DLSU Business & Economics Review 34(2) 2025 p. 14-30

RESEARCH ARTICLE

The Global Value Chain Effects of RCEP: Estimating the Impact on the Philippines

Caesar B. Cororaton
De La Salle University, Manila, Philippines
ccororaton@gmail.com

This paper extends the global CGE model results of Cororaton (2022) by disaggregating further the RCEP trade creation effects on the Philippines into global value chain (GVC) impacts. The GVC analysis indicates that the trade agreement in RCEP results in higher Philippine exports of US$ 2.8 billion in 2031, of which the increase in Philippine domestic value added is US$ 2.4 billion, significantly higher than the foreign value added of US$ 403 million. Electronic products contribute 67% of the value added generated within the Philippines. The increase in the import contents of Philippine exports is only US$ 413 million. Furthermore, the Philippine value added to produce Philippine final goods consumed in other ASEAN, other RCEP members, as well as in countries/regions outside of the partnership area also improves.

Keywords: Global value chains, Global computable general equilibrium (CGE) model, Regional Comprehensive Economic Partnership (RCEP), the Philippines, Trade policy

JEL Classifications: C68, C67, F13, F15, F17

The Regional Comprehensive Economic Partnership (RCEP) is a regional trade agreement (RTA) signed by 15 countries (10 countries in the Association of Southeast Asian Nations (ASEAN)[1] and five non-ASEAN countries[2]) on November 15, 2020. On February 21, 2023, the Philippine Senate ratified the country's membership in RCEP, making the partnership the country's most recent major trade policy. The effectivity of the Philippine membership started on June 2, 2023.

RCEP is the largest regional trading block. The total GDP of the region was US$ 28.8 trillion in 2020, representing 30.6% of the world economy (Table 1). The population base is large, with 2.28 billion people, representing 30.3% of the global population. The level of development varies across countries in the region, as indicated by the wide variation in the per capita income. Singapore had the highest per capita income of US$ 59.8 thousand in 2020, with Myanmar the lowest at US$ 1.4 thousand. The per capita income in the Philippines is US$ 3.3 thousand.

Table 1. *Gross Domestic Product and Population*

Country	2020		
	US$ billion, nominal values	Population, million	Per capita, US$ thousand
Australia	1,330.9	25.7	51.8
Brunei Darussalam	12.0	0.4	27.5
Cambodia	25.3	16.7	1.5
China	14,722.7	1,402.1	10.5
Indonesia	1,058.4	273.5	3.9
Japan	4,975.4	125.8	39.5
South Korea	1,630.5	51.8	31.5
Lao PDR	19.1	7.3	2.6
Malaysia	336.7	32.4	10.4
Myanmar	76.2	54.4	1.4
New Zealand	210.9	5.1	41.5
Philippines	361.5	109.6	3.3
Singapore	340.0	5.7	59.8
Thailand	501.8	69.8	7.2
Vietnam	271.2	97.3	2.8
World	84,578.0	7,673.3	11.0
RCEP % of World	30.6	30.3	

Sources: World Bank (2023)

Using a global computable general equilibrium (CGE) model, Cororaton (2022) analyzed the potential effects of RCEP on the Philippines by simulating scenarios involving both Philippine RCEP participation as well as non-RCEP participation. Cororaton (2022) provided estimates of the potential effects from 2023 to 2031 on trade creation and trade diversion, macro effect effects such as gross domestic product (GDP), inflation, factor prices, sectoral production and employment, exports and imports, and consumer welfare. The paper also extends the analysis by using a Philippine poverty microsimulation to get insights into the potential impacts on poverty and income distribution of Philippine participation/non-participation. However, missing in the impact analysis are the effects of RCEP on global value chains (GVCs) in the Philippines.

The original argument for the desirability of RTAs for participating countries is based on two effects: trade creation and trade diversion (Viner, 1950). The trade creation effects of RTA will increase trade within the agreement zone, whereas the trade diversion effects will decrease trade outside of the RTA area. This view is largely inspired by the trade of final goods, where consumers search for markets where prices, inclusive of tariffs and other trade costs, are lowest. This original argument, however, misses a key important feature of the recent evolution in the structure of international trade: the rise of GVCs. Apart from the effects of trade creation and trade diversion, the agreements in RTA will also facilitate access to cheaper inputs by producers within the partnership, which in turn affects the competitiveness of the production sectors of countries within the zone. These are the GVC effects, the estimates of which are presented in this paper.

Framework of Analysis

Johnson (2017) provided a review and overview of the methods available for measuring GVCs. Available in the literature are two approaches: macro-level and micro-level. The macro-level approach uses a multiregional input-output (MRIO) framework[3]. The MRIO framework is used to analyze trade in value added by decomposing value-added, intermediate inputs, and final goods. This method can be used to calculate value-added contents in final goods, value-added in exports, and global value chain income. The MRIO-based technique can also be used to measure trade-in factors and environmental contents. However, MRIO-based GVC analysis has several limitations in terms of the construction of the MRIO transaction tables. In particular, the level of aggregation in the MRIO data omits important border information that is relevant to policy analysis. Thus, alongside the research on measuring GVC using MRIO data, other important data sources such as census data, customs data, and firm surveys have been utilized to extend GVC linkages at the firm level. This is the micro-level approach. Although the micro-level approach provides richer information for policy analysis, it is beyond the scope of the present paper. The paper uses the macro-level approach.

Advances in research on GVC at the macro-level are facilitated by two important developments: (a) the World Input-Output Database (WIOD)[4] and (b) the GTAP[6] global trade database. WIOD is commonly utilized to estimate MRIO-based value-added multipliers to measure GVC, whereas GTAP is used to calibrate global CGE models. Although both methods (MRIO-based and global CGE) measure the interdependence among sectors in the production system in the global economies to capture the impacts due to a policy shock, the methods are greatly different.

One limitation in an MRIO-based GVC analysis is the assumption of perfectly elastic supply, which implies that output can instantaneously adjust without cost to any variations in the level of the final demand. Perfectly elastic supply implies an unlimited/unconstrained supply of factors, which makes the supply curve perfectly horizontal. A multiplier that is derived from a horizontal supply curve is *fixed* and will overestimate the impact on output for any change in the final demand because of the absence of price effects.

The use of a global CGE in GVC analysis addresses this limitation by incorporating factor constraints and by allowing relative prices to adjust to reallocate factors across sectors while allowing substitution effects in production and consumption both within and across countries. Thus, the use of the global CGE model, which captures price and substitution effects, can address a broader set of issues than an MRIO-based GVC analysis of RTA. Furthermore, allowing for price and substitution effects in the GVC analysis makes the value-added multipliers *endogenous* and responsive to substitution and reallocation effects due to a policy shock.

Formally, consider the following global system consisting of two economies $(s, r \in \{1,2\})$

$$\begin{bmatrix} \boldsymbol{y_1} \\ \boldsymbol{y_2} \end{bmatrix} = \begin{bmatrix} \boldsymbol{A_{11}} & \boldsymbol{A_{12}} \\ \boldsymbol{A_{21}} & \boldsymbol{A_{22}} \end{bmatrix} \begin{bmatrix} \boldsymbol{y_1} \\ \boldsymbol{y_2} \end{bmatrix} + \begin{bmatrix} \boldsymbol{f_{11}} & \boldsymbol{f_{12}} \\ \boldsymbol{f_{21}} & \boldsymbol{f_{22}} \end{bmatrix} \boldsymbol{i} \quad (1)$$

where y_1 and y_2 are vectors of industry output of economies **1** and **2**; A_{sr} *where* $s = r$ is the intra-industry matrix of technical coefficients of transactions within each of the economies and A_{sr} *where* $s \neq r$ the inter-industry matrix of technical coefficients of transactions between the economies; f_{sr} *where* $s = r$ vector of final demand in each of the economies and trade (exports and imports) of final goods between the economies; and i denotes a conformable vector of ones. Note that A_{sr} *where* $s \neq r$ are matrices of trade (exports and imports) of intermediate inputs between the two economies.

