ASEAN	621.8	2,460.7
"+6"		
Australia	23.1	1,468.5
New Zealand	4.5	185.8
Japan	127.3	4,898.1
S. Korea	50.2	1,304.6
China	1,360.7	9,181.2
India	1,228.8	1,798.6
Total "+6"	2,794.7	18,836.8
Overall total (ASEAN and "+ 6")	3,416.4	21,297.5

Source: ADB Economic Indicators

*Local currency converted to US$ using average US$ rate; 2012 for Myanmar

The negotiations in RCEP have several components which include: (i) trade in goods wherein tariffs and non-tariff barriers are eliminated within RCEP; (ii) trade in services wherein possible and existing restrictions and discriminatory measures that restrict trade in services within RCEP are eliminated; (iii) facilitate the flow of investment within RCEP; (iv) economic and technical cooperation; (v) protection and enforcement of intellectual property rights; (vi) competition promotion; and (vii) establishment of dispute settlement mechanism[3].

The Philippines is one of the founding members and a key economy in ASEAN. If concluded, RCEP will have an impact on the Philippine economy because Japan, China, and South

[3] http://www10.iadb.org/intal/intalcdi/PE/CM%202013/11581.pdf

Korea are key markets for Philippine exports and major sources of imports (Table 2). The Philippines is an open economy with merchandize exports representing 21.1 percent and merchandize imports 24.1 percent of GDP. 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).

Table 2. Philippine Trade with Partners

	Exports, 2010-2013			Imports, 2010-2013	
Countries	Average, US $mil.	Average Share,%	Countries	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

In addition, Japan is a major source of foreign direct investments in the Philippines. In 2009-2013, the total inflow of Japanese investment into the Philippines amounted to US$1.8 billion, representing 41 percent of the total inflows during the period (Table 3).

Table 3. 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: Bangko Sentral ng Pilipinas

The objective of this paper is to estimate the potential trade impact of RCEP at the regional level as well as at the individual member countries using a global computable general equilibrium (CGE) model. The paper will present estimates of the potential creation trade effects within RCEP as well as the trade diversion effects in countries outside the area.

There are two mega-FTAs in Asia and the Pacific: the Trans-Pacific Partnership (TPP) and RCEP. TPP is far advanced that RCEP. In February 2016, the TPP proposal was finalized and signed. The agreement is now being discussed in the respective congress/parliament of each the member countries. The Philippines is not in the 12-country TPP, but the government is currently performing due diligence to assess the potential benefits and the domestic policy adjustments required should it decides to join in the coming years. Cororaton and Orden (2014) used a global

CGE model to estimate the potential effects on the Philippines if decides to participate in the TPP. Their results indicate that the trade diversion effects on the Philippines of non-participation are small, but the trade creation effects of participation may be notable.

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.

In addition, the paper will calculate the potential effects on the Philippine economy, particularly on sectoral production, factor and commodity prices, GDP, welfare, household incomes, poverty and income distribution. The poverty and income distribution effects are estimated separately using a poverty microsimulation model that is calibrated to the 2012 Philippine Family Income and Expenditure Survey (FIES).

The analysis in the paper focuses on the effects of a reduction in tariffs and non-tariff barriers (NTBs) within RCEP. The tariff data used in the analysis was calculated from the GTAP 8 database. There are no official information on NTBs. In the paper the average ad valorem tariff

equivalent (AVE) of NTBs in RCEP was estimated econometrically using a gravity-border effect model, also using GTAP 8 database.

The paper is organized in 5 sections. After an introduction in this section, Section 2 discusses briefly the global CGE and the poverty microsimulation models used in the analysis, the framework used in the estimation of NTBs, and the dataset used. Section 3 defines two simulations: (i) a baseline scenario, and (ii) a scenario involving a reduction in trade barriers (tariffs and NTBs) in RCEP. Section 4 presents the simulation results on regional and country trade creation and diversion effects, and on the potential effects in the Philippine economy. The paper ends in Section 5 with a summary of results and some insights for policy.

In addition, the paper includes 3 appendices. Appendix A presents the sectoral and country mapping in the global CGE model with the GTAP 8 database. Appendix B presents the detailed specification of the global CGE model. Appendix C discusses the poverty microsimulation model.

2. Framework of Analysis

This section discusses the GTAP 8 database, the specification of the global CGE model and the poverty microsimulation. The gravity-border effect method used in estimating the average AVE of NTBs in RCEP is presented in this section, as well as the average applied tariff rates computed from the GTAP 8 database. In addition, the performance of the Philippines in attracting foreign investments relative to its neighbors is presented.

Data Aggregation. The GTAP 8 database consists of 57 commodities in 129 countries and regions. The database was aggregated in the analysis to 24 commodities in 20 countries and regions. The database includes two types of labor (skilled and unskilled), capital, land, and natural resources. The 24 commodity sectors reflect the disaggregation of important sectors in RCEP as

well as in the Philippine economy. Critical agricultural commodities which have high trade barriers such as rice, other cereals, meat and dairy have separate accounts in the model. The manufacturing sector was also appropriately disaggregated. The model has separate accounts for textile and wearing apparel and electronic equipment sectors, which are important sectors in the regions. The service sectors was also disaggregated.

In the model, RCEP region includes 8 ASEAN and 6 non-ASEAN countries[4]. In addition, the other main geographic regions in the model are the other East Asian countries, North American Free Trade Agreement (NAFTA), European Union 25 (EU25), Latin America (excluding Mexico), Africa and a remaining Rest of the World.

Structure of the Global CGE Model. The detailed specification of the model is given in Appendix B. The important features of the model include (Robichaud, et al., 2011): (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.

[4] Brunei and Myanmar are not in the model because these countries do not have data in the GTAP 8 database.

Production. Specifically, the production sector of the model has a three-level structure. At the first level, sectoral output is produced using value added and aggregate intermediate consumption using a set of fixed coefficients. At the second level, the aggregate intermediate consumption is broken down into intermediate demand for goods and services using another set of fixed coefficients. Also at the second level, sectoral value added is specified as a constant elasticity of substitution (CES) function of composite capital and composite labor. At the third level, composite labor is specified as a CES function of two types of labor (skilled and unskilled). Also at the third level, composite capital is specified as a CES function of three types of capital: physical capital, land, and natural resources.

Household. There is only one household in each country/region in the model. This household earns income from earnings from the two types of labor and the two types of capital. It pays income tax. Household savings is a linear function of disposable income. Household demand for goods and service is specified as a linear expenditure system (LES).

Government. In each country/region, the government earns revenue from income taxes, indirect taxes on commodities, taxes on the use of capital and labor in each sector, import tariffs, export taxes, and production taxes. Government savings is determined as the difference between total government revenue and total government expenditure. Total government expenditure is distributed among commodities using a set of fixed shares. For a given amount of government expenditure budget, the quantity demanded for each commodity varies inversely with the price of the commodity.

Investment. In the model, investment expenditure (gross fixed capital formation, GFCF) in each country/region is constrained by the savings-investment equilibrium. GFCF is distributed among commodities using a set of fixed shares. For a given amount of investment expenditure,

the quantity demanded for each commodity for investment purposes varies inversely with the price of the commodity.

Exports. The producer allocates output to three market outlets in order to maximize sales revenue for a given set of prices in these market outlets. These outlets are: domestic market, export market, and international transport margin services. Imperfect substitutability is assumed among products sold in these outlets by means of a CET aggregator function. Sales revenue maximization will result in a supply function in each of the outlets: supply to the domestic market, supply to the export market, and supply to the international transport margin services.

Export of each commodity is further disaggregated using another CET function to the various export destinations. This specification implies imperfect substitutability among exports to these destinations. The producer maximizes export revenue for a given set of export prices. This will result in a supply function of each commodity in each export destination.

Domestic Demand. The goods and services available in the domestic market consist of those that are domestically produced and imports. In the model, domestically produced and imported goods are imperfect substitutes and are differentiated by prices. This product differentiation is through a CES function. Prices of domestically produced goods include indirect taxes, while prices of imported goods include import tariffs, international transport margins, and indirect taxes. Cost minimization will result in demand functions for domestically produced goods and imports.

Imports. Imports of each commodity are further disaggregated using another CES function to the various sources of imports or import origin, which also implies product differentiation among imports from the various origins. Cost minimization will result in demand functions for imports in each of the import origins.

External Account. In the GTAP 8 database, information is available on the amount of trade margin in each sector associated with each bilateral trade flows between countries/regions. However, there is no information available matching the producers of the international transport margin services to the individual bilateral trade flows. Therefore, disaggregating the international transport margin services similar to the breaking down of exports of goods and services to the various export destinations may not be possible as there is no information available in the GTAP 8 database needed to calibrate this part. Thus in the model, the supply of international transport margin services in each country/region is pooled in "external account (EA)," and its production is shared among suppliers in each country/region through a competitive process. Furthermore, this EA vis-à-vis each country/region includes payments for the value of the country's/region's imports including international transport margins. The expenditure in the EA consists of the value of exports, including international margins. The difference between revenue and expenditure in the EA is foreign savings. The negative of foreign savings is the current account balance of each country/region.

Prices and Mark-Ups. The model has a system of prices that reflects the cost of production plus a series of mark-ups which consists of layers of taxes and international transport margins. The model has a unique price vector that clears the market for goods and services and the market for factors of production.

Model Closure. The details of the model closure is given in Appendix A. Some of its features include fixing the following variables: nominal exchange rate, real government expenditure, government investment demand, supply of factors of production in each period, and current account balance. The numeraire of the model is the GDP deflator of a reference country/region.

Model Dynamics. The model is dynamic-recursive. The model links one period to the next using two types of equations. One equation updates exogenous variables that increase from one period to the next. For example, labor is updated using the population projections of the United Nations. Another equation controls the accumulation of capital in each country/region using a rule that determines the sectoral capital stock in the succeeding period using information on the sectoral capital stock in the preceding period, the volume of new sectoral capital investment, and the sectoral depreciation rate. The new sectoral capital comes on-line one period after the new sectoral capital investment has been made. The sectoral capital stock is updated using a sectoral capital investment function similar to Tobin's q where sectoral capital investment is a function of the ratio of the rental rate of capital and the user cost of capital in each sector. The user cost is the sum of interest rate and the sectoral depreciation rate.

