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Comparison and analysis of tariff reduction of infrastructural sectors and its economic impact: ACGE approach

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ABSTRACT

BACKGROUND AND OBJECTIVES: The reduction of tariffs in Public infrastructure sectors is believed to be one of the key factors in addressing the socio-economic challenges of high unemployment, income inequality, and poverty. The primary objective of this paper is to design a general equilibrium model for infrastructural sectors among Germany, France, Italy, United Kingdom, China, USA, Australia, Japan and Korea, and evaluate potential economic impact of tariff reduction.
METHODS: The research method of this paper was to construct a Computational General Equilibrium model to assess the economic effects. The global trade analysis project model was calibrated and discussed in this paper. The global trade analysis project database was used to validate the model.
FINDINGS: Simulation result showed that tariff removal in infrastructure has the most significant effects in China, Japan, and Korea's economic growth and employment than other countries. Gross Domestic Product, output price, and social welfare increase significantly in China compared to other countries. Gross Domestic Product increases in China by 616%, decreases in Japan and Korea 77% and 7% after mutual tariff reduction on infrastructure sectors. Meanwhile, China's export on infrastructural sector increases by 1.71%, Japan and Korea's export increases by 0.75% and 0.05%. On the other hand, export decreases in Germany, France, Italy, UK, USA and Australia. Finally, social welfare increases in China by $2.26 billion and Japan by $239 million.
CONCLUSION: The presence of tariff reduction in infrastructure sectors will likely strengthen the market share of most of the simulated regions. These findings may provide policy-makers with crucial information for better understanding about new tariff policy. Computable General Equilibrium analysis in infrastructure sectors had paid little attention in past and this paper tries to fill the gaps and attempts to find the benefit of mutual tariff policy among countries based on global trade analysis project model.