In compact form, Equation 1 can be written as

$$y = Ay + Fi \quad (2)$$

where $\boldsymbol{A} = \begin{bmatrix} \boldsymbol{A_{11}} & \boldsymbol{A_{12}} \\ \boldsymbol{A_{21}} & \boldsymbol{A_{22}} \end{bmatrix}$; $\boldsymbol{y} = \begin{bmatrix} \boldsymbol{y_1} \\ \boldsymbol{y_2} \end{bmatrix}$ and

$$\boldsymbol{F} = \begin{bmatrix} \boldsymbol{f_{11}} & \boldsymbol{f_{12}} \\ \boldsymbol{f_{21}} & \boldsymbol{f_{22}} \end{bmatrix}$$

The value-added vector is

$$v' = y' - i'A\hat{y} \quad (3)$$

where $\hat{y}$ denotes a diagonal matrix with the vector along the diagonal. The value-added multiplier is

$$va\ mult = \hat{v}\hat{y}^{-1}[I - A]^{-1} \quad (4)$$

where $\hat{v}\hat{y}^{-1}$ is a matrix with value-added-to-output ratios along the diagonal.

In the global CGE approach to measuring GVC, the values of variables in Equations 1 to 4 are not fixed but are derived endogenously by the CGE model (both in the baseline run and in the policy simulation [counterfactual] run). Thus, the information needed to measure GVC is responsive to substitution and reallocation effects due to a policy shock.

Cororaton (2022) generated yearly simulation results from 2022 to 2023 in the baseline where there are no RCEP agreements and in various scenarios involving Philippine RCEP participation as well as non-participation. However, the simulation results need to be reorganized so they can be utilized in GVC analysis. The paper adopts the method of Antimiani et al. (2018) to reorganize results, which is discussed in Appendix B.

After the simulation results are re-organized to the MRIO format, the value-added multipliers are computed and used in the GVC measurement. Appendix A discusses details of the method, in particular the various formula to compute the value-added contents in final goods, the decomposition of the value-added contents in exports, and import contents in exports.

Trade Creation, Trade Diversion and Macro Effects in the Philippines

The global CGE model used in Cororaton (2022) was calibrated using an aggregated GTAP 10 database[6]. The aggregated database consists of 32 commodities in 17 countries/regions.

The key features of the model include: (a) a three-level production structure where value added and intermediate inputs are used in fixed proportion to produce output and the second and third levels are constant elasticity of substitution (CES) functions of various disaggregated factor inputs; (b) the model has four primary factors (skilled labor, unskilled labor, capital, and land and natural resources); (c) a linear expenditure system demand structure; (d) domestically produced and imported goods are imperfect substitutes and modeled using CES function; (e) 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; (f) 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; (g) 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; and (h) the model allows for some variations in foreign direct investment flows.

The model has two alternative closures. The default closure consists of the following. The numeraire for each period *t* is the GDP deflator of the reference country/region. Real government expenditure and public investments for all regions are fixed. Variables that are considered to be exogenous are fixed exogenously. The exchange rates in each country/region are also fixed. An alternative model closure fixes the GDP deflator of all countries/regions and the exchange rate of the reference region as the numeraire. With this alternative closure, exchange rates are real exchange rates between countries/regions and the world.

Cororaton (2022) considered trade barriers that consist of tariffs and non-tariff measures (NTMs). Among the key elements in NTMs are sanitary and phytosanitary measures (SPS), technical barriers to trade (TBT), and contingent trade-protective measures.

Following Andriamananjara et al. (2003), Cororaton (2022) treated NTMs in the analysis as additional tariffs, export taxes, and as losses in import efficiency. The last item is called in the literature as the "sand in the wheels" effect, which reduces imports because of "institutional frictions" arising from factors like SPS, technical regulations, administrative procedures, and so forth. Unlike tariff and export tax equivalents, changes in these types of NTMs do not have revenue implications as they only account for efficiency losses.

In the analysis, Cororaton (2022) used the estimates of the ad valorem tariff equivalent (AVE) of NTMs of Kee et al. (2009). These estimates were derived through econometric estimation of a gravity equation using world trade flows, tariffs, several geographical variables such distance between trading centers and links between countries such as colonial past, common languages, contiguity, and so forth.

In addition, Cororaton (2022) used sectoral tariff rates of countries and regions calculated from the GTAP database but adjusted to account for the tariff rates within ASEAN (ASEAN Trade in Goods Agreement, ATIGA).

Empirical studies indicate strong evidence of the complementarity between trade and foreign direct investments. Following Martens (2008), Cororaton (2022) adopted this complementarity in the model.

Furthermore, Cororaton (2022) extended the analysis by utilizing the simulation results in a randomized Philippine poverty microsimulation model that uses the 2018 Family Income and Expenditure Survey (FIES) to calculate three commonly used FGT (Foster et al., 1984) poverty indices: poverty incidence (P0), poverty gap (P1), and poverty severity (P2). The paper also estimates the impact of income inequality using the GINI coefficient.

Cororaton (2022) simulated six RCEP scenarios. However, in the measurement of GVC effects here, the simulation results of the following scenarios are used: baseline and gradual reduction in the trade barriers within RCEP.

The baseline scenario is generated by simulating the global CGE model from 2014 to 2020 using the actual real GDP and population growth of countries/regions during the period. From 2021 to 2031, the model is simulated using the projected GDP growth of the World Bank and the projected population growth of the United Nations. In the baseline, which is a business-as-usual scenario, all sectoral applied tariffs and sectoral AVE of NTMs are incorporated without any changes during the simulation period in all countries/regions in the model, both within RCEP and in non-RCEP[7].

In the RCEP scenario (scenario RCEP 1 in Cororaton, 2022), all 15 member countries in RCEP gradually eliminated sectoral tariffs on imports traded within RCEP over the period from 2022 to 2031. The Philippines, however, excludes its existing tariffs on rice and sugar in the reduction. Non-RCEP countries/regions retain their baseline sectoral tariffs. In addition, all RCEP member countries gradually reduced all sectoral AVE of NTMs on all imports traded goods within RCEP from 2022 to 2031 by 50%. All countries/regions outside of RCEP retain their baseline trade barriers (sectoral tariffs and NTMs). In the analysis, the marginal effects of RCEP were measured as the difference (value and/or percentage change) between RCEP scenario and the baseline.