Poverty Microsimulation. The global CGE model generates sectoral volume and price effects on exports, imports, output, and consumption at the country level. It also generates country level results on sectoral employment, as well as on factor prices: wages of skilled and unskilled labor, and returns to capital and land. Country GDP results are also generated, while equivalent variation as a measure of welfare are computed. However, there is only one aggregated household in each country in the model. Poverty analysis however requires results on disaggregated households, in particular results on household income at various groups and consumer prices at the respective groups. The poverty analysis also requires movements of skilled and unskilled labor across agriculture and non-agriculture.

Cororaton (2013) has constructed a social accounting matrix (SAM) of the Philippine economy for 2012. The SAM consists of 241 sectors, 10 household groups (decile), for factors (skilled labor, unskilled labor, capital and land). In the analysis, the original SAM was aggregated

to 24 commodity sectors similar to the commodity aggregation in the global CGE model. The sources of factor income of the 10 household groups in the Philippine SAM is similar to the sources of household income in the global CGE, which are income from skilled and unskilled labor, land and capital. Furthermore, each of the 10 household groups in the Philippine SAM has expenditure shares across the 24 commodities.

Changes in factor prices generated from the global CGE model together the factor income of household groups in the Philippine SAM can be used to disaggregate the changes in household incomes across the 10 household groups in the Philippines. Changes in the Armington sectoral composite prices generated from the global CGE model can be applied to the 24-commodity expenditure shares of each of the 10 household groups in the Philippine SAM to compute the changes in consumer prices facing each group. These changes in household income, consumer prices and movement of labor across sectors are applied to a randomized poverty microsimulation process using data in the 2012 FIES to compute the potential impact of RCEP on Philippine poverty and income distribution.

There are several approaches to linking CGE models with data in the household survey to analyze poverty issues. One approach is a top-down method where the results of CGE models with representative households are applied recursively to data in the household survey with no further feedback effects. Within the top-down method there are wide variations. A popular one is to assume a lognormal distribution of income within household category where the variance is estimated from data in the survey (De Janvry, et al 1991). In this method, the change in income of the representative household generated in the CGE model is used to estimate the change in the average income for each household category, while the variance of this income is assumed fixed. Decaluwé et al (2000) argue that a beta distribution is preferable to other distributions such as the

lognormal because it can be skewed left or right and thus may better represent the types of intra-category income distributions commonly observed. Instead of using an assumed distribution, Cockburn et al. (2001) apply the actual incomes from a household survey and use the change in income of the representative household generated in the CGE model to each individual household in that category.

There are recent more sophisticated microsimulation methods that link CGE models with household data to analyze poverty issues through the labor market transmission channel. Ganuza et al (2002) introduce a randomized process to simulate the effects of changes in the labor market structure. Random numbers are used to determine key parameters in the labor market such as: (i) which persons at working age change their labor force status; (ii) who will change occupational category; (iii) which employed persons obtain a different level of education; and (iv) how are new mean labor incomes assigned to individuals in the sample. The random process is repeated a number of time in a Monte Carlo fashion to construct 95% confidence intervals for the indices of poverty. The CGE model is used to quantify the effects of a macroeconomic shock on key labor market variables such as wages, employment, etc., and apply them to the microsimulation process. The advantage of this method is that it works through the labor market channel.

The top-down method usually uses CGE models with representative households. One criticism of this approach is that it does not account for the heterogeneity of income sources and consumption patterns of households within each category. Intra-category income variances could be significant part of the total income variance. That is, there is increasing evidence that households within a given category may be affected quite differently according to their asset profiles, location, household composition, education, etc. To address this issue an integrated CGE microsimulation allows full integration of all households in the survey in the CGE model. As

demonstrated by Cockburn (2001) and Cororaton and Cockburn (2007), this poses no particular technical difficulties because it involves constructing a standard CGE model with as many household categories as there are households in the household survey providing the base data.

In this paper we apply a simpler version of the Ganuza et al (2002) method. The idea is to allow a change in employment status after a policy change. Thus, if a household does not earn labor income initially because of unemployment, it will have a chance to gain employment after the policy shock. Similarly, if it earns labor income initially, it will have a chance of getting zero labor income after the policy change. Thus, household labor income is affected by changes in wages as well as the chance of getting unemployed after the policy shock. Similar to the Ganuza et al (2002) method we introduce a randomized process to simulate the effects of changes in sectoral employment. This approach has been applied in Cororaton and Corong (2009). Appendix C describes the details of the randomized poverty microsimulation model.

Gravity-Border Effect Estimation of NTBs. Because of the difficultly in estimating *directly* the protection due to NTBs and their effects on international trade, there is a growing literature that uses an *indirect* approach which utilizes the gravity-border effect methodology Some of the papers in this area include Anderson and van Wincoop (2003); Baier and Bergstrand (2006); Befus, Brockmeier, and Bektasoglu (2013); Chang and Hayakawa (2010); Egger, Francois, Manchin, and Nelson (2014); Feenstra, (2002); Olper and Raimondi (2008); and Winchester (2009).

If the allocation of trade across countries is separated from the allocation of production and consumption within countries, Anderson and van Wincoop (2003) argued that a gravity-like structure of trade model can be derived. Assume a constant elasticity of substitution (CES) preferences over goods differentiated by country of origin and transport margin/cost that is proportional to the quantity of trade. The maximization of the CES preference function by a

representative consumer in country *j* subject to his budget constraint which is composed of the product vector of prices and consumption will yield the following demand function for commodity *k* by consumer (country) *j* of goods produced in country *i*.

(1) $$x_{ij}^k = \frac{C_j^k Y_i^k}{Y^k}\left(\frac{t_{ij}^k}{P_j^k \Pi_i^k}\right)^{1-\sigma_j^k}$$

where

(2) $$\left(\Pi_i^k\right)^{1-\sigma_j^k} k = \sum_j \left(\frac{t_{ij}^k}{P_j^k}\right)^{1-\sigma_j^k} \frac{C_j^k}{Y^k}$$

and

(3) $$\left(P_j^k\right)^{1-\sigma_j^k} = \sum_i \left(\frac{t_{ij}^k}{\Pi_i^k}\right)^{1-\sigma_j^k} \frac{Y_i^k}{Y^k}$$

x_{ij}^k represents exports from *i* to *j* of commodity *k*; Y^kworld output commodity of *k*; Y_i^k (C_j^k) exporter (importer) output (consumption) of *k*; Π_i^k and P_j^k inward and outward price indices respectively which capture multilateral resistance factors that are affected by bilateral resistance terms t_{ij}^k (or the trade barrier factor); σ^k substitution elasticity between domestically produced goods and imports of commodity *k* of the importing country *j*, or the CES elasticity in the preference function of the representative consumer in country *j*.

The trade barrier factor can be separated into transport cost, d_{ij}, and border component b_{ij} and can be expressed in log-linear form

(4) $$t_{ij} = d_{ij}^{\rho} b_{ij}^{\delta_{ij}}$$

where d_{ij}^{ρ} is the between economic centers of *i* and *j*, and ρ is a parameter. The parameter δ_{ij} is equal to zero if *i* and *j* are in the same country (i.e. intra-country trade) and is equal to 1 if they are separate countries (cross-border or international trade). Substitute (4) into (1) and then express the

equation in log-linear form. This will result in the following estimable equation (omitting the constant and the superscript *k*)

(5) $$x_{ij} = y_i + c_j + (1-\sigma_j)\rho \ln d_{ij} + (1-\sigma_j) d_{ij} \ln b_{ij} - \ln(\Pi_i)^{\sigma_j - 1} - \ln(P_j)^{\sigma_j - 1}$$

where the lower case variables represent the natural logarithms of their uppercase variables. Equation (5) is a gravity equation. But the main difficulty in estimating (5) is that it involves unobservable multilateral resistance factors, Π_i and P_j. These factors capture the cost of bilateral trade between two countries relative to the average trade cost of country with the rest of its trading partners. Anderson and Van Wincoop (2003) refer these multilateral resistance factors as the substitutability between the country's different trading partners. Traditional gravity equations omit these relative trade costs. The omission leads to misspecification error.

There are three suggested ways of estimating (5): (a) the use of consumer price index to measure the price effects in the gravity equation; (b) the use of non-linear least squares to solve the system of equations involving (1) and (2); and (c) the use of country dummies to capture the multilateral resistance factors. Feenstra (2002) argued that only (b) and (c) approaches lead to consistent estimates. However, approach (b) entails complex computer programming. The use of country dummies in approach (c) is preferable because equation (5) can be estimated using fixed effects. Another advantage of using approach (c) is that the fixed effects estimation will eliminate any other unobservable variables omitted in the trade cost functions in (4). In estimating (5) approach (c) was used.

Equation (5) can further be simplified into the following estimating equation

(6) $$x_{ij} = \beta_0 + \theta_i + \lambda_j + (1-\sigma_j)\rho \ln d_{ij} + \gamma_j \delta_{ij} + (1-\sigma_j)\varepsilon_{ij}$$

where β_0 is the constant term; $\theta_i = y_i - (1-\sigma_j) \ln \Pi_i$ is a fixed effect of the exporting country; $\lambda_j = c_j - (1-\sigma_j) \ln P_j$ a fixed effect of the importing country; and $\varepsilon_{ij}$the error term. Aside from

the fixed effects, the key parameters to be estimated in (6) are the distance coefficient $(1-\sigma_j)\rho$ and border coefficient $\gamma_j = (1-\sigma_j)$. The border coefficient is $[-exp(-\gamma_j)]$, where exp is anti-log. The border coefficient shows how much trade within a country is above the international trade due to cross border measures such as tariffs, NTBs, and all other factors that limit the flow of goods internationally. As shown by Anderson and van Wincoop (2004), the formula of ad valorem (AVE) tariff equivalent of border barriers facing exports from country *i* and country *j* is

$$(7) \qquad t_{ij} = exp\left(\frac{\gamma_j}{\sigma_j}\right) - 1$$

There were two databases used to estimate the gravity equation in (6). Data on country exports, production, consumption, tariffs, and export taxes were from the GTAP 8. Information of the other variables such as distance between major ports of trading countries, and other country-specific geographical variables such as whether trading countries are contiguous or not, whether they share common official language or not were taken from the GeoDist database (Mayer and Zignago, 2011).

The GTAP 8 contains the 2007 data on 57 commodities of 129 countries and regions. The data of 42 countries were used in the regression. These countries include the 8 countries in the ASEAN, the additional 6 countries in the RCEP, 3 countries in the North American Free Trade Agreement (NAFTA), and 25 countries in the European Union. Cororaton (2015) provides the list of countries in the database used in the regression and the mapping of commodities to the GTAP 8 database. Table 4 summarizes the average AVE of NTBs in RCEP.

