A Computational Approach for Global Trade Analysis Sensitive to Free Trade Agreement Circumstances: A Case Study Focusing on the Great Mekong Subregion

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Abstract

In the Global Trade Analysis Project (GTAP), GDP and economic statistical indices can be analyzed for forecasting future trends in multiple countries by using the GTAP database and GEMPACK utilities, which realize the numerical calculation based on the concept of Computable General Equilibrium (CGE) models. Even with such well-prepared tools with the official database, appropriate forecasting is still difficult due to the sensitivity of the Free Trade Agreement (FTA) circumstances. FTA scenarios with a uniform tariff reduction can be assumed in general, while an abrupt and unreasonable change may occur in the simulation depending on the network structure of trading countries and the upper and lower bounds of tariffs in the time course. In the present study, we focused on the Great Mekong subregion (GMS) and explored possible methods to calculate substantially.

Keywords: computable general equilibrium (CGE), General Equilibrium Modelling PACKage (GEMPACK), Global Trade Analysis Project (GTAP), Free trade agreements (FTA).

1. Introduction

Computable General Equilibrium (CGE) analysis has emerged as a competitive tool for policy evaluation. Its widespread application includes research on trade policy, regional infrastructure development, and environmental protection. However, challenges in the technical implementations explained in [1], [2], [3], data preparation, and interpreting the simulation results pose significant burdens in the current state of CGE modeling. To lower this technical barrier involved, this research investigates the roadmap to handle the implementation of the GTAP model. It discusses preparing data and measures the effect of altering the growth rates and reduction in the tariff value. Moreover, it forecasts the changes in the real GDP among the countries in the Great Mekong subregion (China, Lao-PDR, Myanmar, Vietnam, Thailand, and Cambodia).

2. Methodology

2.1. *Simulation environment*

2.1.1. General Equilibrium Modelling PACKage (GEMPACK)

One of the fundamental characteristics of the CGE models is their computational capability, specifically, they can generate numerical solutions to shocks (changes) using the provided database and parameters. GEMPACK short for General Equilibrium Modelling Package is a set of software created for solving applied general equilibrium models. This package comprises various tools for managing economic models, databases, and simulations. In GEMPACK, data is typically presented in the format of HAR files, which are header-array files capable of storing multiple numeric and string arrays with dimension labels, accommodating up to seven dimensions. The outcome of the simulation is also multiple HAR files or solution files (e.g., .slc, .sl4) can be saved in header files.

2.1.2. Modifying header files

It is often required to adjust the input parameters, shock files, and process the model's outputs, and that involves modifying the data within header files. The conventional approach for handling HAR files has been to employ executable programs provided by GEMPACK (e.g., seehar.exe or modhar.exe). However, utilizing these programs may pose a challenge. Manual transfer of data between HAR files and data editing software (e.g., Excel) using a basic clipboard method is also a common practice. However, this process is highly manual, time-consuming, and prone to errors. Another approach for modifying HAR files is to create a data manipulation TABLO Input file using ViewHAR. That can be done by exporting the header file as a TABLO Code from the Export menu within the ViewHAR program. This process automatically generates the foundational code, which can be further edited using the Tablo language to include specific filenames, formulas, updates, assertions, and other adjustments tailored to the model's requirements. In addition, this approach requires creating a Command file (CMF) to define the input, output, and auxiliary file. This can also be generated automatically through the menu (view/Create CMF) within the Tablo file (.tab file).

2.1.3. Executing a model in GEMPACK

GEMPACK compiles a model by interpreting a model written in the TABLO language into a system of equations and generating an executable file (e.g., ‘gtapv7.exe‘). Users must specify the endogenous and exogenous variables, along with the chosen solution method (e.g. Gragg, Johansen, Euler, 1,3,5 steps) in the CMF file. Subsequently, the model is executed, and the coefficients of the model are filled with the actual data. The simulation generates a set of files (.tab, .cmf, .exe, .sl4, .slc, .har) associated with the model. To retrieve the solution, users can utilize ViewSol, AnalyzeGE, or ViewHAR to access data in '.slc' and '.sl4' files.

2.2. *Data and Model Preparation*

2.2.1. GTAP Database

The GTAP-RD model is calibrated to the most recent database produced by the Global Trade Analysis Project GTAP database version 11 [2]. The database GTAP 11 reconciles different data sources at a global scale and offers a time series of 5 reference years (2004, 2007, 2011, 2014, and 2017), distinguishing 65 sectors in each of 141 countries and 19 aggregate regions [4]. The GTAP database is typically supplied in the default format of the HAR file (flows file, parameters, sets,..etc). This database has been precisely adjusted to achieve equilibrium in the world’s initial state [5].