Table 2. *Trade Creation and Trade Diversion Effects of RCEP, Difference From Baseline (US$ Million)*

	2027	2031
Exports		
RCEP	12,545	23,320
Non-RCEP	-2,789	-5,318
Imports		
RCEP	5,639	9,536
Non-RCEP	-1,594	-2,797

Source: Cororaton (2022)

Table 2 presents the effects of trade creation and trade diversion. Exports within the RCEP area expand by US$ 12.5 billion in 2027 and US$ 23.3 billion in 2031. Imports within RCEP will increase as well by US$ 5.6 billion in 2027 and US$ 9.5 billion in 2031. This increase in both exports and imports within the RCEP area is the trade creation effect due to the partnership. On the other hand, exports of non-RCEP countries/regions decline by -US$ 2.8 billion in 2027 and -US$ 5.8 billion in 2031. Imports outside of the RCEP area will decrease by -US$ 1.7 billion in 2027 and -US$ 2.8 billion in 2031. The decline in both exports and imports in non-RCEP countries/regions is caused by the trade diversion effect.

Table 4 presents the welfare effects in both values and percent of GDP in 2027 and 2031 across all countries/regions. Relative to countries within the RCEP area, the welfare effect in the Philippines is in the mid-range: 0.65% of GDP in 2027 and 1.08% in 2031. The top in the list of welfare gains are Malaysia and Viet Nam. Non-RCEP countries/regions have welfare losses as a result of the trade diversion.

Table 3. *Philippine Macro Effects of RCEP*

	2027	2031
% Change from baseline:		
Real GDP	1.18	1.93
Consumer price index	-0.27	-0.48
Factor prices:		
Skilled wages	1.00	1.61
Unskilled wages	0.88	1.47
Returns to capital	0.97	1.45
Land rent	0.57	0.74
Poverty:		
Poverty Incidence	-1.23	-3.62
Poverty gap	-1.84	-3.49
Poverty severity	-2.00	-3.82
Welfare:		
Equivalent Variation, US$ billion	291.1	541.2
Equivalent Variation, % of GDP	0.65	1.08

Source: Cororaton (2022)

Table 4. *Comparative Welfare Effects*

	2027	2031
Equivalent Variation, US$ million		
RCEP:		
Philippines	291	541
Indonesia	352	676
Malaysia	570	1,010
Singapore	304	540
Thailand	216	394
Viet Nam	244	463
Other ASEAN*	47	82
Australia	540	984
New Zealand	85	159
China	1,264	1,642
Japan	1,542	2,678
South Korea	1,200	2,343
Non-RCEP	-682	-1,191
Equivalent Variation/GDP, %*		
Malaysia	1.09	1.77
Viet Nam	0.82	1.36
South Korea	0.67	1.23
Singapore	0.71	1.15
Other ASEAN*	0.71	1.12
Philippines	0.65	1.08
Thailand	0.40	0.68
New Zealand	0.31	0.52
Japan	0.30	0.51
Australia	0.28	0.48
Indonesia	0.26	0.46
China	0.07	0.09

Source: Cororaton (2022)

** Includes Brunei Darussalam*

*** Sorted using 2031 ratios*

Global Value Chain Effects on the Philippines

Effects in 2031

The GVC analysis in this section uses the above simulation results of 2031[8], both under the baseline and in the RCEP run. To facilitate the analysis and focus on the effects on the Philippines, the trading partners of the country are grouped into: (a) other ASEAN, (b) other RCEP, and (c) non-RCEP.

Table 5 presents the aggregate exports of the Philippines of intermediate inputs and final goods to the country's trading partners, derived using the term x_{12} Equation (A8) in Appendix A, in particular $x_{12} = A_{12}y_2 + f_{12}$, where subscript 1 denotes the Philippines, while subscript 2 the country's trading partners. Exports of intermediate inputs to other RCEP countries are the largest (31.3% in the baseline)[9]. In terms of final goods exports, the largest share is with non-RCEP countries (19.4%).

In terms of Philippine exports of intermediate inputs, the largest increase (3.2%) is with other ASEAN countries. In terms of exports of final goods, the highest increase is with other RCEP countries. The country's exports of intermediate inputs and final goods to non-RCEP countries also improve, but the increase is relatively smaller compared to countries within the partnership. The trade agreements in RCEP led to 3.2% increase in Philippine exports of intermediate inputs to other ASEAN. Overall, exports of the Philippines as a result of RCEP improve by 2% relative to the baseline.

Table 6 disaggregates Philippines exports by major sectors. Exports of non-food manufacturing, which have the largest combined share of more than 60% of total exports, have the highest increase of 3.03% relative to the baseline. Exports of agri/food manufacturing, which have a share of about 10% percent, improved by 1.15%. Exports of other industries (which include utilities and construction), as well as mining-related commodities, improve marginally by 0.3% and 0.23%, respectively.

Table 7 presents the value added needed to produce the final demand. The columns indicate the final demand consumed/absorbed in the Philippines, other ASEAN, other RCEP, and non-RCEP, whereas the rows indicate the source of the value added. For example, the total final demand in the Philippines under Sim 2031 is US$ 568 billion, of which US$ 409 billion is value added from the domestic economy, US$ 24 billion from other ASEAN, US$ 61 billion from other RCEP, and US$ 75 billion from non-RCEP.

The results indicate that the value added needed within RCEP countries to produce the final demand in the Philippines increases relative to the baseline: 1.38% from within the Philippine domestic economy, 2.98% from other ASEAN, and 5.42% from other RCEP. The value added from non-RCEP declines by -2.26%.

The increase in the final demand in other ASEAN countries requires a higher value added from the

Table 5. *Philippine Aggregate Exports of Intermediate Inputs and Final Demand to Other ASEAN, Other RCEP and Non-RCEP*

	Intermediate Inputs			Final Demand			
	Other ASEAN	Other RCEP	Non-RCEP	Other ASEAN	Other RCEP	Non-RCEP	Total
	Sim 2031						
Value US$ million	10,442	44,343	37,455	5,040	16,992	27,239	141,512
Share, %	7.4	31.3	26.5	3.6	12.0	19.2	100.0
	Baseline 2031						
Value US$ million	10,121	43,348	36,976	4,910	16,390	26,944	138,689
Share, %	7.3	31.3	26.7	3.5	11.8	19.4	100.0
% change (Base vs Sim)	3.2	2.3	1.3	2.7	3.7	1.1	2.0

Source: Author's estimates

Table 6. *Philippine Sectoral Exports of Intermediate Inputs and Final Demand to Other ASEAN, Other RCEP and Non-RCEP*

	Sim 2031, Philippine Exports (US$ million)				Baseline 2031, Philippine Exports (US$ million)				
	(a)	(b)	(c)		(d)	(e)	(f)		(c)/(f)
	Intermediate Demand	Final Demand	Total	Share, %	Intermediate Demand	Final Demand	Total	Share, %	% Change
Agri/food manufacturing	7,910	5,996	13,906	9.8	7,885	5,864	13,749	9.9	1.15
Mining, including oil	10,282	155	10,437	7.4	10,259	155	10,414	7.5	0.23
Non-food manufacturing	54,563	34,907	89,470	63.2	52,829	34,008	86,837	62.6	3.03
Other industry	119	336	455	0.3	119	335	454	0.3	0.30
Services	19,367	7,877	27,243	19.3	19,353	7,882	27,235	19.6	0.03
Total	92,240	49,271	141,512	100.0	90,444	48,244	138,689	100.0	
(% change of total)	1.99	2.13	2.04						

Source: Author's estimates

Philippines by 3.83% relative to the baseline. In the final demand in other RCEP, the value added needed that comes from the Philippines is also higher by 3.96%. Although the total final demand in non-RCEP countries declines marginally by -0.08% relative to the baseline, the value added that comes from the Philippines needed in the final demand in these countries improves by 2.32%.