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INTRODUCTION

Infrastructure plays a significant part in the economic development of a country and can be divided into economic and social sectors. Infrastructure projects such as transport, electricity, water, and other systems promote the prosperity and economic growth of a country. Economic infrastructure typically includes transports, utilities, communication, and renewable energy, and social infrastructure including schools and other facilities such as education, healthcare, defense and so on. Investment in infrastructure can improve the regional economic performance of the economy by improving international trade. Tariff removal on infrastructure increases production facilities that stimulate overall economic activities of a country. Computable General Equilibrium (CGE) model can capture the economic benefit of each economic agent and policymakers can easily understand the economic change after a shock (i.e. a new policy) by computer-generated numeric results. There are numerous studies that have been employed in previous literature to examine the infrastructural investment contribution to national or regional economic growth. A portion of these studies have discovered public infrastructure investment has a positive relationship in national or regional economic growth, while different investigations found no solid connection between public investment and economic growth (Garcia-Mila *et al.,* 1996; Ferreira *et al*., 2006).There are lots of studies in previous literature that provides regional CGE models to investigate regional economic policies. Other study builds a recursive dynamic CGE model to analyze the effects of public infrastructure investment on productivity for the province of Quebec in Canada and their result suggests that infrastructure investments by the public sector have positive contributions on the productivity of private sectors (Boccanfuso *et al.,* 2014; Arman *et al.,* 2015; Annala *et al.,* 2008; Stewart and Yermo, 2012). Crescenzi and Rodríguez-Pose, 2012),use a competitive general equilibrium model to investigated financing schemes for public infrastructure investment and finds that other variables and parameters remain unchanged after reducing public consumption and increase public investment in infrastructures. Esfahani and Ramírez (2003), utilize cross-country panel regressions and found that infrastructure services' commitment to Gross domestic product (GDP) is significant and surpasses the expense of their arrangement. Rioja (2001), developed a dynamic general equilibrium model and analyzed the impact of infrastructure investment on Brazil, Mexico, and Peru, and finds a positive effect of infrastructure investment on welfare. Limão and Venables (2001) directly investigate the relationship between infrastructure, transportation cost, and trade volume. They found that the relationship between trade volume and transportation cost is negative. Partridge and Rickman (1998) present a useful discussion of the contributions of regional CGE models which explain the strengths and weaknesses of the regional CGE model. Besides the CGE model, Graham (2000) found infrastructure plays a significant role between flow, movement, and exchange in modern cities and towns. Improved infrastructure plays a significant role in quicken urbanization and local reconciliation which has been the motor for development in many nations. Liu (2015) find that investment in transportation infrastructure has a positive development in China economy. Zou *et al.* (2008) affirmed that the transportation framework assumed a significant part in China by investigating panel data from 1994 to 2002 and time-series data from 1978 to 2002. They suggested that the most important reason for the high growth rate of Central and East China is the investment in transportation infrastructures. Bougheas *et al.,* (1999) separately analyzed two datasets and finds that improvements in infrastructures can increase the volume of trade and this relationship is statistically significant. Démurger (2001) inspects the role of infrastructure in development performance across 24 regions in China and presumes that infrastructure investment significantly affects development across regions. Jalan and Ravallion (2002) find that expansion street thickness has a significant beneficial outcome on rural farm households in poor regions of China. Fan and Chan-Kang (2004) use provincial-level data for 1982-1999 and finds road infrastructure to increase economic growth and reduce poverty in China. On the other hand, Haynes *et al.,* (2004) discovered investment in telecommunications framework (both fixed and portable) increments territorial economic growth in China for the period 1986-2002. Investment in physical infrastructure can play a significant role of all inputs in the production process. Another examination done by Bronzini and Piselli (2009) found that a 1 percent expansion in public infrastructure prompts a 0.11 percent increment in total factor productivity in Italy. Démurger (2001) discovered transport facilities reduces the burden of isolation in a country. Other study finds that infrastructure investment has direct impact on economic growth (Stewart and Yermo, 2012; Sloboda and Yao, 2008; Sahoo *et al.*, 2010; Savard, 2010).The improvement of transport framework builds the availability of weaker regions to developed regions which makes the economic benefit in regions. Infrastructure investments reduce transaction costs between agents, reduced transportation costs (Seung and Kraybill, 2001; Walmsley, 2006). The improvement of transport infrastructure generates the mobility of people which, thusly, may prompt more prominent advancement, knowledge circulation, and economic efficiency. Garcia-Mila and McGuire (1992) discovered high yield flexibility of public infrastructure investment. Canning and Pedroni (2004) accentuate that there is an ideal degree of framework that amplifies the development rate. Public infrastructure positively affects in economy of a region. Growing urbanization will help boost the investment infrastructure in sectors. Reduction in tariff will enormously impact of a country economy. Based on above analysis, this paper utilizes a Computable general equilibrium (CGE) model, to examine the impacts of a change in infrastructure sectors on Gross domestic product (GDP), sectoral output, regional output, and household welfare. The primary goal of this paper is to estimate the economic effects of infrastructural sectors tariff removal in various nations by analyzing computable general equilibrium model. The current study has been carried out in largest economies countries in the world in 2021 based on the computable general equilibrium model. The model in this paper is static, and the remainder of the paper dissects the principle model and the result of the examination.

MATERIALS AND METHODS

The GTAP Model

Johansen set up a multi-sectoral growth model in 1960 to consider the economic development in Norway, which implies the start of the CGE model. From that point forward, practically all the developed and developing nations have established their own CGE model among those the GTAP model is one of the most favorite models universally. GTAP model is a CGE model created by the Center for Global Trade Analysis, Purdue University, and this model can catch all economic linkages through value system (Hertel 1999; Rutherford 1998; Aguira *et al.*, 2016). The computable general equilibrium models like GTAP utilize the Armington structure (McDaniel and Balistreri, 2002). Hence, Armington elasticity is a proportion of the level of replacement among home and imported products and furthermore differentiation by exporting nation. There are two Armington elasticity's for every product in the model named ESUBD and ESUBM. GTAP model makes linkage among production, consumption, global savings, and investment. Most of its behavioral and identity equations of the GTAP model represents in percentage-change form rather than in level-form. Household expenditures are governed by a utility function that allocates private, government, and savings expenditures. Cobb-Douglas function assures constant budget shares in the standard closure of regional households. The simulation pattern in the model catches linkages across various nations and markets. In addition, the GTAP model in this paper is explicitly picked because of its broad treatments of interregional trade which is esteemed to be appropriate for conducting global trade policy analysis.

