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Intra-BRICS Trade Opening and Its Implications for Carbon Emissions: A General Equilibrium Approach

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Abstract

The BRICS countries of Brazil, Russia, India, China and South Africa came together to call for an Action Plan for proceeding with their plans on trade and investment. This article analyzes the impact of a possible trade and investment agreement among BRICS countries on carbon emissions by using the general equilibrium approach. Based on two-policy scenarios, the analysis is done in short and long runtime path concerning capital movement across BRICS countries. Using modified GTAP-E model, scale and composition effects of trade opening and capital movement among these countries on carbon emission are measured. When we compare the short run effects with the long run effects of intra-BRICS trade opening, we see that the BRICS countries experienced higher increases in real GDP due to increases in capital stocks in the long run. Unfortunately, a grater increase in real GDP results in increase in carbon emissions depending on the strength of scale effects.

Key words: Trade openness; Capital mobility; Free trade agreement; Trade and environment; Computable general equilibrium model

I. Introduction

The BRIC[2]thesis which was conspicuously used in Goldman Sachs report first, presumed that the BRIC members would have brought the largest world economies together by 2050 and these economies would be wealthier than most of the world economic powers (O'Neill, 2001)[3]. According to the BRIC thesis, it is predicted that China and India may be the principal suppliers of manufactured goods and services, while Russia and Brazil may be similarly the principal suppliers of raw materials such as crude oil, coal, and natural gas. When we take the reserves of these energy goods into account, we can be concluded that Russia is the biggest energy power in the world. World's biggest natural gas reserves and the 8th biggest crude oil reserves, and the second biggest coal reserves are in Russia. Accordingly, Russia is one of the world's biggest natural gas and oil exporter/producer.

Even though some development scenarios concerning the BRICS[4] which are based on the intensity of their overall political and economic integration are presented, it is asserted that BRIC thesis is not only political cooperation that is military and political alliance, North Atlantic Treaty Organization (NATO)but also thesis has the potential to form a powerful economic bloc. Nowadays it is recalled that it represent more generic marketing term to refer to world's leading emerging countries.

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[2]BRIC is an acronym for Brazil, Russia, India, China countries
[3] The presumptions were updated in following years (Purushothaman and Wilson, 2003; O'Neill, 2007) and (O'Neill andStupnytska, 2009).
[4]See more detail information. Imagine BRICS: Four Scenarios of the Future

The group was initially known as "BRIC" before the incorporation of South Africa into group in 2010. After South Africa officially becomes a member of BRIC, the group was renamed as BRICS to indicate new extended membership. The BRICS members came together calling for an Action Plan for proceeding their plans on trade opening with facilitation and joint investment. Therefore, the aim of this paper is to analyze the impact of a possible trade and investment agreement among BRICS countries on carbon emissions in the context of general equilibrium approach. BRICS countries have met annually at formal summits since 2010. After the first Summit, six other annual summits were held (Brasilia, 2010; Sanya, 2011; New Delhi, 2012; Durban, 2013; Fortaleza, 2014; and Ufa 2015).In 2012, the fourth summit has laid out some substantial attempts that include planning a BRICS Development Bank for cooperation. They aimed to establish a development bank for facilitating intra-BRICS trade and investments cooperation and to make it a powerful economic institution to improve trade and investment opportunities. In subsequent summits establishing a New Development Bank came into question and country leaders with their trade ministers focused on fostering commercial ties and they decided to build it (BRICS New Delhi 2012).

In last fifty years,World trade has grown rapidly.The share of global trade volume i.e. exports plus imports in world GDP has increased from 5.5 percent in 1950 to 48 per cent in 2014. It is obvious that the rapid increase in world trade is dependent on too many factors. Some important ones are as follows: First are the decreasing costs of transportation and communications due to technological advances. Second is more trade opening and joint investment policies. It is estimated that the regional economic integration projects such as EU, NAFTA,APEC, and ASEAN account for more than two-thirds of world trade today. In the context of regional economic integration projects, countries have opened up their trade regimes unilaterally, bilaterally, regionally, and multilaterally in order to eliminate or make significant reductions in trade barriers. The economic policies in line with globalization facilitate trade and increases number of countries contributing to world trade expansion as well. Particularly, developing countries now account for 36% of world exports. Compared to the early 1960s, this percentage with respect to their share is approximately doubled.