Table 8 and Table 9 disaggregate the total value needed from the Philippines to produce the final demand absorbed in all countries (i.e., US$ 492 billion in Sim 2031 and US$ 484 billion in Baseline 2031). Among the sectors in the Philippines, the largest increase comes from non-food manufacturing, in particular, transport equipment (14.79%) and electronic products (12.68%). This is followed by agri/food manufacturing, particularly dairy products (7.86%) and meat products (4.52%).

Table 7. *Value Added Needed from All Countries/Regions to Produce Final Demand Consumed in All Countries/Regions (US$ billion)*

		Consumed/Absorbed in				
		Philippines	Other ASEAN	Other RCEP	Non-RCEP	Total
		Sim 2031				
Sources of value added	Philippines	409	6	29	47	492
	Other ASEAN	24	2,304	406	823	3,557
	Other RCEP	61	477	23,311	4,249	28,098
	Non-RCEP	75	646	3,086	72,935	76,742
	Total	568	3,434	26,832	78,054	108,888
		Baseline 2031				
Sources of value added	Philippines	403	6	28	46	484
	Other ASEAN	23	2,300	396	820	3,539
	Other RCEP	58	470	23,227	4,262	28,017
	Non-RCEP	77	656	3,112	72,986	76,831
	Total	561	3,432	26,764	78,114	108,871
		% Change				
Sources of value added	Philippines	1.38	3.83	3.96	2.32	1.64
	Other ASEAN	2.98	0.18	2.43	0.45	0.51
	Other RCEP	5.42	1.49	0.36	-0.31	0.29
	Non-RCEP	-2.36	-1.52	-0.84	-0.07	-0.12
	Total	1.34	0.04	0.26	-0.08	0.02

Source: Author's estimates

Table 8. *Philippine Major Sectoral Value Added Needed to Produce Philippine Final Goods Consumed in all Countries/Regions*

	Sim 2031		Baseline 2031		% Change Sim vs Base
	US$ million	Share, %	US$ million	Share, %	
Agriculture/food manufacturing	132,720	27.0	131,071	27.1	1.26
Mining, including oil	9,026	1.8	9,099	1.9	-0.81
Non-food manufacturing	40,733	8.3	38,664	8.0	5.35
Other industry	42,125	8.6	42,264	8.7	-0.33
Services	266,999	54.3	262,549	54.3	1.69
Total	491,602	100.0	483,646	100.0	1.64

Source: Author's estimates

Table 9. *Philippine Industry Value Added Needed to Produce Philippine Final Goods Consumed in All Countries/Regions*

	Sim 2031		Baseline 2031		% Change Sim vs Baseline
	US$ million	Share, %	US$ million	Share, %	
Rice	16,999	4.1	16,650	4.07	2.09
All other cereals	4,367	1.0	4,366	0.98	0.01
Vegetables, fruit, nuts	21,435	3.9	21,286	3.95	0.70
Oil seeds	4,530	0.8	4,561	0.80	-0.68
Sugar	2,458	0.5	2,428	0.54	1.23
Other agriculture	6,670	1.4	6,721	1.43	-0.76
Fishing	30,269	6.9	29,883	6.87	1.29
Minerals, including oil	9,026	1.2	9,099	1.19	-0.81
Live animal	16,357	3.9	16,437	4.01	-0.49
Meat and products	7,070	1.7	6,764	1.66	4.52
Dairy products	1,523	0.4	1,412	0.34	7.86
All other food products	21,043	4.6	20,561	4.59	2.34
Textiles	2,546	0.4	2,617	0.45	-2.72
Wearing apparel	3,793	0.4	3,791	0.45	0.08
Leather products	451	0.1	446	0.06	1.06
Chemicals rubber plastic	5,398	0.9	5,439	0.89	-0.76
Metals	1,713	0.2	1,666	0.16	2.80
Transport equipment	1,297	0.2	1,130	0.13	14.79
Electronic products	15,064	0.4	13,369	0.38	12.68
Machinery equipment	6,436	0.5	6,265	0.50	2.73
Other manufactures	4,036	0.7	3,941	0.68	2.39
Utilities	15,612	3.2	15,423	3.20	1.23
Construction	26,513	6.4	26,841	6.59	-1.22
Trade	69,301	13.5	68,256	13.47	1.53
Transport	17,289	3.0	16,869	2.92	2.49
Recreation	16,227	3.7	16,026	3.65	1.25
Finance	35,625	8.0	34,951	7.98	1.93
Communication	22,576	4.6	22,200	4.57	1.69
Business services	15,068	2.1	14,938	2.13	0.87
Other services	73,664	17.3	72,307	17.17	1.88
Public administration	17,250	4.2	17,003	4.18	1.45
Total	491,602	100.00	483,646	100.00	1.64

Source: Author's estimates

Table 10. *Decomposition of Philippine Exports, US$ million (2031 and 2027)*

	Sim 2031	Baseline 2031	Change Value	Change %	Sim 2027	Baseline 2027	Change Value	Change %
Philippine exports	141,512	138,689	2,823	2.04	135,879	134,317	1,562	1.16
Philippine domestic value added to produce its exports	82,903	80,479	2,424	3.01	79,112	77,717	1,395	1.79
Foreign value added to produce Philippine exports	58,702	58,299	403	0.69	56,863	56,693	170	0.30
Double-counting residuals	178	167			180	174		
Import contents of Philippine exports	58,880	58,467	413	0.71	57,043	56,867	176	0.31

Source: Author's estimates

Table 11. *Industry Breakdown of Philippine Domestic Value Added to Produce its Exports and Import Contents, US$ Million*

	Domestic Value Added				Import Contents			
	Change, 2031*		Change, 2027		Change, 2031		Change, 2027	
	Value	%	Value	%	Value	%	Value	%
Rice	6	2.7	3	1.5	1	0.7	1	0.7
All other cereals	-5	-1.3	-3	-0.7	6	1.6	3	0.9
Vegetables fruit nuts	58	1.1	60	1.3	29	4.4	14	2.7
Oil seeds	-27	-2.0	-13	-0.9	7	2.6	4	1.7
Sugar	4	1.5	3	0.9	1	1.4	1	0.8
Other agriculture	-18	-1.9	-9	-1.0	24	3.7	11	2.1
Fishing	2	0.1	3	0.2	11	4.2	4	2.5
Minerals, including oil	-1	0.0	-1	0.0	-31	-0.2	-23	-0.2
Live animal	0	-0.1	0	-0.1	6	3.5	3	2.1
Meat and products	4	5.2	2	3.0	2	4.8	1	2.7
Dairy products	3	6.4	1	3.5	2	4.4	1	2.6
All other food products	50	2.4	30	1.4	14	3.3	8	2.0
Textiles	-40	-5.0	-23	-3.0	9	1.4	5	0.8
Wearing apparel	-17	-0.8	-8	-0.4	2	1.9	1	1.2
Leather products	-7	-3.1	-3	-1.4	1	0.5	1	0.4
Chemicals rubber plastic	-22	-1.2	-15	-0.8	34	0.8	20	0.5
Metals	50	4.9	34	3.1	-20	-0.4	-20	-0.4
Transport equipment	84	14.0	49	8.5	3	0.9	1	0.4
Electronic products	1,615	13.6	899	7.6	89	0.9	28	0.3
Machinery equipment	155	3.6	92	2.2	8	0.6	4	0.3
Other manufactures	25	2.1	11	0.9	26	2.2	15	1.3
Utilities	24	1.0	16	0.7	7	0.5	3	0.2
Construction	2	0.8	1	0.4	-4	-1.2	-3	-0.8
Trade	265	1.9	150	1.1	35	0.9	16	0.4
Transport	129	2.5	72	1.5	65	2.3	37	1.3
Recreation	3	0.2	2	0.2	11	1.6	6	0.8
Finance	17	0.6	9	0.4	0	0.0	-1	-0.1
Communication	47	1.3	25	0.7	1	0.1	-1	-0.1
Business services	-3	-0.1	-7	-0.1	47	1.1	22	0.5
Other services	22	0.7	11	0.4	25	1.2	13	0.6
Public administration	-1	-0.5	0	-0.3	1	1.1	1	0.6
Total	2,424	3.0	1,395	1.8	413	0.7	176	0.3

