A Computational Approach for Global Trade Analysis in Korea Contributing to the Forecasting of Future Efficacy in Global and Domestic Korean Transportations

Bo-Young Lee
Logistics Revolution Korea Co. Ltd.,5th FI. 47, Gangnam-daero 101-gil, Seocho-gu, Seoul 06034, Republic of Korea

Ahmad Altaweel
Kyushu Institute of Technology, 2-4 Hibikino, Wakamatsu-ku, Kitakyushu, 808-0196, Japan

Kazuhito Mine
School of Computer Science and Systems Engineering, Kyushu Institute of Technology 680-4 Kawazu, Iizuka-shi, Fukuoka, 820-8502, Japan

Jang-Sok Yoon
Logistics Revolution Korea Co., Ltd. 5th FI. 47, Gangnam-daero 101-gil, Seocho-gu, Seoul 06034, Republic of Korea

Hiroaki Wagatsuma
Kyushu Institute of Technology, 2-4 Hibikino, Wakamatsu-ku, Kitakyushu, 808-0196, Japan
Email: bylee@logisroad.com, {altaweel.ahmad770, mine.kazuhito139}@mail.kyutech.jp, kjsyoon@logisroad.com, waga@brain.kyutech.ac.jp

Abstract

Economic forecasting studies are integral for shaping strategic policy decisions by providing data-driven insights that guide resource allocation, logistics and transportation, and long-term planning. This study investigate the trade dynamics of the Republic of Korea through the Global Trade Analysis Project Recursive dynamic GTAP-RD model with the GTAP v11 database to forecast economic scenarios and Shared Socioeconomic Pathways (SSPs) serve as growth trajectories. The analysis centers on the Republic of Korea's key trading partners, as identified by the GTAP database, and top trading sectors from the Korea Transport Database (KTDB) to compare the key influencers on Korea's trade thereby providing deeper strategic economic planning. This study investigates further the involvement of Korea's logistics and transportation by focusing on changes in import/export tonnage to inform infrastructure planning and strategic transport development. The evaluation of Korea's trade in the global context is of the essence to ensure adaptive logistics, backing economic resilience, and aligning with changeable global trade conditions.

Keywords: Computable general equilibrium (CGE), General Equilibrium Modelling PACKage (GEMPACK), Global Trade Analysis Project Recursive Dynamic (GTAP-RD)

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1. Introduction

Computable General Equilibrium (CGE) Models have emerged as competitive tools for policy evaluation. Their widespread applications include research on trade policy, regional infrastructure development, and environmental protection. Developments and investments in the Republic of Korea's infrastructure require a meticulous economic analysis to build a data driven decisions based on a clear vision. In this study, we focus on forecasting economic quantities that have an impact on the development of transportation infrastructure in the Republic of Korea (ROK). The method used in the research guarantees a wide range of economic trajectories to extract insights about Korean economic development in the context of global changes. This supports a reliable evaluation of the uncertainty in future narratives.

The main objectives of the study are to forecast the values of bilateral trade of the Republic of Korea using the Global Trade Analysis Project Recursive dynamic model GTAP-RD [4] and the latest version of the GTAP database ver. 11 [1] with 2017 as a reference year. In addition, by implementing the forecasting changes from the GTAP-RD model which represents the global changes based on the Shared Socioeconomic Pathway narratives [6], we calculated the bilateral Volume of the Export and Import starting from the volume of commodities extracted from the Korean transportation database KTDB [8]. This study serves as a standing point for decision makers in their efforts for data informed strategies. The methodology section outlines the modeling procedure and utilized database, while section 2.2 describes the experimental setup of the baseline and policy Scenarios. Section 3 presents the results and Section 4 concludes the study and findings.

2. Methodology

2.1. Model and Database Preparation and Tools

First developed in 1992, the Global Trade Analysis Project GTAP model has become the de facto standard and starting point for many economy-wide analyses of global trade issues. The first full documentation of the GTAP model became available in Hertel's book [2]. also, the dynamic extension of the GTAP model has been included in a dynamic version, called GDyn, which is described in [3], and Global Trade Analysis Project Recursive Dynamic GTAP-RD the so-called WTO Global Trade Model [4] which we use in this study to forecast the trade dynamic of the Republic of Korea. Within the model, each region has its own economy, and the regions are linked through inter-regional trade flows. In each region, firms perform production activity using a multi-level, nesting production structure. Top-level nesting, lower-level nesting structure, and bottom-level nesting [5].