Model Database

The model of this paper used the Global Trade Analysis Project (GTAP) database version 9 (Aguira *et al*., 2016). The information base in the model covers 140 territorial units and 57 sectors with three reference years, for example, 2004, 2007, and 2011. The reference year 2011 has been utilized for the outcome investigation of this paper. In this paper

Table 1: Aggregation used in the Model

Regions	Sectors	Factors
Germany	Infrastructure	Land
France	Agriculture	Unskilled Labor
Italy	Process Food	Skilled Labor
United Kingdom	Manufacturing	Capital
China	Service	Natural Resources
USA		
Australia		
Japan		
Korea		
Rest of the World		

Note: Rest of the world means countries included in the GTAP database (excluded above mentioned simulated regions).

reference year 2011 has been chosen in order to avoid unexpected simulation error of the model.

The Methods of this Paper

This study aggregated 140regions in the GTAP 9A database into ten regions: Germany, France, Italy, UK, China, USA, Australia, Japan, Korea, and the Rest of the World. Ten regions have been chosen because those countries are the giant economic countries in the world. However, there is no independent infrastructural sector in the GTAP 9A database and it is necessary to separate the infrastructural sector from other sectors. With this GTAP database, this study added a new sector (infrastructural) into the GTAP 9A database because individual infrastructural sectors database not included in the main GTAP database. The new aggregated infrastructural sector includes manufactures, construction, transport equipment, electronics, electricity, transport necessary, communication, water transport and air transport. Rail and road transport are not included in the model because those database are not included in the main database file. Sectors are aggregated into infrastructure; agriculture; process food; manufacture and service. Other sectors not included into the model because of the limitation of the study. Factors of production are aggregated into Land, Skilled Labor, Unskilled Labor, Capital, and Natural Resources category. Land and natural resources are limited mobility across sectors (Table 1). Aggregation of the model has been done by the GTAP aggregation software tools.

The variable that simulates the effect of the policy change in the GTAP database is tms (i,r,s), which will impacts the policy scenario by decreasing infrastructural sectors. For the policy shock this paper decrease infrastructural sectors tariff by 25 percent among Germany, France, Italy, UK, USA, China, Australia, Japan, Korea and the rest of the world. This study utilized 25 percent tariff reduction as an experiment purpose to know what will be the impact of the economy if reduces tariff. This diminishing on infrastructural sectors tariff deliberately impacts in trade balance, import and export prices, which thusly influences the domestic market price and the volume of imports and exports. Eqs. 1 to 7 shows the policy change formulae:

$$pms(i,r,s)=tm(i,s)+tms(i,r,s)+pcif(i,r,s); \quad (1)$$

$$tms(i,r,s)=pms(i,r,s)-tm(i,s)-pcif(i,r,s); \quad (2)$$

$$pcif(i,r,s)=FOBSHR(i,r,s)*pfob(i,r,s)+TRNSHR(i,r,s)*ptrans(i,r,s); \quad (3)$$

$$pfob(i,r,s)=pm(i,r)-tx(i,r)-txs(i,r,s); \quad (4)$$

$$pim(i,s)=sum(k,REG,MSHRS(i,k,s)*[pms(i,k,s)-ams(i,k,s)]); \quad (5)$$

qxs(i,r,s)=-ams(i,r,s)+qim(i,s)-ESUBM(i)[pms(i,r,s)-ams(i,r,s) - pim(i,s)]* ; *(6)*

*go(i,r) = SHRDM(i,r)*qds(i,r)+ sum(s,REG,SHRXMD (i,r,s)* qxs(i,r,s)+tradslack(i,r)* ; *(7)*

Where pms represents the domestic market price; pcif represents the landed price of the goods; pfob represents the FOB price of the commodity; pim represents the market price of the imported commodity; qxs represents the commodity Export volume; qo represents the output of the commodity. This study does not utilize intangible assets because of the database limitation. Based on the above, this paper established a static global CGE model whose benchmark scenario is calibrated according to the GTAP9A database. This study is a static model so there is no baseline scenario in the model calibration. In this paper run GTAP software was used to perform the GTAP model simulations andGragg'*s*2-4-6 steps solution method taken consideration to get the maximum result accuracy.