Source: Author's estimates
**Change is relative to baseline*

Dynamic GVC Effects of RCEP: 2027 and 2031

This section presents the dynamic GVC effects of RCEP on the Philippines by presenting the comparative marginal effects in 2027 and 2031. The increase in Philippine exports improves from 1.16% in 2027 to 2.04% in 2031 (Table 10). The Philippine domestic value added to produce its exports also improves from 1.79% in 2027 to 3.01% in 2031. The foreign value added to produce Philippine exports and the import contents of Philippine exports also grow over time, but the increase is significantly lower than the improvement in the domestic value added.

Table 11 presents the industry breakdown of the Philippine domestic value added and the import contents of its exports. There is a significant increase in the domestic value added on exports of transport equipment and electronic products. In transport equipment, the increase improves from 8.5% in 2027 to 14.0% in 2031, whereas in electronic products from 7.6% to 13.6%. The change in the import contents is marginally smaller.

Similar dynamic patterns are observed in the value added needed to produce Philippine final goods that are consumed in all countries and regions, as indicated in Table 12.

Summary and Insights

RCEP is the most recent major trade policy of the Philippines. The regional trade partnership of 15 countries was ratified in the Philippine Senate on February 21, 2023. For the Philippines, the trade agreements with the rest of the RCEP member countries became effective on June 2, 2023.

RCEP generates trade creation effects within the partnership and trade diversion effects in non-participating countries. Using a global CGE model, Cororaton (2022) quantified the potential dynamic economic impacts from 2022 to 2031 by disaggregating the trade creation effects on the Philippines into: real GDP, commodity and factor prices, sectoral output, consumer welfare, and poverty. Missing in the analysis is the impact of greater access to cheaper inputs by producers within the partnership as a result of the trade agreements in RCEP. This paper addresses this gap by utilizing the results in Cororaton (2022) to analyze the global value chain effects on the Philippines using available tools. The results of the GVC analysis are that:

- Philippine exports of both intermediate inputs and final goods increase within RCEP as well as outside of the partnership. However, the improvement in Philippine exports within the partnership is relatively higher than in countries outside of the RCEP area.

- Philippine exports of non-food manufacturing improve the most (particularly electronic products). Exports of agriculture/food manufacturing increase as well, but the improvement is relatively smaller. However, the improvement is notable in exports of meat products, rice, and vegetables, fruits, and nuts.
- The trade agreement in RCEP results in higher Philippine exports—US$ 2.8 billion increase relative to the baseline in 2031[10]. This generates a significantly higher increase in Philippine domestic value added (US$ 2.4 billion) than foreign value added (US$ 403 million). The increase in the import contents of Philippine exports is marginal—US$ 413 million increase relative to the baseline.
- Within non-food manufacturing, the largest contributor to the improvement in the domestic value added is electronic products (US$ 1.6 billion or 13.6% relative to the baseline). The other non-food manufacturing sectors with notable improvement in value added are machinery equipment and transport equipment. Within agriculture/food manufacturing, all other food products and vegetables (including fruits and nuts) have relatively high value added generated as a result of higher exports. Within services, the biggest improvement in the value added is in trade, transport, communication, and other services.
- The value added needed to produce Philippine final goods consumed in all countries, including within the Philippines, improve. In terms of percentage increase relative to the baseline, the highest improvement in the value added to produce Philippine final goods consumed is in other RCEP countries (3.96%), followed by final goods absorbed in other ASEAN (3.83%). The value added needed to produce Philippine final goods consumed in non-RCEP countries improve as well by 2.32%.

Table 12. *Philippine Major Sectoral Value Added Needed to Produce Philippine Final Goods Consumed in all Countries/ Regions (2031 and 2027)*

	Sim 2031		Baseline 2031		% Change Sim vs Baseline	Sim 2027		Baseline 2027		% Change Sim vs Baseline
	US$ million	Share, %	US$ million	Share, %		US$ million	Share, %	US$ million	Share, %	
Agri/food manufacturing	132,720	27.0	131,071	27.1	1.26	108,017	24.8	107,067	24.8	0.89
Mining, including oil	9,026	1.8	9,099	1.9	-0.81	8,742	2.0	8,793	2.0	-0.58
Non-food manufacturing	40,733	8.3	38,664	8.0	5.35	39,293	9.0	38,154	8.8	2.98
Other industry	42,125	8.6	42,264	8.7	-0.33	41,407	9.5	41,551	9.6	-0.35
Services	266,999	54.3	262,549	54.3	1.69	238,873	54.7	236,317	54.7	1.08
Total	491,602	100.0	483,646	100.0	1.64	436,332	100.0	431,882	100.0	1.03

Source: Author's estimates

In sum, based on these results (including the findings highlighted in Cororaton 2022), Philippine participation in the regional trade agreements will not only generate trade creation effects that are consumer welfare-improving and poverty-reducing, it will also generate domestic value added that is far greater than foreign value added. Furthermore, the import content of Philippine exports is far less than the generated domestic value added.

Endnotes

[1] Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.

[2] Australia, China, Japan, South Korea, and New Zealand.

[3] Detailed discussion of MRIO is given in Miller and Blair (2009).

[4] World Bank Group, 2020

[5] GTAP is Global Trade Analysis Project

[6] The original GTAP 10 database has 65 commodities in 141 countries/regions.

[7] Sectoral tariffs and AVE of NTMs are on agriculture, mining, and manufacturing sectors only. The services sectors, utilities, and construction do not have these added costs.

[8] The GVC results in 2027 are available from the author.

[9] The exports value in Cororaton (2022) may differ from the export values here because, following Antimiani et al. (2018), the regional/country transport services which are part of exports are transferred to imports or buyers of exports (see Appendix B).

[10] RCEP scenario less baseline.

[11] Based heavily on Johnson (2017)

[12] Note that within the domestic economy in country s, the final demand and intermediate purchases are fs,s(i) and Zs,s(i,j), respectively.

[13] Adopted heavily from Antimiani et al. (2018)

References

Andriamananjara, S., Ferrantino, M., & Tsiagas, M. (2003). *Alternative approaches in estimating the economic effects of non-tariff measures: Results from newly quantified measures* (Office of Economics Working Paper 12-C). U.S. International Trade Commission.

Antimiani, A., Fusacchia, I., & Salvatici, L. (2018). GTAP-VA: An integrated tool for global value chain analysis. *Journal of Global Economic Analysis*, *3*(2), 69–105.