2.2.2. The GTAP-RD model

This study uses GTAP-RD, a dynamic multi-region model that is described in detail in [6]. GTAP-RD model was built on the latest GTAP 7 framework [7] and offers features including, capital accumulation, and international capital and investment mobility. In addition, GTAP-RD offers flexibility in terms of closures as well as a more convenient way to perform a modification to the model due to consistent variables, coefficients, and equation-naming conventions.

2.3. *Forecasting Process*

Quantitative policy analysis is typically framed within the confines of a specific scenario (numerical projection). This scenario assumes that the economy will be affected by future adjustments in the macroeconomic forecasts of each country and the expected policy changes. The baseline scenario provides a reference point for evaluating the impact of policy changes [3] and should reflect as closely as possible the changes expected to occur in the world economy. For example, FTAs that are already in effect [8]. In most baselines, external information about certain future trends of the macroeconomic drivers, for example, population, labor force growth, and other drivers are taken from external projections, such as the United Nations Population Division, World Bank, IMF, OECD, CEPII…, etc.). The forecasts gathered from the mentioned sources may lack information and may not align. This necessitates some processing to guarantee the availability of data for all countries and relevant years. Shaping a baseline is important for long-term economic issues, such as climate change, the Intergovernmental Panel on Climate Change (IPCC) has created standard scenarios for future greenhouse gas (GHG) emissions so-called Shared Socioeconomic Pathways (SSPs). The SSPs are five scenarios that form a consistent set of socioeconomic drivers widely used in the climate modeling community, and also in the broader global modeling community [3].

2.3.1. Simulation design and policy scenarios

The baseline projection runs from 2017 to 2050 and includes past data and projections for growth in real GDP, population, and the skilled and unskilled labor supply for all regions. The baseline projection data comes from the Shared Social-Economic Pathways (SSP) database macro forecasts for 230 countries for the period of 2007-2100. This paper uses the SSP2 projections for the baseline (business-as-usual scenario). In the baseline scenario, we did not incorporate policy changes caused by existing and ongoing FTAs. Absence of the policy changes in the baseline may affect the simulation results of the policy scenarios [9]. The baseline projection is run under the default GTAP-RD closure for all regions and to make the GTAP model follow a chosen growth path, real GDP (qgdp) is swapped with the region-wide technological change (afereg) to be calculated endogenously. In subsequent model runs, technological change are then maintained at those estimated levels, while GDP is endogenously computed in the base rerun.

The study focuses on global logistics in Southeast Asia and the Great Mekong subregion, and therefore, countries in this area are the targets of the analysis and are treated as individual countries. Countries in other regions are consolidated into regional units, with each treated as a hypothetical country in the GTAP Model.

We aggregated the GTAP database to 25 countries/regions and 10 sectors (Table 1) The region of the rest of Southeast Asia contains Myanmar and East Timor after making all the other countries in this region as individual countries.

Table 1. Regional aggregation of the GTAP Data Base.

NO	***ID***	***COUNTRY/REGION***	***NO.***	***ID***	***COUNTRY/REGION***
1	lao	Lao-PDR	14	ind	INDIA
2	chn	China	15	aus	India
3	tha	Thailand	16	nzl	Australia
4	khm	Cambodia	17	xoc	New Zealand
5	vnm	Vietnam	18	sas	Oceania
6	mmr	Myanmar, East Timor	19	eas	East Asia
7	phl	Philippines	20	nwa	North America
8	idn	Indonesia	21	lam	Latin America
9	mys	Malaysia	22	wer	Western Europ
10	brn	Brunei	23	men	Middle East
11	sgp	Singapore	24	ssa	Sub-Saharan and North Africa
12	jpn	Japan	25	row	Rest of World
13	kor	South Korea			

The analysis begins with the 2017 GTAP database serving as the base year (Fig. 1). It shifts forward by three years to establish 2020 as the benchmark year. Subsequently, for each period, there is a five-year increment until reaching the year 2050 in all scenarios.