RESULTS AND DISCUSSION

In this study, all simulation results are in changes in the economy in the year 2011 because economic shock has been created in the year 2011. Simulation result shows that the tariff reduction into infrastructural sectors results in changes to trade balances. Most countries experience a decrease and increase in its trade balance. As shown in Table 2, trade balance decreases in China by $US currency 1088 million, Australia by $US currency 14 million, Japan by $US currency 130 million, Korea by $US currency 12 million, and the rest of the world by $US currency 211 million. Interestingly, Germany, France, Italy, UK, and the USA experiences a $US currency 39 million, $US currency 254 million, $US currency 125 million, $US currency 126 million, and a $US currency 911 million increase in its trade balance. China's trade balance decreases significantly, on the other hand, the USA trade balance increases rapidly (Table 2).

As presented in Table 3, the infrastructure sector trade balance falls $US currency 556 million in Germany, $US currency 433 million in France, $US currency 231 million in Italy, $US currency 341 million in the UK, $US currency 822 million in the USA, $US currency 7 million in Korea, and $US currency 142 million in Australia. The infrastructure sector trade balance rises in China and Japan by $US currency 8418 million and $US currency 1605 million. China and Japan remain the highest trade balance increase in infrastructural sectors. Meanwhile, the agricultural sector trade balance decreases in China and Japan by $US currency 200 million and $US currency 20 million. The process food sector trade balance decreases in Germany, China, and Japan and by $US currency 9 million, $US currency 170 million, and $US currency32 million. The manufacturing sector trade balance in China and Japan decreases more significantly by $US currency 8638 million and $US currency 1504 million, where, service sectors decrease by $US currency 497 million and $US currency 180 million (Table 3).

As shown in Table 4, real Gross domestic product (GDP) decreases most regions. Decrease in real GDP indicates a decrease in average interest rates in the economy. Real GDP decreases in Germany, France, Italy, USA, Australia, Japan, and Korea by 1.2%, 19%, 18%, 80%, 9%, 77%, and 7%. France, Italy, and Japan's real GDP decrease remains high compared to other countries. The decrease in real GDP impacts customer purchasing power and spending patterns, which in turn affect the overall business of the economy. Nevertheless, China's real GDP increases significantly by 616% compared to pre simulation scenario (Table 4).

Export in infrastructure sectors decreases in most countries, where, in China and Japan export increases by 1.7% and 0.7%. On the other hand, agriculture sectors and process food sector export increases in France, Italy, the UK, and the USA; the manufacturing and service sectors export increases in France, UK, and the USA. Increases in exports bring money into the country and increase the GDP of the country. Meanwhile, China's export in agriculture, process food, manufacturing, and service sectors decreases rapidly compared to other countries (Table 5).

Changes in aggregate imports reflect the increasing patter in China, Germany, Australia, and Japan. Infrastructural sectors import increases in China by 1.3%, Japan, and Korea by 0.1% both followed by a

Table 2: Change in trade balances (millions of dollars)

Regions	Change
Germany	39.1
France	254.66
Italy	125.19
UK	126.55
China	-1088.37
USA	911.83
Australia	-14.28
Japan	-130.71
Korea	-12.17
Rest of the World	-211.79

Table 3: Change in trade balances by sector (millions of dollars)

Sectors	Germany	France	Italy	UK	China	USA	Australia	Japan	Korea	ROW
Infrastructure	-556.4	-433.32	-231.5	-341.56	8418.5	-822.73	-142.42	1605.14	-7.16	-7545.6
Agriculture	0.48	14.79	3.81	8.4	-200.72	47.19	-1.19	-19.68	0.53	136.96
Process Food	-9.33	25.2	1.41	12.22	-170.75	32.06	-1.54	-31.13	0.66	145.45
Manufacturing	625.43	596.69	343.14	390.13	-8638.43	1552.52	136.62	-1504.69	15.24	6545.5
Service	-21.08	51.29	8.33	57.35	-496.98	102.79	-5.75	-180.35	-21.44	505.85