Expanding world trade is one of the reasons for trade to take a larger part in climate change debates and this explains why there is a growing interest in the impact of trade opening on carbon emissions. While there are numerous empirical studies (Libo et al, 2013; Sachinand Sharma, 2012) carrying out on the issue of trade opening for BRICS countries, only few focuses on the impact of trade opening on environment. Thus, it is important to develop empirical studies for examining how trade opening can affect the environment. In the literature, the impact of trade opening on the environment can be classified into scale, composition and technique dimensions in the study of impact of the North American Free Trade Agreement (NAFTA) in the context of the link between trade opening and climate change (CEC, 1999).

The scale effect indicates the effect of increased production or consumption resulting from trade opening or freer trade on carbon emissions. It is assumed that trade opening increases economic activity and hence energy consumption. Fossil fuels including coal, natural gas, and oil account for about 80 percent of global primary energy consumption. It is clear that when they are burned, the relative weight of these energy sources emitting carbon dioxide into the atmosphere are at very high level. Everything else being equal, this rise in the scale of economic activity and thereby fossil fuel consumption results in higher levels of carbon emissions. In modeling approach, weknow that carbon emissions are closely related to coal, oil and natural gas consumption. Therefore, carbon emissions are associated with all emitting activities, including current production, investment, and private and government consumption.

In composition effect of trade opening, the composition of production changes in favor of products having comparative advantage. The impact on carbon emissions relies heavily on the sectors in which a region has comparative advantage. The composition effect leads to the less carbon emissions when the growing sectors are less energy intensive than the contracting sectors. This is true for reverse. In simulation analysis, it is easy to determine whether the composition effect results in higher or lower carbon emissions by comparing the change in output of energy intensive sectors with non-energy intensive sectors. On the other hand, trade opening may also improve energy efficiency so that the production generates less carbon emissions. This refers to the technique effect. Decline in carbon emission intensity can happen into different ways: First, trade opening increase the availability and lower the

cost of environmentally-friendly commodities and technologies. Second, the increase in welfare resulting from trade opening can give rise to firm or household demand for better environmental quality generating less carbon emissions.

This paper aims at analyzing the relationship between trade opening and carbon emissions within the big emerging countries named BRICS, during the period of trade and capital account liberalization that has happened in broader terms since the initiation of the first summit.

2. Overview of macroeconomic performance and intra BRICS trade

All BRICS members are developing or industrialized countries, but they are different with respect to their rapidly growing economies and substantial political power on both regional and international level. They are also G-20 members. As shown in Table-1, the BRICS countries account for over 3 billion people that is 42% of the world population. These countries produce total GDP(on a purchasing power parity basis) of US$ 34,385 billion that is approximately 20% of the world's GDP, and counted 6,546 billion USD in total trade volume. When we look for economic structure and the level of socio-economic development of the BRICS members, we see that they are at different stages. Table-1 indicates that GDP per capita (on a purchasing power parity basis) was $24,067 in Russia, $15,941 in Brazil, $13,215 in South Africa, $13,801 in China and $6,266 in India in 2014. According to Table figures, Russia's per capita income is approximately four times greater than India's per capita income. Even though their sizeable geography, population and GDP, they face serious problem of social inequality and even poverty.

Last column of Table-1 shows another indicator revealing different stages of development. China and Russia run a surplus on the capital account, but India had small deficit and South Africa had a significant deficit.

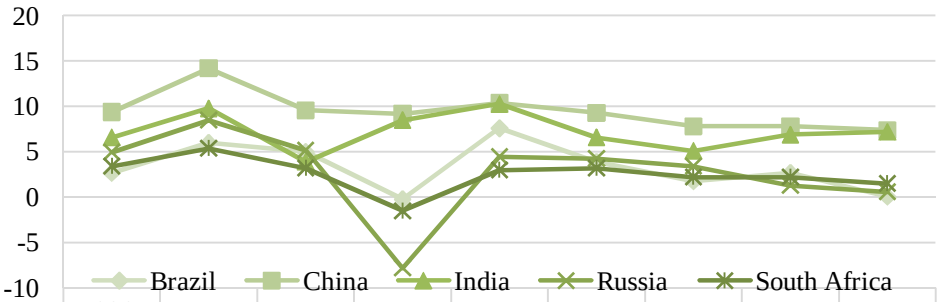
Table-1: BRICS countries, population and macroeconomic real indicators, 2014