Table 4. **Estimates of Average AVE of NTBS in RCEP**

	Agri-Food	Crops	Cereals	Sugar	Meat	Dairy-Milk	Manu.	Services
RCEP	11.63	17.15	20.43	17.13	12.02	16.68	2.49	28.31

Source: Author's calculations

Tariff Rates. The 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) and regionally under the various regional trading agreements 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. Table 5 presents the applied tariff rates computed from GTAP 8.

Table 5. Tariff Rates

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
AUS	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.02	0.02	0.08	0.13	0.02	0.03	0.05	0.01	0.03
NZL	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.02	0.02	0.04	0.13	0.01	0.03	0.04	0.01	0.03
JPN	3.14	0.22	0.39	0.84	0.01	0.11	0.04	0.00	0.10	0.06	0.07	0.01	0.00	0.00	0.00	0.02
KOR	0.03	2.18	0.10	0.51	0.61	0.16	0.59	0.03	0.32	0.07	0.10	0.04	0.01	0.04	0.01	0.03
CHN	0.46	0.14	0.40	0.07	0.09	0.07	0.11	0.04	0.10	0.10	0.12	0.23	0.04	0.06	0.02	0.04
IND	0.52	0.82	0.83	0.33	0.60	0.15	0.27	0.12	0.47	0.15	0.14	0.14	0.17	0.13	0.04	0.13
MYS	0.31	0.00	0.00	0.02	0.01	0.01	0.20	0.05	0.16	0.07	0.11	0.03	0.08	0.04	0.00	0.05
PHL	0.40	0.07	0.21	0.02	0.06	0.09	0.06	0.04	0.07	0.07	0.10	0.04	0.03	0.04	0.01	0.05
SGP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VNM	0.16	0.06	0.20	0.13	0.11	0.11	0.10	0.07	0.26	0.20	0.26	0.06	0.03	0.09	0.06	0.09
IDN	0.08	0.02	0.16	0.04	0.02	0.02	0.02	0.03	0.09	0.06	0.10	0.03	0.03	0.04	0.01	0.04
THA	0.10	0.09	0.16	0.14	0.17	0.10	0.13	0.05	0.15	0.08	0.38	0.07	0.03	0.10	0.01	0.22
KHM	0.06	0.04	0.07	0.13	0.06	0.16	0.08	0.08	0.19	0.08	0.20	0.08	0.10	0.14	0.13	0.13
LAO	0.05	0.02	0.04	0.05	0.05	0.13	0.14	0.03	0.23	0.06	0.07	0.07	0.04	0.09	0.06	0.08
EAS	0.02	0.01	0.06	0.04	0.02	0.03	0.04	0.02	0.07	0.03	0.04	0.02	0.01	0.03	0.01	0.01
NAFTA	0.03	0.02	0.16	0.29	0.01	0.02	0.02	0.01	0.03	0.08	0.09	0.01	0.01	0.01	0.00	0.02
EU25	0.14	0.06	0.39	0.19	0.05	0.10	0.04	0.01	0.08	0.05	0.07	0.01	0.01	0.01	0.01	0.02
LTN	0.08	0.04	0.14	0.11	0.08	0.05	0.07	0.05	0.12	0.13	0.14	0.05	0.07	0.09	0.06	0.10
AFR	0.08	0.07	0.16	0.15	0.09	0.09	0.10	0.07	0.15	0.16	0.25	0.07	0.09	0.08	0.05	0.12
ROW	0.14	0.05	0.12	0.11	0.09	0.13	0.07	0.05	0.15	0.08	0.09	0.10	0.04	0.06	0.03	0.06

Source: GTAP 8

AUS	Australia	IDN	Indonesia	S1	Rice	S9	All other food
NZL	New Zealand	THA	Thailand	S2	Wheat and all other cereals	S10	Textile
JPN	Japan	KHM	Cambodia	S3	Sugar	S11	Wearing apparel
KOR	Korea	LAO	Lao Peoples Dem Rep.	S4	Milk	S12	Petroleum and chemical
CHN	China	EAS	Rest of East Asia	S5	Oils fats	S13	Metal products
IND	India	NAFTA	North America Free Trade	S6	Meat	S14	Transport and machinery
MYS	Malaysia	EU25	European Union 25	S7	All other agriculture	S15	Electronic equipment
PHL	Philippines	LTN	Latin America	S8	Mining	S16	All other manufacturing
SGP	Singapore	AFR	Africa				
VNM	Viet Nam	ROW	Rest of the World				

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 in the past couple of decades. 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 Philippine are significantly below the global FDI frontier by about US$30 – 40 billion (Table 6). 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.

Table 6. 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).

3. Definition of Simulation

To analyze the potential effects of the RCEP, a baseline and a reduction in trade barrier in RCEP scenarios were simulated using the global CGE model. The details of the scenarios are:

Baseline. This is also called the business as usual (BaU) scenario. The global CGE was simulated for 10 years (T1 to T10) using the projected GDP growth of the United States Department of Agriculture/Economic Research Service (USDA/ERS) and the population projection of the United Nations. A calibrated (pre-solved) multifactor productivity in each country/region is used to ensure that the model replicates exactly the real GDP used in the baseline.

Reduction in Trade Barriers in RCEP. The trade barriers in RCEP were reduced starting in T1 until T10. RCEP negotiations are still ongoing and no definite agreements have been reached as of October 2015. For this reason, an assumed adjustment is hypothesized in the paper to occur in the following manner. The applied tariffs in RCEP were reduced in the simulation from the current level by 80 percent over the 10-year period (T1 to T10). Tariffs were reduced using a geometric growth formula and no exceptions are provided for special products.

Issues related to NTBs are sometimes contentious, and their negotiations are quiet involved and their resolutions are often times 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 in RCEP were by 10 percent. The NTBs were reduced using a geometric growth formula over the 10-year period (T1 to T10). Both tariffs and NTBs in non-RCEP countries were retained.

Furthermore, this simulation assumes a gradual increase in foreign investment inflows into the Philippine over the 10 year period. The increase in the inflow was calculated using a geometric growth formula. Over this period, the inflows were increased by US$2.5 billion, which is about 50

percent of the total foreign investment in 2009-2013. However, this level is significantly less compared to the amount needed for the Philippines to move towards the FDI frontier in Table 6 estimated by Petri, Plummer, and Zhai (2012).

4. Simulation Results

This section presents the trade creation and trade diversion effects of RCEP at the regional level as well as at the country members. Detailed effects on the Philippine economy is also discussed. To facilitate the analysis, the results are presented as percentage differences from the baseline over the simulation period from T1 to T10. The trade barriers outside of RCEP are retained during the simulation.

Regional and Country Effects. Table 7 summarizes the gains from trade in RCEP and the loss in regions outside RCEP. The total exports in RCEP increases from 0.6 percent relative to the baseline in T1, and improves further over time to 3.3 percent in T10. There are notable trade creation effects within RCEP as indicated by higher exports within the area. Exports within RCEP improve from 1.9 percent relative to the baseline in T1 and to 9.9 percent in T10. There are however diversion of exports as indicated by RCEP's declining exports to the countries outside of the area. RCEP's exports to the rest of the world decline from -0.2 percent in T1 to -1.1 percent in T10.

The results indicate that within RCEP, ASEAN as a whole has relatively smaller positive exports effects compared to "+6". ASEAN's exports within RCEP increase by 1 percent in T1, relatively smaller compared to the export improvement in "+6", which is 2.3 percent. In T10, the increase in ASEAN's exports within the area is 5.4 percent, which is lower than the 12.3 percent

improvement in "+6". The total exports of countries outside RCEP decline, largely due to the declining exports to RCEP.

Table 7. Regional Effects, % change from Baseline

	Initial	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
RCEP											
Total Exports	0.00	0.60	1.11	1.57	1.95	2.28	2.56	2.80	3.00	3.17	3.31
To RCEP	0.00	1.87	3.48	4.83	5.99	6.97	7.80	8.48	9.04	9.51	9.89
To Outside RCEP	0.00	-0.20	-0.37	-0.51	-0.63	-0.74	-0.84	-0.92	-1.00	-1.07	-1.14
ASEAN											
Total Exports	0.00	0.44	0.83	1.16	1.42	1.64	1.81	1.94	2.05	2.14	2.21
To RCEP	0.00	1.03	1.95	2.70	3.34	3.87	4.32	4.69	4.99	5.24	5.44
To Outside RCEP	0.00	-0.20	-0.36	-0.52	-0.69	-0.86	-1.04	-1.21	-1.39	-1.56	-1.73
"+6"											
Total Exports	0.00	0.65	1.20	1.70	2.12	2.49	2.80	3.08	3.32	3.51	3.68
To RCEP	0.00	2.26	4.20	5.86	7.30	8.51	9.55	10.42	11.15	11.76	12.27
To Outside RCEP	0.00	-0.20	-0.37	-0.51	-0.62	-0.71	-0.79	-0.85	-0.91	-0.95	-1.00
Non-RCEP											
Total Exports	0.00	-0.02	-0.04	-0.06	-0.08	-0.09	-0.10	-0.11	-0.12	-0.13	-0.14
To RCEP	0.00	-0.26	-0.51	-0.71	-0.88	-1.03	-1.16	-1.27	-1.37	-1.46	-1.53
To Outside RCEP	0.00	0.02	0.05	0.06	0.08	0.10	0.12	0.14	0.15	0.17	0.18

Source: Author's calculations

The export effects vary significantly across the member countries as indicated in Table 8. Within ASEAN, Indonesia benefits the most in terms of higher exports within RCEP. However, Indonesia's exports to the rest of the world decline. Vietnam benefits both in terms of higher exports within RCEP and exports to the rest of the world. Although Cambodia benefits from higher exports within RCEP, this is offset by the reduction in its exports to the rest of the world. The net export effects in Malaysia and Thailand are smaller because of negative exports to the rest of the world. Philippine exports within RCEP improve. Initially, its exports to the rest of the world decline, but they recover towards T10.

The export effects across "+6" countries vary as well. Japan benefits the most in terms of higher exports within RCEP. There are also notable improvements in exports of China, Australia, and New Zealand within RCEP. India benefits from higher exports within RCEP and as well as exports to the rest of the world.