Note: Infrastructure sectors include manufacturers, construction, transport equipment, electronics, electricity, transport, communication, water transport, and air transport

Table 4: Real gross domestic product changes (% change)

Regions	% Change
Germany	-1.25
France	-19.25
Italy	-18
UK	0.5
China	616.5
USA	-80
Australia	-8.88
Japan	-77.5
Korea	-6.88
Rest of the World	22

slight decrease in France and Italy. Agricultural and process food sectors import increases slightly in China, Australia, and Japan by 0.1% to 0.2%. On the other hand, the manufacturing and service sectors import increases in China by 0.2% and 0.3% compared to other countries (Table 6).

Table 5: Change in aggregate exports by sector (%)

Sectors	Germany	France	Italy	UK	China	USA	Australia	Japan	Korea	ROW
Infrastructure	-0.17	-0.25	-0.29	-0.17	1.71	-0.17	-0.36	0.75	0.05	-0.22
Agriculture	-0.01	0.05	0.01	0.04	-0.46	0.05	0	-0.24	-0.01	0.03
Process Food	-0.01	0.05	0.01	0.03	-0.39	0.04	-0.02	-0.19	0.01	0.03
Manufacturing	0.07	0.14	0.08	0.11	-0.61	0.1	0.07	-0.22	0.01	0.1
Service	-0.01	0.05	0	0.03	-0.49	0.03	-0.01	-0.21	-0.06	0.03

Table 6: Change in aggregate imports by sector (%)

Sectors	Germany	France	Italy	UK	China	USA	Australia	Japan	Korea	ROW
Infrastructure	0.04	-0.07	-0.03	0.05	1.31	0.01	0.13	0.1	0.1	0.18
Agriculture	0	-0.01	0	-0.01	0.18	-0.01	0.02	0.05	0.01	-0.01
Process Food	0.01	-0.01	0	-0.01	0.2	-0.02	0.01	0.06	-0.01	-0.01
Manufacturing	0.01	-0.02	-0.01	-0.01	0.21	-0.04	0	0.04	0	-0.01
Service	0.01	-0.02	0	-0.01	0.26	-0.02	0.02	0.1	0.02	-0.02

Table 7: Change in output volume by sector (%)

Sectors	Germany	France	Italy	UK	China	USA	Australia	Japan	Korea	ROW
Infrastructure	-0.05	-0.06	-0.04	-0.05	0.21	-0.03	-0.02	0.08	0	-0.07
Agriculture	-0.01	0.02	0	0.01	-0.05	0.01	0	-0.03	0	0.01
Process Food	-0.01	0.02	0	0	-0.04	0	-0.01	-0.01	0	0.01
Manufacturing	0.04	0.07	0.03	0.05	-0.14	0.03	0.04	-0.09	0.01	0.05
Service	0	0	0	0	0	0	0	0	0	0
CGDS	-0.01	-0.04	-0.03	-0.02	0.08	-0.03	0	0.01	0	0

Note: CGDS stands for Capital goods. Capital goods are physical assets that a company uses in the production process to manufacture products and services. This includes buildings, machinery, equipment, vehicles, and tools.

Output in infrastructural sectors decreases in Germany, France, Italy, UK, and Australia from 0.02% to 0.06%, where, output in China increases by 0.2%. In France, total domestic production increases in agriculture, process food, manufacturing, and service sectors, where, in Italy and the UK increases a slight amount. The results are presented in Table 7.

Changes in output and trade reflect changes in market prices. Market prices decrease in Germany, France, Italy, UK, USA, Australia, and Korea from 0.01% to 0.03% in infrastructure, agriculture, process food, manufacturing, and service sectors, where, domestic output in China and Japan increase by 0.03% to 0.1% (Table 8).