	Population (Million)	GDP (PPP) ($Bil.)	Exports ($ Bil.)	Imports ($Bil.)	GDP per capita (PPP)	Current account deficit* (percent of GDP)
Brazil	203	3.250	396	278.8	15.941	-2,1
China	1.354	18.970	2.021	1.780	13.801	4,6
India	1.210	7.990	462.21	500.3	6.266	-2,7
Russia	146	3.450	542.5	358.1	24.067	4,2
S.Africa	52	725	101.2	106.8	13.215	-13,5

* 2007-2014 average of current account deficit. Source: IMF

Looking at the GDP growth performance of the BRICS countries in last couple of decades, one can see that GDP growth has differed among the countries: average GDP growth in the period of 1996-2007 in China was 9.4%, in India 6.6%, in Brazil 2.7%, in Russia 5%, and in South Africa 3.4% as shown Figure-1. Taking into consideration on the BRICS countries only in the recent period (2007-2014), that is after the financial crisis of 2007, the GDP growth performance changes as follows: Yearly average for GDP growth is 9.5% in China, 7.3% in India, 2.5% in Russia, 3.4% in Brazil and %2.4 in South Africa. Overall average GDP growth for BRICS is 5% in this period. It is clear that the highest growth rates have been in India and China.

Figure-1: Growth rate of real GDP. %. 1996-2014



	1996-2007	2007	2008	2009	2010	2011	2012	2013	2014
Brazil	2.7	6	5	-0.2	7.6	3.9	1.8	2.7	0.1
China	9.4	14.2	9.6	9.2	10.4	9.3	7.8	7.8	7.4
India	6.6	9.8	3.9	8.5	10.3	6.6	5.1	6.9	7.2
Russia	5	8.5	5.2	-7.8	4.5	4.3	3.4	1.3	0.6

Source: IMF

On the trade side, the BRICS as a group accounted for only 3% of global trade in 1990. In 2014, the BRICS as a group accounted for 15% of global exports and 14% of global imports of commodities. It is clear that the share of the BRICS in global trade has increased significantly over the last two decades.

Table-2 is arranged to demonstrate the intra BRICS trade in matrix form. The rows of the table represent exports of each BRICS member while columns represent imports of each BRICS member. Total intra BRICS exports or imports is $353,104 billion. According to the International Trade Center data, total exports of BRICS members to world is $1,125,400 billion, and their imports from world is $1,074,924 billion in 2014. Total intra BRICS exports is nearly one-third of total exports to world. As shown in Table-2, China is the biggest trade partner for other BRICS with 45% export share and 44% imports share in intra-BRICS trade. In terms of the trade share, Brazilis the second largest partner of the group. India and South Africa have the smallest share in the intra-BRICS trade.

Table 2: Intra BRICS Exports-Imports matrix, US dollar Billion, 2014

		Exports to:						
		China	India	Russia	Brazil	S. Africa	BRICS total	% Share
Imports from:	China	-	54.237	53.686	34.915	15.704	158.542	45
	India	16.386	-	2.217	7.141	5.722	31.466	9
	Russia	41.625	4.208	-	2.283	285	48.401	14
	Brazil	51.914	5.544	3.954	-	1.226	62.638	18
	S. Africa	44.645	5.994	686	732	-	52.057	15
	BRICS total	154.570	69.983	60.543	45.071	22.937	353.104	100
% share		44	20	17	30	6	100	

Source: ITC, Trade Map Trade statistics for international business development, retrieved from http://www.trademap.org/Bilateral_TS.as

Even though carbon abatement policies, renewable energy development, and energy efficiency enhancement, world's carbon emissions from fuel combustion continue to increase by 51.3% between 1990 and 2012, reaching 31,700 MtCO2.