Table 8. Country-Level Effects, % change from the baseline

	Initial	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
ASEAN											
Philippines											
Total Exports	0.00	-0.16	0.16	0.53	0.87	1.20	1.53	1.84	2.13	2.40	2.65
To RCEP	0.00	0.11	0.63	1.16	1.63	2.07	2.49	2.87	3.21	3.50	3.76
To Outside RCEP	0.00	-0.58	-0.55	-0.44	-0.32	-0.19	-0.02	0.15	0.32	0.50	0.66
Malaysia											
Total Exports	0.00	0.35	0.56	0.69	0.74	0.73	0.68	0.61	0.52	0.42	0.32
To RCEP	0.00	0.92	1.61	2.11	2.48	2.73	2.90	3.00	3.04	3.05	3.04
To Outside RCEP	0.00	-0.20	-0.45	-0.71	-0.99	-1.29	-1.59	-1.89	-2.17	-2.45	-2.71
Singapore											
Total Exports	0.00	0.35	0.66	0.95	1.20	1.43	1.62	1.80	1.97	2.12	2.25
To RCEP	0.00	0.90	1.65	2.29	2.83	3.28	3.66	3.98	4.25	4.48	4.68
To Outside RCEP	0.00	-0.30	-0.53	-0.68	-0.80	-0.90	-0.96	-1.01	-1.05	-1.08	-1.10
Vietnam											
Total Exports	0.00	1.06	1.95	2.66	3.26	3.74	4.10	4.38	4.59	4.75	4.86
To RCEP	0.00	1.65	3.01	4.06	4.94	5.63	6.16	6.59	6.92	7.18	7.38
To Outside RCEP	0.00	0.62	1.16	1.59	1.95	2.23	2.41	2.53	2.58	2.59	2.55
Indonesia											
Total Exports	0.00	0.72	1.35	1.92	2.43	2.88	3.27	3.63	3.95	4.23	4.48
To RCEP	0.00	1.63	3.17	4.48	5.73	6.81	7.79	8.64	9.39	10.04	10.61
To Outside RCEP	0.00	-0.48	-0.97	-1.44	-1.92	-2.36	-2.77	-3.15	-3.50	-3.82	-4.11
Thailand											
Total Exports	0.00	0.51	0.88	1.17	1.37	1.50	1.59	1.63	1.64	1.63	1.59
To RCEP	0.00	1.18	2.10	2.84	3.43	3.89	4.25	4.52	4.72	4.86	4.95
To Outside RCEP	0.00	-0.10	-0.23	-0.38	-0.57	-0.76	-0.97	-1.19	-1.42	-1.65	-1.88
Cambodia											
Total Exports	0.00	0.62	0.94	1.06	1.01	0.83	0.55	0.24	-0.09	-0.42	-0.74
To RCEP	0.00	1.29	2.22	2.97	3.47	3.86	4.13	4.36	4.54	4.68	4.81
To Outside RCEP	0.00	0.52	0.75	0.78	0.64	0.38	0.02	-0.39	-0.81	-1.24	-1.64
Laos											
Total Exports	0.00	0.39	0.74	1.06	1.33	1.57	1.78	1.97	2.13	2.27	2.38
To RCEP	0.00	0.51	0.94	1.32	1.64	1.90	2.13	2.33	2.48	2.61	2.70
To Outside RCEP	0.00	0.23	0.47	0.69	0.91	1.10	1.28	1.45	1.60	1.74	1.88
"+6"											
Australia											
Total Exports	0.00	0.73	1.40	2.01	2.56	3.05	3.49	3.88	4.24	4.56	4.85
To RCEP	0.00	1.55	3.00	4.25	5.42	6.43	7.34	8.13	8.84	9.47	10.02
To Outside RCEP	0.00	-0.48	-0.94	-1.38	-1.80	-2.17	-2.51	-2.84	-3.15	-3.45	-3.73
New Zealand											
Total Exports	0.00	0.48	0.88	1.26	1.59	1.88	2.14	2.39	2.61	2.82	3.01
To RCEP	0.00	1.46	2.70	3.82	4.81	5.64	6.36	7.02	7.61	8.13	8.59
To Outside RCEP	0.00	-0.31	-0.58	-0.84	-1.06	-1.25	-1.42	-1.58	-1.74	-1.88	-2.01
Japan											
Total Exports	0.00	0.88	1.66	2.37	3.02	3.58	4.09	4.58	5.03	5.44	5.82
To RCEP	0.00	3.25	6.12	8.63	10.88	12.79	14.49	15.98	17.27	18.40	19.38

To Outside RCEP	0.00	-0.75	-1.42	-1.99	-2.52	-2.96	-3.34	-3.71	-4.05	-4.35	-4.62
Korea											
Total Exports	0.00	0.60	1.10	1.51	1.85	2.14	2.37	2.58	2.75	2.89	3.02
To RCEP	0.00	1.69	3.12	4.25	5.21	5.97	6.61	7.12	7.54	7.87	8.15
To Outside RCEP	0.00	-0.27	-0.50	-0.68	-0.85	-0.99	-1.11	-1.23	-1.34	-1.45	-1.55
China											
Total Exports	0.00	0.54	0.99	1.40	1.74	2.05	2.29	2.50	2.68	2.82	2.93
To RCEP	0.00	2.00	3.72	5.17	6.43	7.48	8.36	9.10	9.72	10.24	10.68
To Outside RCEP	0.00	0.01	0.00	0.02	0.02	0.03	0.03	0.02	0.01	-0.01	-0.04
India											
Total Exports	0.00	0.52	0.99	1.39	1.74	2.04	2.29	2.51	2.70	2.85	2.99
To RCEP	0.00	1.59	2.94	4.04	4.97	5.72	6.34	6.86	7.29	7.65	7.95
To Outside RCEP	0.00	0.27	0.53	0.76	0.96	1.14	1.30	1.42	1.53	1.61	1.68

Source: Author's calculations

Philippine Effects. Table 9 summarizes the effects of RCEP across Philippine sectors. Rice, which is the most protected sector in the country, is negatively affected by the reduction in trade barriers within RCEP. Rice output declines by 4.3 percent relative to the baseline in T10. Another sector that is negatively affected is the textile sector. However, the inflow of cheaper textile imports benefits the wearing apparel sector. The sector that benefits the most is construction, mainly due to higher inflows of foreign investments. Output of the transportation and machinery equipment sector improves along with the increase in the construction sector. Output of the electronic equipment sector, which produces the country's largest export item, declines initially, but recovers over time. There are notable positive output effects in the service sectors, particularly in the transportation sector which benefits from the improvement in agriculture and manufacturing.

Table 9. Philippine Sectoral Output, % change from baseline

	Initial	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Rice	0.00	-0.91	-1.59	-2.11	-2.63	-3.07	-3.38	-3.67	-3.91	-4.10	-4.26
Wheat and all other cereals	0.00	-0.07	0.05	0.16	0.25	0.31	0.36	0.40	0.43	0.44	0.45
Sugar	0.00	-0.22	-0.11	0.03	0.17	0.31	0.49	0.65	0.81	0.98	1.13
Milk	0.00	-0.24	0.08	0.46	0.82	1.18	1.54	1.89	2.21	2.51	2.79
Oils fats	0.00	-0.42	-0.43	-0.36	-0.28	-0.18	-0.04	0.11	0.27	0.42	0.57
Meat	0.00	0.14	0.39	0.63	0.87	1.12	1.39	1.65	1.92	2.18	2.44
All other agriculture	0.00	0.03	0.32	0.57	0.75	0.91	1.06	1.18	1.27	1.35	1.41
Mining	0.00	-0.23	-0.18	0.05	0.42	0.88	1.45	2.12	2.82	3.55	4.30
All other food	0.00	0.07	0.51	0.93	1.32	1.68	2.02	2.34	2.65	2.92	3.18

Textile	0.00	-0.83	-1.15	-1.35	-1.52	-1.63	-1.65	-1.61	-1.53	-1.41	-1.28
Wearing apparel	0.00	-0.16	0.14	0.49	0.81	1.13	1.45	1.77	2.07	2.37	2.65
Petroleum and chemical prod.	0.00	-0.27	-0.05	0.23	0.50	0.80	1.13	1.49	1.85	2.20	2.55
Metal products	0.00	-0.32	-0.11	0.21	0.59	1.02	1.53	2.09	2.67	3.27	3.87
Transport and Machinery equip.	0.00	0.04	0.65	1.34	2.07	2.85	3.67	4.55	5.43	6.30	7.17
Electronic equipment	0.00	-0.42	-0.36	-0.20	-0.03	0.14	0.33	0.50	0.66	0.80	0.91
All other manufacturing	0.00	-0.33	-0.14	0.13	0.40	0.69	1.01	1.36	1.70	2.03	2.36
Utilities	0.00	-0.01	0.35	0.71	1.07	1.43	1.82	2.21	2.61	3.00	3.38
Construction	0.00	2.13	3.13	3.83	4.71	5.70	6.70	7.76	8.88	10.04	11.21
Trade	0.00	0.04	0.41	0.79	1.17	1.56	1.95	2.34	2.73	3.10	3.46
Transportation	0.00	0.14	0.62	1.08	1.52	1.96	2.40	2.85	3.29	3.72	4.14
Communications	0.00	-0.02	0.36	0.75	1.14	1.53	1.92	2.31	2.70	3.07	3.43
Finance business services	0.00	-0.11	0.22	0.59	0.95	1.32	1.70	2.09	2.48	2.85	3.22
Other services	0.00	0.02	0.52	0.99	1.47	1.92	2.37	2.81	3.24	3.65	4.04
Public administration	0.00	0.01	0.10	0.19	0.27	0.34	0.42	0.50	0.57	0.65	0.72

Source: Author's calculations

Table 10 presents the effects on factor prices. The results indicate higher improvement in the returns to land largely due to the improvement in agricultural output. The improvement in wages and in the returns to capital are higher relative to the returns to land initially in T1, but over time the improvement in the returns to land surpasses the increase in all other factor prices. The returns to capital decline over time. The increase in wages of skilled labor is slightly higher compared to the improvement in wages of unskilled labor.

Table 10. Factor Price Effects, % change from baseline

	Initial	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Skilled wages	0.00	0.88	1.24	1.56	1.91	2.26	2.60	2.94	3.26	3.58	3.88
Unskilled wages	0.00	0.95	1.25	1.54	1.87	2.21	2.54	2.87	3.19	3.50	3.80
Returns to capital	0.00	0.77	0.69	0.55	0.42	0.27	0.08	-0.12	-0.33	-0.53	-0.74
Returns to land	0.00	0.60	1.00	1.50	2.03	2.62	3.27	3.88	4.49	5.10	5.69

Source: Author's calculations

The Philippine macro effects presented in Table 11 are expressed in 2013 prices. The results indicate that RCEP generates higher Philippine real GDP growth of 3 percent in 2023

relative to the baseline. From US$272 billion GDP in 2013, Philippine GDP increases to US$450 billion in 2023 in 2013 prices. RCEP also results in higher Philippine welfare as indicated by positive equivalent variation (EV). Expressed in 2013 prices, the EV is US$2 billion in 2023.