At long last, an essential inquiry for any shock to the economy is the overall welfare impact on the residents of that area. China is the biggest winner compared to other regions by rising welfare index $US currency 2.26 billion. The welfare index falls in Germany, France, Italy, UK, USA, Australia, Korea, by $US currency 26 million, $US currency 154 million, $US currency 55 million, $US currency 102 million, $US currency 615 million, $US currency 16 million,

Table 8: Change in market price by sector (%)

Sectors	Germany	France	Italy	UK	China	USA	Australia	Japan	Korea	ROW
Land	-0.03	0.04	-0.01	0.01	-0.07	0.02	-0.01	-0.05	-0.02	0
UnSkLab	-0.01	-0.04	-0.02	-0.03	0.13	-0.02	-0.01	0.04	0	-0.03
SkLab	-0.01	-0.03	-0.02	-0.02	0.13	-0.02	-0.01	0.05	0	-0.03
Capital	-0.02	-0.04	-0.02	-0.03	0.13	-0.02	0	0.04	0	-0.02
NatRes	0.02	0.03	0.01	0.03	-0.02	0.01	0.04	-0.05	0.01	0.04
Infrastructure	-0.02	-0.03	-0.02	-0.02	0.08	-0.02	-0.01	0.04	0	-0.03
Agriculture	-0.02	-0.03	-0.02	-0.02	0.08	-0.02	-0.01	0.03	-0.01	-0.02
Process Food	-0.02	-0.03	-0.02	-0.02	0.09	-0.02	-0.01	0.03	0	-0.02
Manufacturing	-0.01	-0.02	-0.02	-0.02	0.08	-0.02	0	0.03	0	-0.02
Service	-0.01	-0.03	-0.02	-0.03	0.11	-0.02	-0.01	0.04	0	-0.02
CGDS	-0.02	-0.03	-0.02	-0.02	0.07	-0.02	-0.01	0.03	0	-0.03

Note: CGDS stands for Capital goods. Capital goods are physical assets that a company uses in the production process to manufacture products and services. This includes buildings, machinery, equipment, vehicles, and tools

and $US currency 18 million. On the other hand, the welfare index in Japan increases by $US currency 239 million. The biggest winner in the welfare index is China (Table 9).

CONCLUSION

For the economic growth and poverty reduction, infrastructure investment is an important determinant. Investment in infrastructure assumes a significant function in the economic improvement of a nation. In the long-term, infrastructure investment boosts the economic growth of an economy by increasing the potential supply capacity. This study employs a regional static CGE model to analyze the effects of tariff reduction in infrastructural sectors. The results of simulations show that a decrease of tariffs in the infrastructure sectors has the greatest impact on the economic growth, job-creating, and reduction of the general level of prices in China, Japan, and Korea. The tariff reduction in infrastructure improved the living standard for people and affect economic growth much more than other modes. Meanwhile, tariff reduction harms trade volume and welfare. The result finds that the tariff removal leads to reductions in trade volume and household welfare in most countries. The consequences of this experiment recommend that all simulated regions should consider adopting a balanced approach to development. While infrastructural sector tariff reduction decreases the welfare of its citizens. China, Japan, Korea gains more economic benefits from this policy, an increase in productivity, and a significant improvement in its GDP, export, imports, and domestic output. In conclusion, all regions should continue their pursuit of common tariff policy and utilize their laws, policies, and development strategies to support its other sectors like agriculture, food processing, manufacturing, and service.

AUTHOR CONTRIBUTIONS

S.Sh. Hossain performed the literature review, experimental design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. H. Delin performed the literature review, compiled the data, manuscript preparation and review.

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CONFLICTS OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS

CGE	Computable General Equilibrium
CGDS	Capital Goods
ESUBD	Elasticity of substitution between domestic and imported goods
ESUBM	Elasticity of substitution among imports from different destinations
GDP	Gross domestic product
GTAP	Global Trade Analysis Project
NATRES	Natural Resources
SKLAB	Skilled labor
TMS (i,r,s)	Import tariff
UNSKLAB	Unskilled labor

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