As for the carbon emissions for BRICS countries, since one-third of the world's total GDP belongs to the BRICS all developing countries, their fossil fuel consumption naturally have to increase and hence this causes increase in carbon emissions; the BRICS account for 33% of world energy use and nearly 40% of global emissions in 2012 originated in just BRICS countries; the Brazil (1.4%), the Russia (5.2%), India (6.2%), the China (25.9%), the S.Africa (1.2%) as shown in Table-3.A closer examination of the Table figures on CO2 emissions per capita reveals that Chine has the lowest carbon intensity (1.88 kg/USD) and Russia has the highest CO2 Emissions per Capita (11.56 tCO2/capita).

Table 3: Carbon emissions, 2012

	Carbon Emissions from Fuel Combustion(Mt)	Percentage share of carbon emission	Carbon Emissions per GDP(kg /2005 USD)	CO2 Emissions per Capita(t /capita)
Brazil	444	1.4	0.39	2.22
Russia	1,660	5.2	1,69	11.56
India	1,950	6.2	1.41	1.58
China	8,210	25.9	1.81	6.58
S.Africa	376	1.2	1.22	7.20
BRICS	12,640	39.9	1,30	5,83

Source: IEA

3. Model and data

In order to investigate the potential impacts of trade opening and its implication for carbon emissions among BRICS countries, we employed two policy simulations by using computable general equilibrium model. The specific model used in this paper is the GTAP-E (Global Trade Analysis Project- Energy) model which is known as the extension of standard GTAP[5] model. GTAP-E model[6]has been developed to analyze the carbon emissions from burning of fossil fuels by incorporating energy substitution into the standard GTAP model. GTAP model is multi-sect oral and multi-regional general equilibrium model commonly used in the analysis of regional and global trade issues. The GTAP-E model is also standard multi-regional, static computable general equilibrium model where all markets are assumed to be perfectly competitive and technologies exhibit constant returns to scale.

The model assumes consumers as having identical preferences that allocate income among household and government consumption and savings by using Cobb-Douglas function. There is single representative household maximize a constant difference of elasticity (CDE) objective function. Both household and government consumptions are represented by constant elasticity of substitution (CES) composite of domestic and imports goods. In addition to consumption, the production of sectors is also represented by a nested constant elasticity of substitution (CES) function. By means of Armington assumption, production of firms can be represented by CES composite of domestic and imported intermediate goods in fixed proportions with CES composite factors of production including land, natural resources, unskilled labor, skilled labor, and capital.