Table 11. Philippine Macro Effects

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Real GDP, % change from baseline	0.00	0.00	0.29	0.61	0.92	1.25	1.59	1.94	2.28	2.62	2.95
Real GDP, US$ billion	272.1	285.8	301.0	317.2	334.2	351.2	369.2	388.1	407.9	428.7	450.1
Equivalent Variation, US$ billion	0.00	0.06	0.18	0.33	0.49	0.67	0.87	1.12	1.39	1.70	2.04

Source: Author's calculations

The positive factor price effects presented in Table 10 translate to higher real household income effects (Table 12). The higher positive effects on the returns to land and labor wages lead to higher increase in real income in the first decile relative to the 10^{th} decile. Thus, despite the reduction in output of the rice sector shown in Table 9, the effects of RCEP are generally progressive in the sense that they favor lower income household groups.

Table 12. Real Household Income Effects in the Philippines, % change from baseline

Households	Initial	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
H1	0.00	0.26	0.73	1.26	1.79	2.34	2.93	3.48	4.05	4.60	5.13
H2	0.00	0.12	0.44	0.84	1.27	1.74	2.28	2.79	3.31	3.83	4.33
H3	0.00	0.13	0.46	0.87	1.31	1.79	2.33	2.84	3.37	3.89	4.40
H4	0.00	0.12	0.45	0.85	1.29	1.76	2.30	2.81	3.33	3.85	4.36
H5	0.00	0.13	0.44	0.85	1.27	1.74	2.26	2.76	3.28	3.79	4.29
H6	0.00	0.12	0.44	0.84	1.26	1.72	2.24	2.74	3.26	3.77	4.27
H7	0.00	0.16	0.48	0.88	1.30	1.76	2.28	2.78	3.29	3.81	4.31
H8	0.00	0.18	0.51	0.90	1.33	1.79	2.31	2.82	3.34	3.86	4.37
H9	0.00	0.16	0.47	0.86	1.27	1.73	2.23	2.73	3.24	3.76	4.27
H10	0.00	0.10	0.41	0.82	1.24	1.70	2.23	2.74	3.27	3.80	4.33

Source: Author's calculations

The progressive effects of RCEP on the Philippines can also be observed from the reduction in the poverty index shown in Table 13. Over the 10 year simulation period, the poverty incidence declines from 24.9 percent to 23.3 percent. Among poor households, those under extreme poverty (P2) benefit the most as indicated by a higher decline in the index. The poverty results also indicate that the reduction in urban poor is relatively higher compared to rural poor. In addition, the GINI coefficient declines, indicating favorable distributional effects.

Table 13. Poverty Effects in the Philippines

		End of simulation period: T10	
	2012 /1/	Index	% change from 2012
Philippines			
P0 /2/	24.85	23.29	-6.26
P1	6.84	6.26	-8.39
P2	2.68	2.42	-9.76
Urban			
P0	11.57	10.77	-6.94
P1	2.79	2.51	-10.01
P2	0.99	0.88	-11.40
Rural			
P0	35.58	33.42	-6.09
P1	10.10	9.29	-8.03
P2	4.04	3.66	-9.44
GINI Coefficient	0.4713	0.4709	-0.080

Source: 2012 FIES and author's calculations
/1/ FIES
/2/ P0 - poverty incidence; P1 - poverty gap; P2 - poverty severity

5. Policy Insights

Significant progress has been achieved over the past three decades in reducing tariffs on international trade under the World Trade Organization (WTO) and subsequently in the context of regional and bilateral preferential trade agreements. However, there are still several agricultural products that are protected by high tariffs and NTBs. Rice, cereals, sugar, and milk are still

protected by high trade barriers. One of the major goals of RCEP is the elimination of trade barriers (tariff and NTBs).

The objective of the paper is to assess the potential effects of the reduction in trade barriers in RCEP using a global CGE model. The simulation results indicate that RCEP exports within the area increase while exports to countries outside the region decline. Exports of non-RCEP countries exports to RCEP decline.

ASEAN exports within RCEP improve, but the increase is less than the improvement of exports the other 6 non-ASEAN RCEP members. Within ASEAN, the effects vary. Indonesia benefits the most in terms of higher exports within RCEP, but its exports to the rest of the world decline. Vietnam benefits both in terms of higher exports within RCEP and exports to the rest of the world. Although Cambodia benefits from higher exports within RCEP, this is offset by the reduction in its exports to the rest of the world. The net export effects in Malaysia and Thailand are smaller because of negative exports to the rest of the world. Philippine exports within RCEP improve. Initially, its exports to the rest of the world decline, but they recover over time.

The export effects across "+6" countries vary as well. Japan benefits the most in terms of higher exports within RCEP. There are also notable improvements in exports of China, Australia, and New Zealand within RCEP. India benefits from higher exports within RCEP and as well as exports to the rest of the world.

The paper also looks in detail the impact on the Philippine economy. The production of rice, which is the most protected sector in the economy, declines as imported rice with lower prices enter the market. This would greatly benefit lower income households since rice is a major item in their food basket. The inflow of cheaper textile imports leads to lower textile production, but this benefits the wearing apparel sector. The construction sector benefits from higher inflows of foreign

investments. Output of the transportation and machinery equipment sector improves along with the increase in the construction sector. There are notable positive output effects in the service sectors, particularly in the transportation sector which benefits from the improvement in agriculture and manufacturing.

The returns to land and as well as wages improve while the returns to capital decline. These effects are progressive in the sense that they favor lower income household groups. The effects decrease the poverty incidence in 10 years from 24.9 percent at present to 23.3 percent in 2023. In addition, the effects lower the GINI coefficient, indicating favorable distributional effects.

Philippine real GDP is higher by 3 percent as a result of RCEP. RCEP also generates additional Philippine welfare of US$2 billion in 2023.

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Appendix A: 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 24 sectors in 20 countries/regions and used to calibrate the global CGE model. Table 14 presents the mapping of the 24 sectors in the model to 57 sectors the GTAP 8, while Table 15 the mapping of the 20 countries/regions to the 129 countries/regions in the database. The model specifies each individual countries in the RCEP except for Brunei and Myanmar which are not in the GTAP 8 database.

Table 14. Mapping of Global CGE Sectors to GTAP 8 Database Sectors

Global CGE model		GTAP 8 Database Sectors		
Sector no.	Description	Sector no.	Code	Description
1	Rice	1	pdr	Paddy rice
		24	pcr	Processed rice
2	Wheat	2	wht	Wheat
3	Sugar	25	sgr	Sugar
		6	c_b	Sugar cane-sugar beet
4	Milk/Dairy	11	rmk	Raw milk
		23	mil	Dairy products
5	Oils/Fats	5	osd	Oil seeds
		22	vol	Vegetable oils-fats
6	Meat	9	ctl	Cattle-sheep-goats-horses
		10	oap	Animal products nec
		20	cmt	Meat-cattle-sheep-goats-horse
		21	omt	Meat products nec
7	Other Agriculture	3	gro	Cereal grains nec
		4	v_f	Vegetables-fruit-nuts
		7	pfb	Plant-based fibers
		8	ocr	Crops nec
		12	wol	Wool-silk-worm cocoons
		13	frs	Forestry
		14	fsh	Fishing
8	Other Food	26	ofd	Food products nec
		27	b_t	Beverages-tobacco products
9	Mining/Minerals	18	omn	Minerals nec
		19	nmm	Mineral products nec

10	Textile	28	tex	Textiles
11	Wearing apparel	29	wap	Wearing apparel
12	Oil/Petroleum/Coal/Chem.	30	p_c	Petroleum-coal products
		15	coa	Coal
		16	oil	Oil
		17	gas	Gas
		31	crp	Chemical-rubber-plastic prods
13	Metals	32	i_s	Ferrous metals
		33	nfm	Metals nec
		34	fmp	Metal products
14	Transport/Machinery Equip.	35	mvh	Motor vehicles-parts
		36	otn	Transport equipment nec
		37	ome	Machinery-equipment nec
15	Electronics	38	ele	Electronic equipment
16	Other Manufacturing	39	lea	Leather products
		40	lum	Wood products
		41	ppp	Paper products-publishing
		42	omf	Manufactures nec
17	Utilities	43	ely	Electricity
		44	gdt	Gas manufacture-distribution
		45	wtr	Water
18	Construction	46	cns	Construction
19	Trade	47	trd	Trade
20	Transport Services	48	otp	Transport nec
		49	wtp	Sea transport
		50	atp	Air transport
21	Communications	51	cmn	Communication
22	Finance/Business Services	52	ofi	Financial services nec
		53	isr	Insurance
		54	obs	Business services nec
23	Other services	55	ros	Recreation-other services
		56	dwe	Dwellings
24	Public Administration	57	osg	PubAdmin-Defense-Health-Educ.