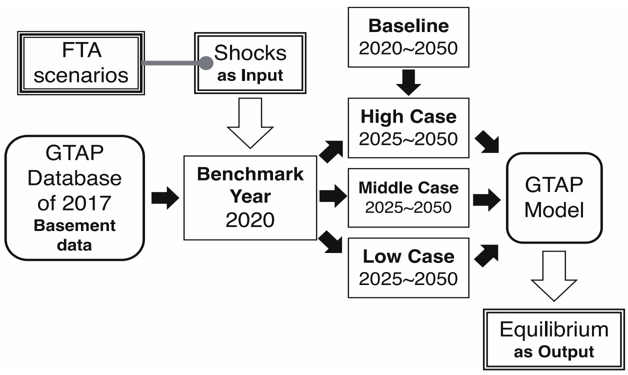

Fig. 1. Forecasting Process and sequence of years

We utilized the GTAP-RD aggregation utility database [10] by making the necessary adjustments to align it with GTAP database version 11. This involved modifying the region mapping from the original 230 countries to fit the 160 countries of the GTAP database and aggregate years to match the relevant years in the study.

Scenario 1 (High Case): The SSP5 scenario percent change for each of real GDP (qgdp), Population (pop), skilled and unskilled labor qe(ENDWL,REG) is applied as target shocks to the years from 2025~2050. In addition, import tariff within the six regions in the GMS area was reduced gradually in the S1 Scenario but maintained between the rest of the world and GMS regions. The reduction periods are as follows (Table 2):

Table 2. Tariff Reduction Schedule between the GMS countries.

Period	Percent change
(2020~2025)→	-20%
(2025~2030)→	-20%

(2030~2035)→	-20%
(2035~2040)→	-40%

It is improbable that an agreement would lead to the complete removal of all import barriers, and therefore, this experiment provides an upper bound for the benefits of a free trade agreement that can be captured by the model.
To control the change in the tariff, we used the "rate%" function in the CMF file of the shocks as a policy file after associating the new levels variable TMS_L (power of import tariff) Eq. (1) with the previously declared linear variable tms in the GTAP model [2].

$$TMS\_L(c,s,d) = VMSB(c,s,d)/VCIF(c,s,d) \quad (1)$$

VMSB: the value of imports of commodity c from s to d at domestic (basic) prices.
VCIF: the value of imports of c from s to d at CIF prices (tradeable only).

After adding the level variable TMS_L, it is possible to model the removal of all import taxes by utilizing the "final_level" function Eq. (2) from GEMPACK as follows:

$$Final\_level \;\; TMS\_L(COMM, GREG, GREG) = uniform\ 1\ ; \quad (2)$$

This function will remove the import taxes; thereby ad valorem (tariff rate) is equal to zero and the power level of the tariff is equal to one from the year 2040 in the S1 scenario. The uniform reduction in the tariff rate is applied to all commodities within the six countries and regions in the Great Mekong subregion by making a new region set GREG in the model to contain the GMS countries.

Scenario 2 (Low Case): The SSP4 scenario for the percent changes in the real GDP, population, and labor force are implemented for the years 2025~2050. This scenario takes a pessimistic stance on the advancement of a trade agreement, envisioning no reduction, and predicts a modest growth rate.

3. Results and Discussion

3.1. *Estimated Gross domestic product growth*

The estimated values of real GDP are displayed in Fig 2. As described in Section 2.3.1, It is exogenously given in the baseline scenario. Looking at the high case the increments in the value of GDP come from the benefit of changes in the tariff reduction and the increase in the total factor of production growth rate in the remarkable countries.

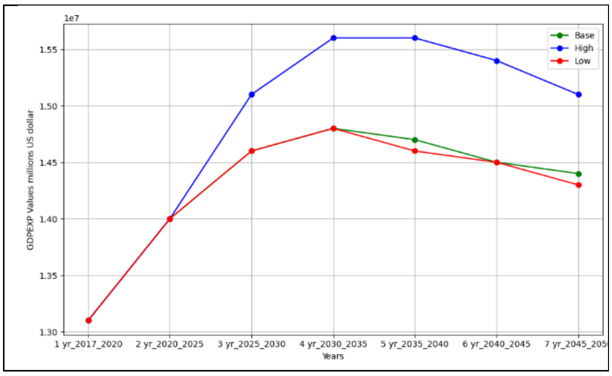

Fig.2. GDP value change in GMS countries

4. Conclusion

In this study, the authors employed the GTAP model to estimate the future GDP value in the Great Mekong subregion area. The study delves into the technical intricacy of implementing modifications in the growth rate and reduction of the tariff rate. It simulates a free trade agreement among the involved countries.

Subsequently, the authors intend to expand the range of Free trade agreements, encompassing the agreements currently in force in the baseline scenario. Additionally, they plan to refine the calibration to the growth rate in the GMS area.

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