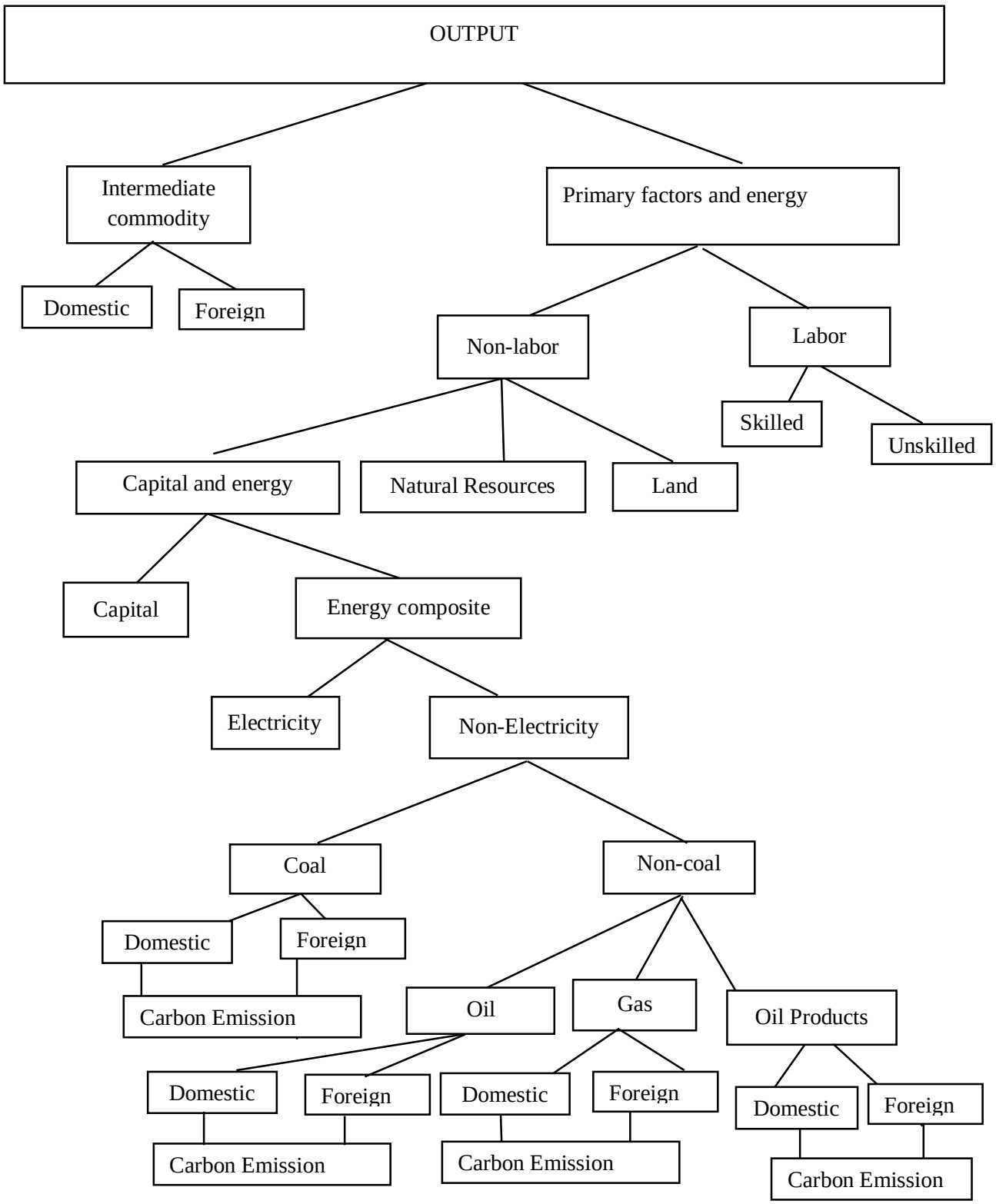
Figure-2 shows that the production function is made up of seven-layer nested CES function. Two forms of energy substitution have been incorporated into the model: First is the substitution within energy sources, and second is the substitution between primary factors and energy. Each industry employs two types of labor in terms of occupations; skilled and unskilled. The possibility of substitutions in labor demand for an industry is only between skilled and unskilled labor. Any change in the relative prices of two kinds of labor induces substitution in favor of relatively cheaper occupations.

In addition, we treat capital stock as an endogenous variable in order to simulate second policy shock by incorporating comparative static long-run extension to the GTAP-E model. It is required some certain modifications to the structural form of the model and the development of a new closure for this extension. After modifications we assume that factor capital is mobile across regions depending on rates of return in the long run steady state.

[5]Hertel (1997) provides detail information about the structure and overview of GTAP model

[6]Burniaux, J. and T. Truong, (2002) provides detail information about the structure and overview of GTAP-E model

Figure 2: Production structure



We use version 9 of the GTAP database which is detailed in Badri et al. (2015). This database consists of 140 regions and 57 commodities and its base year is 2011. All regions are aggregated to 8 regions covering five BRICS countries and USA, EU and the rest of the world. Moreover, GTAP database contains information on tariffs and other taxes represented as ad valorem equivalents of the actual applied rates and it includes some extensive information on distortions in goods sectors such as trade taxes/subsides, output and input taxes/subsides, and consumption taxes/subsides. But it does not cover distortions in trade in services. It allows the model to be simply used for analyzing regional trading arrangements by defining tariffs and export subsidies on a region-to-region basis.

4. Simulation Analysis

4.1 Policy scenarios

It is claimed that important cooperation mechanisms have been improved conditions for deepening intra-BRICS cooperation. One of them is Intra-BRICS trade. In addition to the intra BRICS trade, bilateral investment flows among BRICS members are increasing. The fourth summit in New Delhi has made important contributions to the BRICS thesis by introducing Free Trade Agreement in the context of liberalization of trade between BRICS members. It will have some important implications in terms of overall welfare, macroeconomic, trade and environmental indicators. In order to analyze the economic and environmental impacts of intra BRICS trade opening together with trade facilitation in short and long run, we design two policy scenarios as described below.