Table 15. Mapping of Global CGE Countries/Regions to GTAP 8 Countries/Regions

Global CGE			GTAP 8 Database Countries/Regions	
No.	Code	Description	Code	Description
1	1MYS	Malaysia	MYS	Malaysia
2	1PHL	Philippines	PHL	Philippines
3	1SGP	Singapore	SGP	Singapore
4	1VNM	Viet Nam	VNM	Viet Nam
5	1IDN	Indonesia	IDN	Indonesia
6	1THA	Thailand	THA	Thailand
7	1KHM	Cambodia	KHM	Cambodia
8	1LAO	Lao Peoples Dem. Rep	LAO	Lao Peoples Dem. Rep
9	1AUS	Australia	AUS	Australia
10	1NZL	New Zealand	NZL	New Zealand
11	1JPN	Japan	JPN	Japan
12	1KOR	Korea	KOR	Korea
13	1CHN	China	CHN	China
14	1IND	India	IND	India
15	1NFTA	NAFTA	CAN	Canada
			USA	United States of America
			MEX	Mexico
16	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
			NLD	Netherlands
			POL	Poland
			PRT	Portugal
			SVK	Slovakia
			SVN	Slovenia

			ESP	Spain
			SWE	Sweden
			GBR	United Kingdom
17	1LTN	Latin America	ARG	Argentina
			BOL	Bolivia
			BRA	Brazil
			CHL	Chile
			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
			1PER	Peru
			SLV	El Salvador
			XCA	Rest of Central America
			XCB	Caribbean
18	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
19	1EAS	East Asia	HKG	Hong Kong
			MNG	Mongolia
			TWN	Taiwan
			XEA	Rest of East Asia
20	1ROW	Rest of the World	XOC	Rest of Oceania
			XSE	Rest of Southeast Asia
			BGD	Bangladesh
			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

Appendix B: Specification of a Global CGE Model

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 ($XS_{j,z,t}$)

(B1) $VA_{j,z,t} = v_{j,z} XS_{j,z,t}$

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

Sectoral intermediate consumption is also a fixed proportion of sectoral output

(B2) $CI_{j,z,t} = io_{j,z} XS_{j,z,t}$

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

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: 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

(B3) $$LDC_{j,z,t} = \beta_{LDC,j,z}^{\sigma_{VA,j,z}} \left(\delta_{LDC,j,z}\alpha_{VA,j,z}\right)^{\sigma_{VA,j,z}-1} \left(\frac{PVA_{j,z,t}}{WC_{j,z,t}}\right)^{\sigma_{VA,j,z}} VA_{j,z,t}$$

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

(B4) $$KDC_{j,z,t} = \beta_{KDC,j,z}^{\sigma_{VA,j,z}} \left(\delta_{KDC,j,z}\alpha_{VA,j,z}\right)^{\sigma_{VA,j,z}-1} \left(\frac{PVA_{j,z,t}}{RC_{j,z,t}}\right)^{\sigma_{VA,j,z}} VA_{j,z,t}$$

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

(B5) $$PVA_{j,z,t} = \left(\frac{1}{\alpha_{VA,j,z}}\right)\left(\beta_{LDC,j,z}\left(\frac{WC_{j,z,t}}{\delta_{LDC,j,z}}\right)^{1-\sigma_{VA,j,z}} + \beta_{KDC,j,z}\left(\frac{RC_{j,z,t}}{\delta_{KDC,j,z}}\right)^{1-\sigma_{VA,j,z}}\right)^{\frac{1}{1-\sigma_{VA,j,z}}}$$

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

(B6) $$LD_{l,j,z,t} = \beta_{l,j,z}^{\sigma_{LD,j,z}} \left(\delta_{l,j,z}\alpha_{LD,j,z}\right)^{\sigma_{LD,j,z}-1} \left(\frac{WC_{j,z,t}}{WTI_{l,j,z,t}}\right)^{\sigma_{LD,j,z}} LDC_{j,z,t}$$

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

(B7) $$WC_{j,z,t} = \left(\frac{1}{\alpha_{LD,j,z}}\right)\left(\sum_l \beta_{l,j,z} \left(\frac{WTI_{l,j,z,t}}{\delta_{l,j,z}}\right)^{1-\sigma_{LD,j,z}}\right)^{\frac{1}{1-\sigma_{LD,j,z}}}$$

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

(B8) $$KD_{k,j,z,t} = \beta_{k,j,z}^{\sigma_{KD,j,z}} \left(\delta_{k,j,z}\alpha_{KD,j,z}\right)^{\sigma_{KD,j,z}-1} \left(\frac{RC_{j,z,t}}{RTI_{k,j,z,t}}\right)^{\sigma_{KD,z}} KDC_{j,z,t}$$

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

(B9) $$RC_{j,z,t} = \left(\frac{1}{\alpha_{KD,j,z}}\right)\left(\sum_k \beta_{k,j,z} \left(\frac{RTI_{k,j,z,t}}{\delta_{k,j,z}}\right)^{1-\sigma_{KD,j,z}}\right)^{\frac{1}{1-\sigma_{KD,j,z}}}$$

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 ($YHK_{z,t}$).

(B10) $YH_{z,t} = YHL_{z,t} + YHK_{z,t}$

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,

(B11) $YHL_{z,t} = \sum_{l,j} W_{l,z,t} LD_{l,j,z,t}$

(B12) $YHK_{z,t} = \sum_{k,j} R_{k,j,z,t} KD_{k,j,z,t} - Dep_{z,t}$

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

(B13) $YDH_{z,t} = YH_{z,t} - TDH_{z,t}$

(B14) $CTH_{z,t} = YDH_{z,t} - SH_{z,t}$

(B15) $SH_{z,t} = PIXCON_{z,t}^{\eta} sh0_{z,t} + sh1_z YDH_{z,t}$

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 ($TPRCT_{z,t}$).

(B16) $YG_{z,t} = TDH_{z,t} + TPRODN_{z,t} + TPRCT_{z,t}$

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

(B17) $TDH_{z,t} = PIXCON_{z,t}^{\eta} ttdh0_{z,t} + ttdh0_{z,t} YH_{z,t}$

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 ($TIPT_{z,t}$).

(B18) $TPRODN_{z,t} = TIWT_{z,t} + TIKT_{z,t} + TIPT_{z,t}$

The tax on payroll is

(B19) $TIWT_{z,t} = \sum_{l,j} TIW_{l,j,z,t} = \sum_{l,j} ttiw_{l,j,z,t} W_{l,z,t} LD_{l,j,z,t}$

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

(B20) $TIKT_{z,t} = \sum_{k,j} TIK_{k,j,z,t} = \sum_{k,j} ttik_{k,j,z,t} R_{k,j,z,t} KD_{k,j,z,t}$

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

(B21) $TIPT_{z,t} = \sum_{j} TIP_{j,z,t} = \sum_{j} ttip_{j,z,t} PP_{j,z,t} XS_{j,z,t}$

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 ($TIXT_{z,t}$).

(B22) $TPRCTS_{z,t} = TICT_{z,t} + TIMT_{z,t} + TIXT_{z,t}$

The indirect tax on commodities is

(B23) $TICT_{z,t} = \sum_{i} TIC_{i,z,t}$

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

(B24) $TIC_{nm,z,t} = ttic_{nm,z,t} PL_{nm,z,t} DD_{nm,z,t}$

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

(B25) $TIC_{m,z,t} = ttic_{m,z,t}\{PL_{m,z,t} DD_{m,z,t} \sum_{zj}[(1 + ttim_{m,zj,z,t})(PWM_{m,zj,z,t} + \sum_{ij} PWMG_{ij,t} tmrg_{ij,m,zj,z,t}) e_{z,t} IM_{m,zj,z,t}]\}$

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

(B26) $TIMT_{z,t} = \sum_{m,zj} TIM_{m,zj,z,t} = \sum_{m,zj} ttim_{m,zj,z,t}\left(PWM_{m,zj,z,t} + PWM_{m,zj,z,t}\right)e_{z,t}IM_{m,zj,z,t}$

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

(B27) $TIXT_{z,t} = \sum_{x,zj} TIX_{x,z,zj,t} = \sum_{x,zj} ttix_{x,z,zj,t}PE_{x,z,zj,t}EX_{x,z,zj,t}$

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 ($G_{z,t}$).

(B28) $SG_{z,t} = YG_{z,t} - G_{z,t}$

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[5]

(B29) $C_{i,z,t}PC_{i,z,t} = C_{i,z,t}^{MIN}PC_{i,z,t} + \gamma_{i,z}^{LES}\left(CTH_{z,t} - \sum_{ij} C_{ij,z,t}^{MIN}\right)$

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

(B30) $CG_{i,z,t}PC_{i,z,t} = \gamma_{i,z}^{GVT}G_{z,t}$

[5] 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.,

(B31) $G_{z,t} = RG_{z,t} PIXGVT_{z,t}$

The public expenditure price index is defined later. The equation (B31) 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

(B32) $INV_{i,z,t} PC_{i,z,t} = \gamma_{i,z}^{INV} IT_{z,t}$

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[6].

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.,

(B33) $DIT_{i,z,t} = \sum_j DI_{i,j,z,t}$

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

[6]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.

($MRGN_{j,z,t}$); 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 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

(B34) $$EXT_{x,z,t} = \beta_{x,z}^{EXT} \alpha 1_{x,z}^{-(1+\sigma 1_{x,z})} \left(\frac{P_{x,z,t}}{PET_{x,z,t}}\right)^{-\sigma 1_{x,z}} XS_{x,z,t}$$

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

(B35) $$DS_{x,z,t} = \beta_{x,z}^{DS} \alpha 1_{x,z}^{-(1+\sigma 1_{x,z})} \left(\frac{P_{x,z,t}}{PL_{x,z,t}}\right)^{-\sigma 1_{x,z}} XS_{x,z,t}$$

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

(B36) $$MRGN_{x,z,t} = \beta_{x,z}^{MRGN} \alpha 1_{x,z}^{-(1+\sigma 1_{x,z})} \left(\frac{P_{x,z,t}}{e_{z,t} PWMG_{x,z,t}}\right)^{-\sigma 1_{x,z}} XS_{x,z,t}$$

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

(B37) $$P_{x,z,t} = \left(\frac{1}{\alpha 1_{x,z}}\right)\left(\beta_{x,z}^{EXT}\left(PET_{x,z,t}\right)^{1+\sigma 1_{x,z}} + \beta_{x,z}^{DS}\left(PL_{x,z,t}\right)^{1+\sigma 1_{x,z}} + \beta_{x,z}^{MRGN}\left(e_{z,t}PWNG_{x,z,t}\right)^{1+\sigma 1_{x,z}}\right)^{\frac{1}{1+\sigma 1_{x,z}}}$$

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*

(B38) $$EX_{x,z,zj,t} = \beta_{x,z,zj}\alpha 2_{x,z}^{-(1+\sigma 2_{x,z})}\left(\frac{PET_{x,z,t}}{PE_{x,z,zj,t}}\right)^{-\sigma 2_{x,z}} EXT_{x,z,t}$$

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

(B39) $$PET_{x,z,t} = \left(\frac{1}{\alpha 2_{x,z}}\right)\left(\sum_{zj}\beta_{x,z,zj}\,PE_{x,z,zj,t}^{1+\sigma 2_{x,z}}\right)^{\frac{1}{1+\sigma 2_{x,z}}}$$

For commodities which are not exported their output prices are

(B40) $$P_{nx,z,t} = PL_{nx,z,t}$$

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

(B41) $$DD_{m,z,t} = \beta_{DD,m,z}^{\sigma 1_{m,z}} \left(\alpha 1_{m,z}\right)^{\sigma 1_{m,z}-1} \left(\frac{PC_{m,z,t}}{PD_{m,z,t}}\right)^{\sigma 1_{m,z}} Q_{m,z,t}$$

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

(B42) $$IMT_{m,z,t} = \beta_{IMT,m,z}^{\sigma 1_{m,z}} \left(\alpha 1_{m,z}\right)^{\sigma 1_{m,z}-1} \left(\frac{PC_{m,z,t}}{PMT_{m,z,t}}\right)^{\sigma 1_{m,z}} Q_{m,z,t}$$