In this study, we use the GTAP Database which integrates diverse data sources on a global scale, providing a rich dataset on value transactions, quantities, and various tax instruments across time, making it a cornerstone for studies on global economic issues. Version 11 of GTAP includes time series data for five reference years across 65 economic sectors within a total of 160 countries and broader regions. This coverage captures more than 95 % of the world's Gross Domestic Product (GDP) and population [1]. All quantities are measured in millions of current U.S. dollars for the year of the database. The most recent updates of the GTAP database represent the year 2017 serving as a reference year for the equilibrium of the GTAP-RD model at the beginning year of this study.

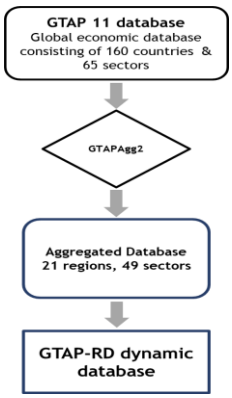

Fig. 1. Regional and Sectors Aggregation flow chart

Since our study focuses on the Republic of Korea, we compiled the top sixteen countries from the GTAP database and selected the top 10 trade export and import partners. In Table 1, we aggregated the regions accordingly using the GTAPAgg2 and the GTAP-RD Data Aggregation Utility [9] as illustrated in Fig. 1. In addition, The 65 sectors in the GTAP Database are combined according to an aggregation scheme of only 24 sectors aggregated into 8 broader categories while retaining the remaining 41 sectors as distinct sectors. The selected aggregation scheme of the 65 GTAP database into the 49-sector aggregation offers a highly granular view of the economy, providing a more detailed breakdown of economic activities.

Table 1. Aggregation of GTAP database vr.11 into 21 region

NO	COUNTRY/REGION	NO.	COUNTRY/REGION	NO.	COUNTRY/REGION
1	South Korea	9	India	17	South Asia
2	China	10	Singapore	18	East Asia
3	United States of America	11	Russia	19	Sub-Saharan and North Africa
4	Japan	12	Southeast Asia	20	Oceania
5	Taiwan	13	Middle East	21	Rest of World
6	Australia	14	Western Europe		
7	Germany	15	Latin America		
8	Saudia Arabia	16	North and Central America		

All tools used in this study are part of the General equilibrium modeling package GEMPACK [7].

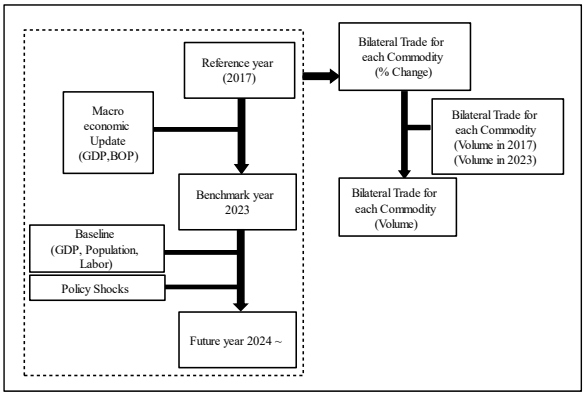

Fig. 2. The Process of Calculating Volume and Value of Bilateral Trade for the Republic of Korea

2.2. Baseline and Policy Scenarios

In the experimental setup, we define closures for different periods of the study to control specific model variables. The closures used are as follows: 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). In the policy closure, we swap the slack variable in the closure(cgdslack) with the trade balance as a percentage of the world income

(del_tbalry) for the Southeast Asia which includes Vietnam. During the period from 2017 to 2023, the changes in GDP growth are based on data from the International Monetary Fund (IMF) [10]. In the baseline run, we assumed that the changes in the economic variables follow the projections of the SSP2 (Shared Socioeconomic Pathway 2) narrative [6]. This approach aligns the baseline scenario with moderate socioeconomic growth assumptions to represent the business as usual. The economic variables that constitute the shock values are population changes, real GDP, and labor. They are sourced from GTAP-RD Data Aggregation Utility [9] which contains the SSP scenarios after adjustments to align with the GEMPACK environment. This data simulates projections of SSP narratives for different growth assumptions about the global economy as policy scenarios. Considering timeline of the forecasting that shown in Fig. 3, we focused solely on the change in GDP growth rate from 2017 to 2023 to update the economic model. In this case, we assumed a fixed trade balance during this period, with no changes in the trade balance as a percentage of the world income, implying that the trade balance remained constant from 2017 to 2023.