Scenario 1- Looking into the future BRICS countries are opening up to new trade opportunities and relations. Not only are they members of regional trade agreements, but they also have been incorporated into the BRICS grouping that is an important step in the country's participation in global trade.

This scenarios related to the full liberalization trade scenario involving reduction imports tariffs to zeroing intra-BRICS trade. BRICS's integration processes not limited to the establishment of trade opening. BRICS's membership provides an opportunity to expand and deepen relations with traditional trading partners even further. Therefore, tariff liberalization is important in improving trade, but other trade-related factors, such as transport and communication services, customs procedures, port efficiency, standards and technical regulations, etc. are also important in improving trade performance. Hence, a full trade liberalization scenario combined with improvements in non-tariff barriers in the form of traded facilitation is considered. In this scenario we present the macroeconomic environment coupled with carbon emission results of removing the import taxes on the goods together with trade facilitation.

Although several recent studies use CGE models to quantify the benefits of improved trade facilitation, we follow an approach where Non-Tariff Barriers (NTBs) are modeled as iceberg or dead-weight trade as the study of Doha Round of the WTO negotiation François (1999, 2001). In line with this approach, Hertel et al. (2001) incorporated NTBs into CGE model by introducing additional "effective" import price that is a function of the observed import price and an exogenous unobserved technical coefficient due to the treating NTBs as unobserved trade costs which are not explicitly in the GTAP data base. In addition to reducing import tariff to zero, we reduce non-tariff barriers by reducing trading costs from trade facilitation efforts among members of the BRICS group, with 2% increase in the availability of technology[7] that can improve the management of cross-border trade. In the model implementation, import goods "i" from region "r" augmenting technology change in region "s" represented by ams_{irs} increase in 2% by shocking.

Scenario 2-We know that previous scenario is designed for short run closure. This means that the period of time which would be needed for economic variables to adjust to a new equilibrium defined as timescale affects the way we model factor markets. In a short run simulation we normally hold capital stocks fixed due to the taking long to install.

In this scenario, wed not use short run closure since its aims to incorporate capital movements across BRICS countries into the GTAP-E model for determining the long-run effects of capital stocks. That is why capital stocks are free to adjust in such a way that capital is allowed to move across BRICS countries.

Accordingly, capital is now able to cross borders and take part in the production processes of foreign firms in different regions, similar to production commodities. The movement of capital generates an endogenous capital inflow and outflow according to each region's capital demand and supply and also leads to interregional rate of return differentials.

4.2. Results of Policy scenarios

This section shows the policy scenario results of the intra BRICS trade opening together with trade facilitation. It reports percentage change in main macroeconomic price and real variables, carbon emissions, welfare and its components, sect oral output for energy and energy intensive sectors of each scenario.

4.2.1 Impacts of trade opening by removing import tariffs associated with trade facilitation in short run

Table-indicates the impacts on some macroeconomic variables for the BRICS and other countries under consideration. All the members of possible intra BRICS trade opening with facilitation would experience an increase in GDP and all the components of GDP from the base run. It is shown that South Africa would be major beneficiary in terms of GDP gain (0.33%) whereas other members would be less fortunate. Non-BRICS regions would experience slight falls in GDP as well as other components of GDP except that investment of EU and rest of the world. The terms of trade are defined as the ratio of price received for traceable that is export price index to the price paid for traceable that is import price index. Accordingly, wean define export price index minus import price index in terms of percentage change. When the removal of tariff experiments conducted in this scenario, the negative changes in the terms of trade occur mainly due to deterioration of country exports price changes.