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.,

(B43) $$PC_{m,z,t} = \left(\frac{1}{\alpha 1_{m,z}}\right)\left(\beta_{DD,m,z}\left(PD_{m,z,t}\right)^{1-\sigma 1_{m,z}} + \beta_{IMT,m,z}\left(PMT_{m,z,t}\right)^{1-\sigma 1_{m,z}}\right)^{\frac{1}{1-\sigma 1_{m,z}}}$$

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*

(B44) $$IM_{m,zj,z,t} = \beta_{m,zj,z}^{\sigma 2_{m,z}} \left(\alpha 2_{m,z}\right)^{\sigma 2_{m,z}-1} \left(\frac{PMT_{m,z,t}}{PM_{m,zj,z,t}}\right)^{\sigma 2_{m,z}} IMT_{m,z,t}$$

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

(B45) $PMT_{m,z,t} = \left(\frac{1}{\alpha 2_{m,z}}\right)\left(\sum_{zj} \beta_{m,zj,z} \left(PM_{m,zj,z,t}\right)^{1-\sigma 2_{m,z}}\right)^{\frac{1}{1-\sigma 2_{m,z}}}$

For commodities without competing imports their purchasing prices are given by

(B46) $PC_{nm,z,t} = PD_{nm,z,t}$

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.,

(B47) $YEA_{z,t} = e_{z,t} \sum_{m,zj}\{IM_{m,zj,t}\left(PWM_{m,zj,z,t} + \sum_i PWMG_{i,t} tmrg_{i,m,zj,z}\right)\}$

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

(B48) $SEA_{z,t} = YEA_{z,t} - e_{z,t}\sum_{x,zj} PWX_{x,z,zj,t}\, EX_{x,z,zj,t} - e_{z,t}\sum_{m} PWMG_{m,t}\, MRGN_{m,z,t}$

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.,

(B49) $CAB_{z,t} = -SEA_{z,t}$

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

(B50) $PP_{j,z,t} = \frac{PVA_{j,z,t}VA_{j,z,t} + PCI_{j,z,t}CI_{j,z,t}}{XS_{j,z,t}}$

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

(B51) $PCI_{j,z,t} = \frac{\sum_i PC_{i,z,t}DI_{i,j,z,t}}{CI_{j,z,t}}$

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 (B37) is the unit cost in (B50) plus production taxes, excluding taxes on the use of labor and capital which have already been included in the unit cost. That is,

(B52) $P_{j,z,t} = \left(1 + ttip_{j,z,t}\right)PP_{j,z,t}$

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

The wage rate of type *l* labor including payroll tax in (B6) and (B7) is

(B53) $WTI_{l,j,z,t} = \left(1 + ttiw_{l,j,z,t}\right)W_{l,z,t}$

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 (B8) and (B9) is

(B54) $RTI_{k,j,z,t} = \left(1 + ttik_{k,j,z,t}\right)R_{k,j,z,t}$

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 (B41) and (B46) is

(B55) $PD_{i,z,t} = \left(1 + ttic_{i,z,t}\right)PL_{i,z,t}$

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

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

(B56) $PE_{x,z,zj,t}\left(1 + ttix_{x,z,zj,t}\right) = e_{z,t}PWX_{x,z,zj,t}$

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

(B57) $PM_{m,zj,z,t} = e_{z,t}\left(1 + ttic_{m,z,t}\right)\left(PWM_{m,zj,t} + \sum_i PWMG_{i,r}tmrg_{i,m,zj,z}\right)\left(1 + ttim_{m,zj,z,t}\right)$

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

(B58) $PWX_{x,z,zj,t} = PWM_{m,z,zj,t} \qquad \forall\, x = m$

The consumer price index is a Laspeyres index defined as

(B59) $PIXCON_{z,t} = \frac{\sum_i PC_{i,z,t}C^0_{i,z}}{\sum_{ij} PC^0_{ij,z}C^0_{ij,z}}$

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

(B60) $PIXINV_{z,t} = \prod_i \left(\frac{PC_{i,z,t}}{PC^0_{ij,z}}\right)^{\gamma^{INV}_{i,z}}$

This price index is the dual price of a Cobb-Douglas function which describes the commodity demand for investment purposes in (B32).

Similarly, the public expenditure price index is

(B61) $PIXGVT_{z,t} = \prod_i \left(\frac{PC_{i,z,t}}{PC^0_{ij,z}}\right)^{\gamma^{GVT}_{i,z}}$

which is also a dual price of a Cobb-Douglas function which describes the commodity demand for public consumption in (B31).

The GDP price deflator is a Fisher index defined as

(B62) $PIXGDP_{z,t} = \sqrt{\frac{\sum_j (PVA_{j,z,t})\left(VA^0_{j,z}\right)\sum_j (PVA_{j,z,t})(VA_{j,z,t})}{\sum_j \left(PVA^0_{j,z}\right)\left(VA^0_{j,z}\right)\sum_j \left(PVA^0_{j,z}\right)(VA_{j,z,t})}}$

Equilibrium

The equilibrium in the labor market is

(B63) $LS_{l,z,t} = \sum_j LD_{l,j,z,t}$

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 (B53).

The equilibrium in the capital market is

(B64) $KS_{k,j,z,t} = \sum_j KD_{k,j,z,t}$

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 (B54).

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 (B49)).

(B65) $IT_{z,t} = SH_{z,t} + SG_{z,t} - CAB_{z,t} + DEP_{z,t}$

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.,

(B66) $DEP_{z,t} = PK_{z,t} \sum_{k,j} \delta_{k,j,z} KS_{k,j,z,t}$

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.,

(B67) $DS_{i,z,t} = DD_{i,z,t}$

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

(B68) $EX_{x,z,zj,t} = IM_{m,z,zj,t} \qquad \forall\, x = m$

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.,

(B69) $\sum_z MRGN_{i,z,t} = \sum_{z,zj,ij} tmrg_{i,ij,zj,z} IM_{ij,zj,z,t}$

Note that because of (B47), (B48), (B58), (B68) and (B69), 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

(B70) $Q_{i-1,z,t} = C_{i-1,z,t} + CG_{i-1,z,t} + INV_{i-1,z,t} + DIT_{i-1,z,t}$

Note that because of Walras Law, one of the demand-supply product equilibrium conditions is redundant. Thus, (B70) 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.,

(B71) $GDP_{z,t}^{BP} = \sum_j PVA_{j,z,t} VA_{j,z,t} + TIPT_{z,t}$

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

(B72) $GDP_{z,t}^{MP} = GDP_{z,t}^{BP} + TPRCTS_{z,t}$

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* = NAFTA. In the PEP-w-t model *zr* = United States.

(b) Government expenditure in real terms ($RG_{z,t}$) in (B31) 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 (B63) 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 (B64) 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 (B29) 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,

(B73) $KS_{k,j,z,t+1} = KS_{k,j,z,t}(1 - \delta_{k,j,z}) + IND_{k,j,z,t}$

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 (B65), i.e.,

(B74) $IT_{z,t} = PK_{z,t} \sum_{k,j} IND_{k,j,z,t}$

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

(B75) $PK_{z,t} = \left(\frac{1}{A_z^K}\right)\prod_i \left(\frac{PC_{i,z,t}}{\gamma_{i,z}^{INV}}\right)^{\gamma_{i,z}^{INV}}$

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,

(B76) $IND_{k,j,z,t} = \emptyset_{k,j,z}\left(\frac{R_{k,j,z,t}}{U_{k,j,z,t}}\right)^{\sigma_{k,j,z}^{INC}} KS_{k,j,z,t}$

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

(B77) $U_{k,j,z,t} = PK_{z,t}\left(\delta_{k,j,z} + IR_{j,z,t}\right)$

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 (B74).

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

(B78) $gr_{z,t}^{GDP_{pc}} = \frac{gr_{z,t}^{GDP}+1}{gr_{z,t}^{pop}+1} - 1$

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

(B79) $gdpindex_{z,t} = \left(1 + gr_{z,t}^{pop}\right)\left(1 + \overline{gr_z^{GDP}}\right)gdpindex_{z,t-1},\ \ with\ gdpindex_{z,t=1} = 1$

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

(B80) $\overline{gr_z^{GDP}} = \left(\frac{1}{TT-t=1}\right)\left(\sum_{t=1}^{TT-1} gr_{z,t}^{GDP_{pc}}\right)$

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 (B29), $LS_{l,z,t}$ in (B63), $IND_{k=capital,j=govrnment,z,t}$ in item (c) of the model closure, $sh0_{z,t}$ in (B15), $ttdh0_{z,t}$ in (B17), and $RG_{z,t}$ in (B31).

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 (B41), (B42), and (B43)) is

(B81) $\sigma 1_{m,z} = \sum_i sh_{i,m,z}^{Q} ESUBD_i$

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 (B44) and (B45)) 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 (B3), (B4), and (B5)) is

(B82) $\sigma_{VA,j,z} = \sum_j sh_{j,z}^{VA} ESUBVA_j$

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 (B6) and (B7)) 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 (B8) and (B9)) 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 (B34), (B35), and (B36) is $\sigma 1_{x,z} = 2$, while in the second nest in (B38), and (B39) is $\sigma 2_{x,z} = 3$.

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 (B29). Robichaud (2001) has shown that the EV corresponding to a demand system which is LES may be written as

(B83) $EV_{z,t} = \prod_i \left(\frac{PC_{i,z,t}^B}{PC_{i,z,t}^S}\right)^{gamma\_LES_{i,z}} \left(CTH_{z,t}^S - \sum_i CMIN_{i,z,t}^B \, PC_{i,z,t}^S\right) - \left(CTH_{z,t}^B - \sum_i CMIN_{i,z,t}^B \, PC_{i,z,t}^B\right)$

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

Appendix C: Philippine Poverty and Income Distribution Simulation Model

The FIES provides information on household income. Household income is composed of labor income (total wages and salaries, which is further divided into wages and salaries from agriculture and non-agriculture) and all other income (which includes net share of crops, income from entrepreneurial activities, remittances, etc.). Let the total household income be

(C1) $Y_h = w \cdot L + r \cdot OY$

where Y_h is total household income, w wage rate, L labor, rate of return or payment to other income, OY. w and r are factor prices while L and OY are factor endowments of households, which include income from land ownership. In the poverty microsimulation model, the results from the CGE simulation are used to change w, L, and r to determine the change in Y_h.