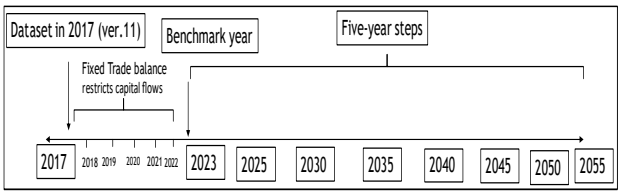

Fig. 3. Temporal Framework of the Forecasting Process

3. Results and Discussion

3.1. Forecasting Trade Values and Volume

The GTAP-RD model ensures that changes in bilateral trade, both exports and imports, for each commodity are reported as nominal values, meaning they reflect changes in both quantity and price. However, our study focuses on reporting the changes in bilateral trade in terms of real quantities, isolating the effect of price and capturing the actual volume changes. Therefore, we use the accumulated percentage change in quantity (qxs) for each commodity and multiply it by the bilateral trade values in free on board prices (VFOB) from the base year (2017). This allows us to express the trade values in base-year prices, specifically 2017 prices reported in millions of USD.

Fig. 4 shows the values of total export from the Republic of Korea to the global economy for all commodities by using SSP narratives assuming the SSP2 is the baseline for comparison to bridge the gap of uncertainty regarding the future development of economies. Similarly, Fig. 5 illustrates the values of imports from the year 2017 till 2055, the final year of the study.

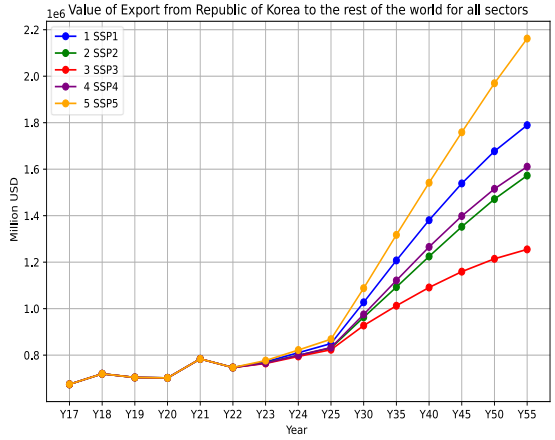

Fig. 4. Export from the Republic of Korea in Million USD

In line with the flowchart Fig. 2, we calculated the bilateral trade volume in tons for all goods (all GTAP database sectors except services) using data from the Korea Transport Database (KTDB) [8].

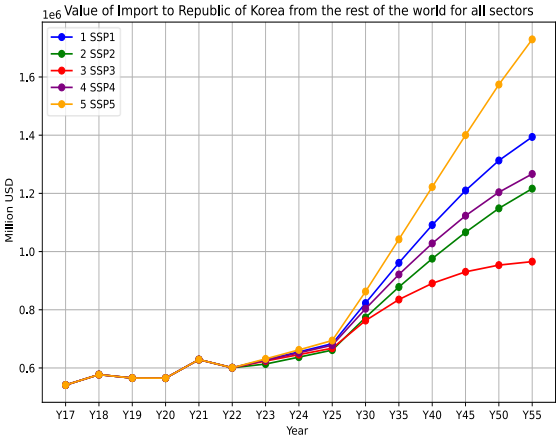

Fig. 5. Value of Import to the Republic of Korea from the rest of the world for all sectors

The following figures Fig. 6 and Fig. 7 compare the trade volume for the Republic of Korea, the calculation is based on the accumulated percentage change in the quantity of bilateral trade from the GTAP-RD model and the bilateral trade volume for each commodity expressed in tons for both 2017 and 2023 as a base year of the calculation.