Cororaton, C. (2022). *Regional Comprehensive Economic Partnership (RCEP): Estimating the potential impact on the Philippine economy*. Philippine Department of Trade and Industry.

Foster, J., Greer, J., & Thorbecke, E. (1984). A class of decomposable poverty measures. *Econometrica*, *52*(3), 761–766. https://doi.org/10.2307/1913475

Johnson, R. (2017). *Measuring global value chains* (Working Paper No. 24027). National Bureau of Economic Research

Kee, H. L., Nicita, A., & Olarreaga, M. (2009). Estimating trade restrictiveness indices. *The Economic Journal, 119*(534), 172–199.

Martens, M. (2008). *Trade liberalization and foreign direct investment (FDI) in emerging countries: An empirical survey*. Unpublished Manuscript. Department of Economics, University of Montreal. https://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/Martens-trade-FDI-final.pdf

Miller, R., & Blair, P. (2009). *Input-output analysis: Foundations and extension*. Cambridge University Press.

Philippine Statistical Authority. 2018. "Family Income and Expenditure Survey".

Viner, J. (1950). *The customs union issue*. New York.

World Bank Group. (2020). *World development report: Trading for development in the age of global value chains*. International Bank for Reconstruction and Development/World Bank.

World Bank (2023). Countries|Data – World Bank Data https://data.worldbank.org/country

Appendix A. Trade in Value-Added[11]

A1. Global Input-Output

Let the index for sectors be $(i, j \in \{1, \dots, N\})$ and the $(s, r \in \{1, \dots, C\})$ countries/regions . wherein:

y_s *(i)* the value of gross output in industry *i* of *s*

$f_{s,r}$ *(i)* the value of final goods from industry *i* in *s* shipped to *r*

$Z_{s,r}$ *(i,j)* the value of intermediates from industry in used by industry *j* in *r*

The first accounting relationship describes how gross output from each country is used by final or intermediate purchases, that is,[12]

$$y_s(i) = \sum_r f_{s,r}(i) + \sum_r \sum_j Z_{s,r}(i,j) \qquad \text{(A1)}$$

The second accounting relationship defines value added as output less inputs used in production, that is,

$$v_s(i) = y_s(i) - \sum_r \sum_j Z_{r,s}(j,i) \qquad \text{(A2)}$$

Following Johnson (2017), the industry-by-industry, country-by-country output accounting equations are stacked to form a global input-output system. Thus, the output is stacked into the vector with dimension (*i x* 1) and whose block elements are y_s. The intermediate shipments are stacked into the matrix *Z* with dimension (*i x j*) and whose block elements are $Z_{s,r}$.The shipments of final goods are stacked into the vector *F* with dimension (*i x* 1) and whose block elements are $f_{s,r}$. Lastly, the value added are stacked into the vector with dimension (*i x* 1) and whose block elements are v_s.

Furthermore, the global matrix of technical coefficients is $A = Z\hat{y}^{-1}$ whose block elements are $A_{s,r} = Z_{s,r}\hat{y}_r^{-1}$, where $\hat{y}$ denotes a diagonal matrix with *y* along the diagonal.

Thus, the global input-output system is

$$y = Ay + Fi \qquad \text{(A3)}$$

$$v' = y' - i'A\hat{y} \qquad \text{(A4)}$$

where *i* denotes a conformable vector of ones.

A2. Value-Added Content in Final Goods

The gross output required to produced final goods is

$$\begin{bmatrix} \boldsymbol{y_1} \\ \boldsymbol{y_2} \end{bmatrix} = [\boldsymbol{I} - \boldsymbol{A}]^{-1}\boldsymbol{Fi} \qquad \text{(A5)}$$

where $[I - A]^{-1}$ is the Leontief Inverse of the global input-output matrix; $\boldsymbol{A} = \begin{bmatrix} \boldsymbol{A_{11}} & \boldsymbol{A_{12}} \\ \boldsymbol{A_{21}} & \boldsymbol{A_{22}} \end{bmatrix}$; and $\boldsymbol{F} = \begin{bmatrix} \boldsymbol{f_{11}} & \boldsymbol{f_{12}} \\ \boldsymbol{f_{21}} & \boldsymbol{f_{22}} \end{bmatrix}$

Thus, for any given vector of final goods *f* the vector of gross output from all countries and industries required to produce final goods is $[I - A]^{-1}f$, which includes both the value of final goods consumed within the countries and all intermediate inputs that are directly and indirectly used in producing those final goods.

The value added embodied in *f* is $\hat{v}\hat{y}^{-1}[I - A]^{-1}$., where $\hat{v}\hat{y}^{-1}$ is a matrix with value added to output ratios along the diagonal.

The value added from all countries needed to produce final goods consumed by country *r* is

$$\begin{bmatrix} \boldsymbol{va_{1r}} \\ \boldsymbol{va_{2r}} \end{bmatrix} = \boldsymbol{\hat{v}\hat{y}^{-1}}[\boldsymbol{I} - \boldsymbol{A}]^{-1} \begin{bmatrix} \boldsymbol{f_{1r}} \\ \boldsymbol{f_{2r}} \end{bmatrix} \qquad \text{(A6)}$$

where va_{2r} is the vector of industry value added from country *s* absorbed in country *r*. Johnson (2017) referred to va_{2r} as value-added exports because they track value added from the country of production to the country of consumption.

Furthermore, below is $gvc_{s,r}$ which gives the industry-level vector of value added from country embodied in final goods produced by *r*.

$$\begin{bmatrix} \boldsymbol{gvc_{1r}} \\ \boldsymbol{gvc_{2r}} \end{bmatrix} = \boldsymbol{\hat{v}\hat{y}^{-1}[I - A]^{-1}} \begin{bmatrix} \boldsymbol{f_{11} + f_{12}} \\ \boldsymbol{0} \end{bmatrix} \quad \text{(A7)}$$

Equation A7 allocates the value added embodied in final goods to the source countries along the global value chain that supply these goods.

A3. Value-Added Content in Gross Exports

To isolate exports for country 1, Equation A3 can be written as

$$\begin{bmatrix} \boldsymbol{y_1} \\ \boldsymbol{y_2} \end{bmatrix} = \begin{bmatrix} \boldsymbol{A_{11}} & \boldsymbol{0} \\ \boldsymbol{A_{21}} & \boldsymbol{A_{22}} \end{bmatrix} \begin{bmatrix} \boldsymbol{y_1} \\ \boldsymbol{y_2} \end{bmatrix} + \begin{bmatrix} \boldsymbol{f_{11}} & \boldsymbol{0} \\ \boldsymbol{f_{21}} & \boldsymbol{f_{22}} \end{bmatrix} \boldsymbol{i} + \begin{bmatrix} \boldsymbol{x_{12}} \\ \boldsymbol{0} \end{bmatrix} \quad \text{(A8)}$$

where $x_{12} = A_{12}y_2 + f_{12}$, which is exports. Thus, the expression in (A8) removes input shipments from country 1 to country 2 ($A_{12}y_2$) from the global input-output matrix x_{12} and places them in exports and leaving the modified matrix $\boldsymbol{A}^* = \begin{bmatrix} \boldsymbol{A_{11}} & \boldsymbol{0} \\ \boldsymbol{A_{21}} & \boldsymbol{A_{22}} \end{bmatrix}$. Also, in the final demand matrix f_{12} is removed and added it to x_{12}. Thus, the final demand matrix is $\boldsymbol{F}^* = \begin{bmatrix} \boldsymbol{f_{11}} & \boldsymbol{0} \\ \boldsymbol{f_{21}} & \boldsymbol{f_{22}} \end{bmatrix}$.