The poverty threshold can be specified as

(C2) $Pov^* = P \cdot MBN$

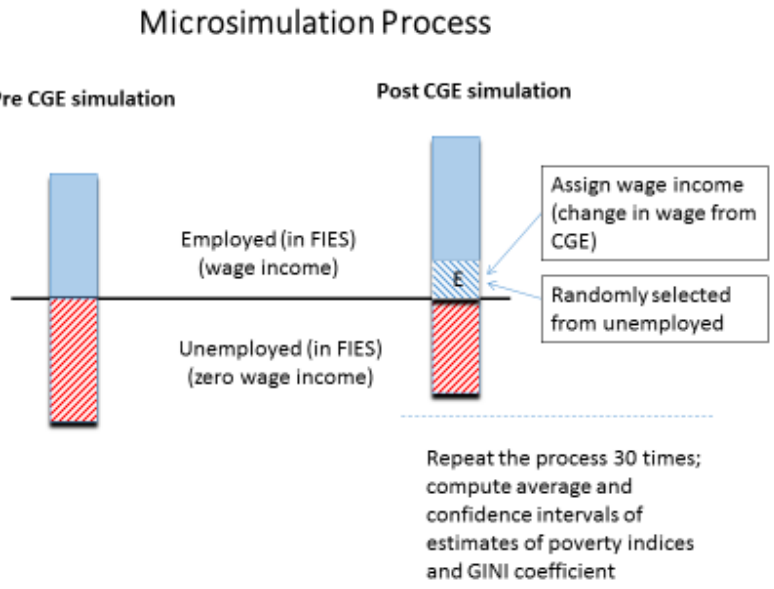
where Pov^* is value of the poverty threshold, P commodity prices, and MBN the minimum basic needs. The value of the poverty thresholds changes with changes in commodity prices. Changes in commodity prices are taken from the CGE simulation results. MBN is held fixed.

Consider a situation where a certain household is initially below poverty, i.e., $Y_h < Pov^*$. Changes in w, r, L and P as a result of the implementation of the NGP could lead to a situation where the household could either remain in poverty (i.e. $Y_h < Pov^*$) or move up the poverty threshold ($Y_h > Pov^*$). This is poverty analysis is conducted in the project. In addition, since Y_h changes across households, the distribution of income also changes. This is also analyzed in the project. These effects across households are analyzed using the poverty microsimulation model that utilizes data from the FIES. The FIES provides several household information including

job/business indicator for the household heads, occupation, as well as employment status (employed/unemployed).

Based on the FIES, households can be grouped into those whose household heads are unemployed and those with employment. This is illustrated in Figure 2 below as the employment bar divided into two parts by a line[7]. Those above the line are employed, while those below are unemployed. Employed household heads earn labor income, while those who are unemployed do not.

Poverty Microsimulation



A CGE policy simulation generates changes in sectoral employment, factor prices (wages, returns to capital, and returns to land), and commodity prices. These results are used to change the

[7] Detailed discussion of the poverty microsimulation is give in Cororaton, C. B., and E. Corong. 2009. *Philippine Agricultural and Food Policies: Implications on Poverty and Income Distribution*. International Food Policy Research Institute (IFPRI) Research Report No. 161. Washington DC: IFPRI.

employment bar in the figure shown. To illustrate, assume the employment bar represents employment in agriculture. Assume a CGE policy shock generates a relative sectoral price ratio that favors agriculture. Since agriculture is profitable relative to industry and services, assuming fixed supply of resources (labor, capital, and land), some of the resources used in industry and services will move to agriculture, thereby increasing the output of the agricultural sector. The demand for labor in agriculture will increase, as well as the demand for other factor inputs.

Higher employment in agriculture will move the employment bar in agriculture up as shown in the figure in the post CGE simulation. The number of unemployed in agriculture will decline (those below the horizontal line), while the number of employed will expand (those above the line). The change in agricultural employment from the CGE simulation will determine how far the employment bar is shifted upwards.

There is an area in the employment bar (Area E) which represents those who were originally unemployed during the pre-CGE simulation but have gained employment in the post-CGE simulation. The question then is: how does one select who among the unemployed household heads during the pre-CGE simulation will gain employment in the post-CGE simulation? In the poverty microsimulation model, the previously unemployed household heads in Area E are randomly selected from a pool of unemployed household heads in the pre-CGE simulation. Once they are selected and included in Area E, they are assigned a wage, *w*, which is determined from the CGE simulation. As a results, these household heads will start generating labor income which will increase their total household income.

The random selection of unemployed household heads is repeated for 30 times. In each repeated random selection of household heads, the composition of households in Area E is different. In each repeated random selection, poverty indices and income distribution coefficient

are calculated. This repeated random selection will allow one to establish confidence interval of the estimates of the poverty indices and the income distribution coefficient.

Conversely, the same process is applied to household heads who belong to the contracting sectors, industry and services. Unemployment in these sectors will increase and some of the employed household heads will get unemployed and will lose labor income. The random selection of the employed household heads is also done for 30 times to establish confidence intervals for the estimates of the poverty indices and income distribution coefficient.

In the project, the Foster-Greer-Thorbecke (FGT) poverty indices (see below for the formula) are computed using data in the FIES data. The income distribution coefficient that will be used is the GINI coefficient. The FGT indices and the GINI coefficient are computed separately during the pre-CGE simulation and in the post-CGE simulation. The results are then compared to determine whether the NGP generates favorable poverty and distributional impacts or not.

FGT Poverty Indices. The simplest measurement of poverty, for a given poverty line, is to assess how many households or individuals fall below that line. Expressed as a proportion of the whole population this constitutes the poverty headcount ratio (P_0). However, this measure overlooks how intense household's poverty is, and for instance does not differentiate between a household living just below the poverty line and another far below. A common measure to account for the intensity of poverty is the poverty gap (P_1), which measures the average distance of poor households from the poverty line. Finally, a third measure is used to capture poverty severity index (P_2) which captures the degree of inequality amongst the poor. All three measures are specific measures of the generalized FGT poverty metric, where alpha equals 0, 1 and 2 respectively.

(C3) $P_\alpha = \frac{1}{N}\sum_{i=1}^{H}(\frac{z-y_i}{z})^\alpha$

There are several ways of measuring inequality. The most common is through the GINI ratio, which measures the area between the 45^0 perfect equality line and the Lorenz Curve. The value of the coefficient ranges between 0 (perfect equality) and 1 (complete inequality). This measurement of inequality is used in the project. The formula of the GINI coefficient is given by

(C4) $$GINI = \frac{1}{2n^2\bar{y}} \sum_{i=1}^{n} \sum_{j=1}^{n} |y_i - y_j|$$

where n is the number of individuals, y_i and y_j are income of the individuals, and $\bar{y}$ is the mean income.

The step-by-step procedure given below adopts some features of the process in Vos (2005).

1. The household head represents the entire family. In the first phase of this procedure, household heads are distinguished by: (a) skill level; and (b) sector of employment. Sector of employment is differentiated into agriculture and non-agriculture whereas skill level is classified into unskilled (no education to non-high school graduates) and skilled (high school graduates and higher). There are 4 labor income sources/sectoral employment groups: unskilled agriculture, skilled agriculture, unskilled non-agriculture, and skilled non-agriculture.

2. Generate a dummy variable called *employed* where 1 = households with wage income and zero otherwise. Compute the total employment rate $u^*$for each of the four groups defined in step 5. The total employment rate for each group, u^* is the weighted mean of the dummy variable *employed* and weights in the household survey. Note that the dummy variable is only a subset of the survey as it only covers those with wage income (dummy variable =1) and those with zero wage income but unemployed (dummy variable = 0).

3. Update the total sectoral employment u^*in the household survey by using the variation in sectoral employment from the CGE model.

4. Assign a random number from a normal distribution to those identified as employed. This is called *random*. The variables *random* and *employed* are then sorted by descending order.

5. Compute the accumulated weight of *employed* in each group (by sector and by skill level as defined in 5).

6. Compute the over-all weight of each group. This is simply the sum of accumulated weight by sector and by skill level as defined in 5.

7. Take the ratio of accumulated weight and the overall weight of each group. This ratio is called r_{ij}.

8. Compare $r_{ij}$and u^*. If $r_{ij} \leq u^*$, then that household head is employed, and unemployed otherwise ($r_{ij} > u^*$).

9. Arrange each group in decile. The decile grouping is based on the sum of labor income and capital income, where capital income is the sum of 'total income from entrepreneurial activities' and 'net share of crops' in the household survey. Other incomes such as dividends, interest income and others are not used in grouping households into decile.

10. Assign the decile mean labor income to those who become newly employed (after a change in u^*), and reduce labor income of those who become unemployed[8] (after a change in u^***,**). For those who become newly employed, and if they belong to the first decile for example, the mean labor income in the first decile will be assigned to them. Those with labor income, but not picked by the random process will retain their labor income. On the other hand, those with zero labor income but not picked by the random process will continue to have no labor income earnings.

[8] In reducing labor income of those who become unemployed, that is, they will move to the area where $\mathbf{r_{ij} > u^*}$after the change in u*. The one we adopted involves deducting the decile mean labor income from the labor income if the former is less than the latter. Otherwise, labor income is reduced to zero.

11. Define total income. It is composed of three major items: labor income, capital income, and other income. Capital income is income derived from the various production sectors other than labor income, while other income includes income from dividends, government transfers, and remittances. Note that similar income sources are found in the CGE model and in the household survey.

12. Derive the change in capital and other income of each household in the survey using the average change in capital and other income per household category from the CGE model.

13. Derive the change in labor income in a two-step procedure: (a) use the change in labor income of each household in the survey from the average change in labor income per household category from the CGE model; (b) update the final labor income using the result of the random process carried in step 8.

14. Compute for the total household income by taking the sum of labor income, capital income, and other income.

15. Update the nominal value of the poverty line of each household in the survey by applying the variation in household specific consumer price index from the CGE model.

16. Calculate the GINI coefficient using the new column of income, as well as the FGT poverty indices using the income and new nominal poverty line.

17. The FGT poverty indices are calculated according to the demographic characteristics of the household head: (1) gender; (2) skill level; and (3) location, urban-rural. In total, the final FGT indices are derived for households both in decile and socio-economic categories. The micro-simulation process is repeated 30 times[9]. Thus, there will be 30 estimates of GINI coefficient and

[9] Vos (2005) observes that 30 iterations are sufficient. Repeating this process additionally does not significantly alter the results.

FGT indices in each simulation. Confidence intervals of estimates from the 30 simulations/runs are derived.