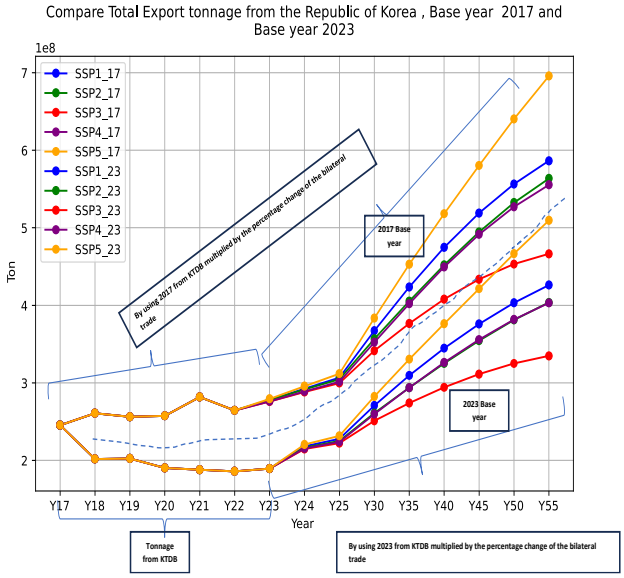

Fig. 6. Compare Total Export tonnage forecasting to the Republic of Korea Base year 2017 and Base year 2023

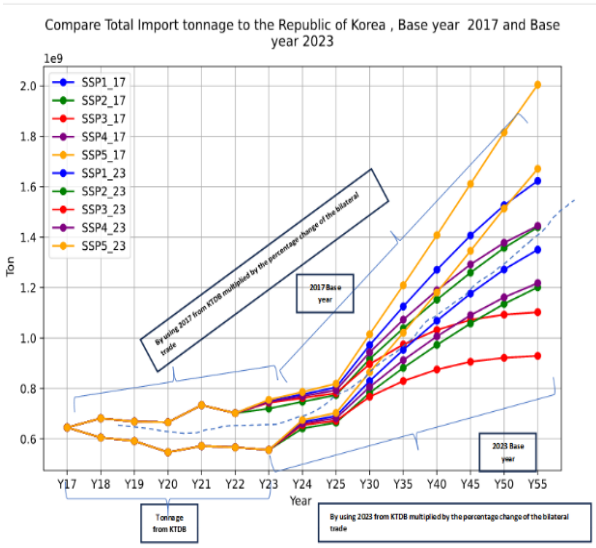

Fig. 7. Compare Total Import tonnage forecasting to the Republic of Korea, Base year 2017 and Base year 2023

4. Conclusion

Analyzing the global trade with the Republic of Korea is highly important for forecasting transportation demands not only for international trades with other countries but also for optimization of the domestic transportation methods. We focused on the top trading partners for the Republic of Korea, which was compiled from the following countries: China, the United States of America, Japan, Vietnam, Australia, Germany, Taiwan Province of China, Saudi Arabia, India, Singapore, and so on. Additionally, the assessment of the aggregation of goods and services was carefully considered and analyzed according to the relationship between the Republic of Korea and those countries. Overall, the GTAP analysis centered on the Republic of Korea was successfully done for the careful consideration of the specific economic dynamics and trade relationships within related countries, as well as the appropriate methodological tools and model adjustments for assessing the potential impacts of trade policy changes.

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Authors Introduction

Ms. BoYoung Lee

She received her Bachelor's degree in Human Relations from Keio University and M.S. in logistics from Inha University in Korea. She is currently a Ph.D. student. She works as a logistics consultant in the Logistics Revolution Korea Co., Ltd.

Mr. Ahmad Altaweel

He received his bachelor's degree in Electronics and Communication Engineering, from the Faculty of Electrical and Mechanical Engineering, ALBAATH University, Syria. He is currently a Ph.D. student at Kyushu Institute of Technology, Japan.

Mr. Kazuhito Mine

He is a bachelor's student in the School of Computer Science and Systems Engineering, Kyushu Institute of Technology, Japan

Dr. JangSok Yoon

He received his M.S. and Ph.D. degrees from Kyunghee University, in South Korea, in 2004 and 2008. He is the founder, CEO, and Consultant over 23 years of Logistics Revolution Korea Co., Ltd.

Dr. Hiroaki Wagatsuma

He received his M.S., and Ph.D. degrees from Tokyo Denki University, Japan, in 1997 and 2005, respectively. He is currently an Associate Professor at Kyushu Institute of Technology.