Equation A8 can be modified to compute the value-added context embodied in a country's exports. That is,

$$\begin{bmatrix} \boldsymbol{xc_{11}} \\ \boldsymbol{xc_{21}} \end{bmatrix} = \boldsymbol{\hat{v}\hat{y}^{-1}[I - A^*]^{-1}} \begin{bmatrix} \boldsymbol{x_{12}} \\ \boldsymbol{0} \end{bmatrix} = \begin{bmatrix} \boldsymbol{\hat{v}\hat{y}^{-1}[I - A_{11}]^{-1}x_{12}} \\ \boldsymbol{\hat{v}_2\hat{y}_2^{-1}[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12}} \end{bmatrix} \quad \text{(A9)}$$

where xc_{ij} is the industry-level vector of value added from country *i* needed to produce exports of country *j*. Adding up across industries, the total amount of *domestic* value added embodied in country 1's exports is $i'xc_{11}$, and the total *foreign* value added to country 1's exports is $i'xc_{21}$.

To understand Equation A9, note that $[I - A_{11}]^{-1}x_{12}$ is the vector of country 1 output required to produce its exports; $A_{21}[I - A_{11}]^{-1}x_{12}$ the vector of imported intermediate inputs in the production of its exports; and $[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12}$ the vector of foreign output needed to produce those imported by country 1. Thus, $\hat{v}_2\hat{y}_2^{-1}[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12}$ is the vector of country 2 value added required to produce exports of country 1.

Johnson (2017) defined vertical specialization trade (*VS*) as

$$VS = i'A_{21}[I - A_{11}]^{-1}x_{12} \quad \text{(A10)}$$

The domestic content of exports (*DC*) is exports (x_{12} in Equation A8) less the import content of exports, that is,

$$\begin{aligned} DC = i'x_{12} - VS &= i'[I - A_{11} - A_{21}][I - A_{11}]^{-1}x_{12} \\ &= i'\hat{v}_1\hat{y}_1^{-1}[I - A_{11}]^{-1}x_{12} = i'xc_{11} \end{aligned} \quad \text{(A11)}$$

The import content of exports can further be disentangled.

$$VS = VS + [i'xc_{21} - i'xc_{21}] = i'xc_{21} + [VS - i'xc_{21}] \quad \text{(A12)}$$

Using Equations A10 and A9, Equation A12 becomes

$$\boldsymbol{VS = i'xc_{21} + \left[i'A_{21}[I - A_{11}]^{-1}x_{12} - \hat{v}_2\hat{y}_2^{-1}[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12}\right]} \quad \text{(A13)}$$

Equation A13 can be simplified as

$$VS = i'xc_{21} + i'A_{12}[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12} \quad \text{(A14)}$$

In sum, gross exports in Equation A8 can be decomposed as follows

$$\begin{aligned} i'x_{12} = {} & i'xc_{11} + i'xc_{21} + \\ & i'A_{12}[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12} \end{aligned} \quad \text{(A15)}$$

where:

$i'xc_{11}$: domestic value added

$i'xc_{21}$:: foreign value added

$i'xc_{21} + i'A_{12}[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12}$: import contents of exports

$i'A_{12}[I - A_{22}]^{-1}A_{21}[I - A_{11}]^{-1}x_{12}$: double-counting residuals

Thus, Equation A15 decomposes exports into domestic value-added content and import context; the latter, in turn, is decomposed into foreign value-added contest and a double-counting residual resulting from round-trip trade inputs.

Appendix B. Extending Global CGE Model to Analyze Global Value Chains[13]

Let the index for sectors be $i, j \in \{1, \dots, N\}$, and the countries and regions $s, r \in \{1, \dots, C\}$. In the CGE model, there are three agents: domestic producers (*d*), private consumers (*p*), and government (*g*).

In country/region *r*, the sum of the value of imports demanded for commodity *i* (sector *i*) by sector *j*, by private consumers for consumption, by the government, and by for investment purposes is equal to the value of exports of the commodity *i* by country/region *s*. This is a balancing constraint.

$$vxmd_i^{s,r} = \sum_j vifms_{i,j}^{s,r} + vipms_i^{s,r} + vigms_i^{s,r} \qquad \text{(B1)}$$

where:

$vxmd_i^{s,r}$: value of exports of from region/country *s* to *r* (market prices)
$vifms_{i,j}^{s,r}$: value of purchases of imports *i* from *s* for use by *j* in *r* (market prices)
$vipms_i^{s,r}$: value of purchases of imports *i* from *s* for private consumption in *r* (market prices)
$vigms_i^{s,r}$: value of purchases of imports *i* from *s* for government consumption in *r* (market prices)

The value of output of sector in country/region *s* (vom_i^s) is

$$\begin{aligned} vom_i^s = {} & \sum_j vdfm_{i,j}^s + vdpm_i^s + \\ & vdgm_i^s + vdfm_{i,cgds}^s + \sum_j \sum_r vif \\ & \sum_r vigms_i^{s,r} + \sum_j vifms_{i,cgds}^{s,r} + vst_i^s \end{aligned} \qquad \text{(B2)}$$

where:

$vdfm_{i,j}^s$: value of intermediate demand for domestic good *i* by sector *j* in *s*
$vdpm_i^s$: value of final demand for domestic good *i* by private households in *s*
$vdgm_i^s$: value final demand for domestic good **i** by the government in *s*
$vdfm_{i,cdgs}^s$: value of final demand for domestic good *i* for investment purposes in *s*
$vifms_{i,j}^{s,r}$: value of intermediate demand for imported good *i* from *r* by sector *j* in *s*
$vipms_i^{s,r}$: value of final demand for imported good *i* from *r* by private households in *s*
$vigms_i^{s,r}$: value of final demand for imported good *i* from *r* by the government in *s*
$vifm_{i,cdgs}^{s,r}$: value of final demand for imported good *i* from *r* for investment purposes in *s*
vst_i^s: value of exports of region to the international transport sector *i*. In the GTAP database, the international transport margins are produced by the transport sector of exporting country, thus added in Equation B2.

In the GTAP database, the breakdown is available for the intermediate demand for *i* by *j* in *r* between internationally and domestically sourced (right hand side of Equation B1). Similar breakdown is available for the final demand for private consumption, government consumption, and investment. However, there is no similar disaggregation in the export of *s* of commodity *i* to *r* (left hand side of the Equation B1). To disaggregate exports, the values of imports at the base are used. Thus, the value of intermediate input *i* from *s* for use by *j* in *r* ($vxims_{i,j}^{s,r}$), we have

$$vxims_{i,j}^{s,r} = shifm_{i,j}^s * vxmd_i^{s,r} \qquad \text{(B3)}$$

where $shifm_{i,j}^s$ in the share of imports *i* used in sector in country/region *r* (calculated using the base values in the GTAP database); and $vxmd_i^{s,r}$ the value of exports of *i* from *s* to *r*.

The value of private consumption of commodity *i* in *r* imported from *s* ($vxpms_i^{s,r}$) is

$$vxpms_i^{s,r} = shipm_i^s * vxmd_i^{s,r} \qquad \text{(B4)}$$

where $shipm_{i,j}^s$ in the share of imports of *i* by private consumers in country/region *r* (calculated also using the base values in the GTAP database).

The value of government consumption of *i* commodity *r* in imported from *s* ($vxgms_i^{s,r}$) is

$$vxgms_i^{s,r} = shigm_i^s * vxmd_i^{s,r} \qquad \text{(B5)}$$

where $shigm_{i,j}^s$ in the share of imports of *i* by government in country/region *r* (calculated also using the base values in the GTAP database).

The value of investment expenditure of *i* in *r* imported from *s* ($vxims_{i,cdgs}^{s,r}$) is

$$vxims_{i,cdgs}^{s,r} = shifm_{i,cdgs}^{s} * vxmd_{i}^{s,r} \quad \text{(B6)}$$

where $shigm_{i,j}^{s}$ in the share of imports of i by government in country/region r (calculated also using the base values in the GTAP database).

The sum of the shares in Equations B3 to B6 is equal to 1.

$$\sum_{j}^{n} shifm_{i,j}^{s} + shipm_{i}^{s} + shigm_{i}^{s} + shifm_{i,cdgs}^{s} = 1 \quad \text{(B7)}$$

In the GTAP database, regional/country transport services are not associated with particular commodities and routes. Following Antimiani et al. (2018), each use of the international transport pool is proportionally distributed over each supplier. This is done by applying the regional/country shares of exports on the transport pool to the international transportation margin defined over j and routes from r to s, that is

$$vste_{i,j}^{s,r} = \frac{vst_{i}^{s}}{\sum_{s} vst_{i}^{s}} \sum_{r} vtwr_{i,j}^{r,s} \quad \text{(B8)}$$

where $vtwr_{i,j}^{r,s}$ is the international transportation margin. Furthermore, the zero profit condition in the international transport sector leads to

$$\sum_{j} \sum_{r} vste_{i,j}^{s,r} = vst_{i}^{s} \quad \text{(B9)}$$

The total value of intermediate demand ($int_{i,j}^{s,r}$) is

$$int_{i,j}^{s,r} = vdfm_{i,j}^{s} + vifms_{i,j}^{s,r} + vste_{i,j}^{s,r} \quad \text{(B10)}$$

The total value of final demand ($fin_{i}^{s,r}$) is

$$\begin{aligned} fin_{i}^{s,r} &= vdpm_{i}^{s} + vdgm_{i}^{s} + vdpm_{i}^{s} \\ &+ vdfm_{i,cdgs}^{s} + vipms_{i}^{s,r} + vigms_{i}^{s,r} + vifm_{i,cdgs}^{s,r} \end{aligned} \quad \text{(B11)}$$

The total value of imports ($vims_{i}^{s,r}$) of i of region/country s from r is

$$\begin{aligned} vims_{i}^{s,r} &= \sum_{j} \sum_{r} vifms_{i,j}^{s,r} + \sum_{r} vipms_{i}^{s,r} \\ &+ \sum_{r} vigms_{i}^{s,r} + vst_{i}^{s} \end{aligned} \quad \text{(B12)}$$

Substitute Equations B10 and B11 into Equation (B2), the value of output of s in r becomes

$$vom_{i}^{s} = \sum_{j} \sum_{r} int_{i,j}^{s,r} + \sum_{r} fin_{i}^{s,r} \quad \text{(B13)}$$

Note that the vom_{i}^{s} in Equation B13 is the row sum of an IO table, that is the sum of intermediate demand across (either home or abroad) j in s, and the sum of final demand for i across agents in s is the value of output of i in s.

The matric of technical coefficients (A) is

$$a_{i,j}^{s,r} = \frac{int_{i,j}^{s,r}}{vom_{i}^{r}} \quad \text{(B14)}$$

The matrix of technical coefficients has a dimension ($NCxNC$) N is the number of commodities/sectors and number of regions/countries. With Equation B14, the value of output Equation B13 can be written as

$$vom_{i}^{s} = \sum_{j} \sum_{r} a_{i,j}^{s,r} * vom_{j}^{r} + \sum_{r} fin_{i}^{s,r} \quad \text{(B15)}$$

In block matrix form (30) is written as

$$\begin{bmatrix} VOM^{1} \\ \vdots \\ VOM^{C} \end{bmatrix} = \begin{bmatrix} A^{11} & \dots & A^{1C} \\ \vdots & \ddots & \vdots \\ A^{C1} & \dots & A^{CC} \end{bmatrix} \begin{bmatrix} VOM^{1} \\ \vdots \\ VOM^{C} \end{bmatrix} + \begin{bmatrix} FIN^{11} & \dots & FIN^{1C} \\ \vdots & \ddots & \vdots \\ FIN^{C1} & \dots & FIN^{CC} \end{bmatrix} \quad \text{(B16)}$$

The matrix of value of output can also be written as

$$\begin{bmatrix} VOM^{1} \\ \vdots \\ VOM^{C} \end{bmatrix} = \begin{bmatrix} I - A^{11} & \dots & -A^{1C} \\ \vdots & \ddots & \vdots \\ -A^{C1} & \dots & I - A^{CC} \end{bmatrix}^{-1} + \begin{bmatrix} FIN^{11} & \dots & FIN^{1C} \\ \vdots & \ddots & \vdots \\ FIN^{C1} & \dots & FIN^{CC} \end{bmatrix} \quad \text{(B17)}$$

where I is an identity matrix with dimension ($NCxNC$). Equation B17 can also be written as

$$\begin{bmatrix} VOM^{1} \\ \vdots \\ VOM^{C} \end{bmatrix} = \begin{bmatrix} L^{11} & \dots & L^{1C} \\ \vdots & \ddots & \vdots \\ L^{C1} & \dots & L^{CC} \end{bmatrix} \begin{bmatrix} FIN^{11} & \dots & FIN^{1C} \\ \vdots & \ddots & \vdots \\ FIN^{C1} & \dots & FIN^{CC} \end{bmatrix} \quad \text{(B18)}$$

where $L = (I - A)^{-1}$ is the global Leontief inverse (multiplier) matrix, which gives the total requirement of output directly and indirectly required to produce one unit of consumption.

Output net of intermediate usage gives the composite value added originated in each producing sector for each economy. The sectoral value-added shares for region/country *s* is

$$vash_j^s = \frac{\left(vom_j^s - \sum_j \sum_r int_{i,j}^{s,r}\right)}{vom_j^s} \tag{B19}$$

Define a (*NCxNC*) diagonal matrix ($\widehat{VASH}$) where the elements in the main diagonal are $vash_j^s$; and the off-diagonal zero. The value-added multiplier matrix is

$$\widehat{VASH} = \begin{bmatrix} VASH^1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & VASH^C \end{bmatrix} \begin{bmatrix} L^{11} & \dots & L^{1C} \\ \vdots & \ddots & \vdots \\ L^{C1} & \dots & L^{CC} \end{bmatrix}$$
$$= \begin{bmatrix} VASH^1 L^{11} & \dots & VASH^1 L^{1C} \\ \vdots & \ddots & \vdots \\ VASH^C L^{C1} & \dots & VASH^C L^{CC} \end{bmatrix} \tag{B20}$$

The sum over all sector/country sources in the value-added multiplier is unity because all values in the production of a unit output is either domestic or foreign. That is,

$$\sum_i \sum_r vash_i^r l_{i,j}^{r,s} = 1 \tag{B21}$$