Table-4: Percentage change in macroeconomic variables for policy scenario-1

	BRICS countries					USA	EU	Row
	China	India	Russia	Brazil	S. Africa			
I-Price variable %								
GDP price index	0.88	-0.31	-0.98	-0.54	-0.05	-0.14	-0.17	-0.15
Import price	-0.11	0.01	0.00	0.01	-0.02	0.00	-0.09	-0.04
Export price	0.66	-0.24	-0.23	-0.14	0.57	-0.13	-0.15	-0.13
Terms of trade	0.77	-0.24	-0.23	-0.15	0.59	-0.13	-0.06	-0.09
Trade Balance	7.747	-1.206	-1.775	-460	-715	541	-1.284	-2.848
II-Quantity variable								
Real GDP	0.07	0.19	0.15	0.09	0.33	-0.00	-0.00	-0.00
Import volume	2.42	3.78	3.85	7.63	8.48	-0.26	-0.12	-0.12
Export volume	1.59	4.99	3.11	7.10	7.47	-0.21	-0.08	-0.08
Investment	0.16	0.64	0.27	0.55	1.63	0.01	0.04	0.02
Private consumption	0.15	-0.06	0.17	-0.03	0.37	-0.02	-0.03	-0.02
Government cons.	0.06	-0.19	-0.19	-0.15	-0.03	-0.01	-0.01	-0.02
III-Carbon variable								
Carbon emission	0.13	0.04	0.16	-0.10	-0.44	-0.04	-0.10	-0.08

Source: Simulation results

The net welfare gains from the proposed trade opening for BRICS countries are measured by Equivalent Variation (EV) in income. The EV measures the amount of income that would have to be given or taken away from an economy before trade liberalization so as to leave the economy as well off as it would be after the policy has been changed. Table-5 indicates the overall changes in welfare of the 8 regions which are provided by the equivalent variation (EV). According to the Table-5 figures, the highest welfare gain is attained by China whereas Russia gained least in terms of welfare effect. It is revealed that Non-BRICS members experienced net welfare losses due to trade opening of BRICS countries. The decomposition of the welfare effects suggest that China and S.Africa's gain from the proposed trade opening is primarily driven by endowment and allocation effects. BRICS countries would experience gain in a locative efficiency as resources will divert from inefficient sectors to the more efficient sectors.

Table-5: Percentage change in decomposition of welfare for policy scenario-1

	Allocation	Technological change	Terms of trade	Investment and saving	welfare
China	3.929	2.861	14.530	-1.865	19.455
India	2.229	2.006	-924	-600	2.710
Brazil	765	1.376	-411	275	2.005
Russia	572	1.536	-926	504	1.686
S. Africa	759	588	649	4	2.000
USA	-450	0	-2.586	-150	-3.185
EU-28	-1.710	0	-3.902	548	-5.065
Rest of World	-1.876	0	-6.496	1.295	-7.077
Total	4.217	8.368	-67	11	12.528

Source: Simulation results

On the other hand, this policy scenario implicitly explores the environmental implications of the trade opening among BRICS countries. Changing patterns of production and consumption, and rising standards of living for the vast numbers of people in BRIC economies, mainly in China and Russia have major implications for the carbon emission. The final point emerging from the Table-4 is that carbon emissions stemming from trade opening are more extensive in China and Russia. Trade opening and facilitation policies, once liberalized multilaterally, generate a different set of international prices, thereby altering pattern of trade flows and composition and level of output as well. The increase in carbon emission for BRICS countries measured by scale effect with rising in output of all energy sector and measured by composition effect with mostly rising in output of energy intensive sector as shown Table-6. Depending on both scale and composition effects, carbon emissions for China increase by 0.13% and for Russia increase by 0.16%, while carbon emissions for Brazil and S. Africa decrease by 0.1% and 0.44% respectively.

Table-6: Percentage change in output for energy and energy intensive sectors for policy scenario-2

	BRICS countries					USA	EU	Row
	China	India	Russia	Brazil	S. Africa			
Energy sectors								
Coal	-0,02	-0,16	0,10	0,50	0,50	0,13	0,07	0,11
Oil	-0,45	-0,04	0,19	-0,47	0,29	0,03	-0,01	-0,01
Gas	-0,58	-0,08	0,09	-1,00	0,24	0,04	0,02	0,02
Electricity	0,17	0,02	-0,14	0,91	0,41	-0,04	-0,02	-0,05
Gas manufacture, dist.	0,00	0,14	-0,28	-5,55	0,58	-0,09	-0,04	-0,12
Petroleum products	0,53	0,48	-0,26	-0,72	0,58	-0,15	-0,06	-0,13
Energy intensive sectors								
Minerals neck	-0,41	0,03	0,35	0,06	1,50	-0,12	-0,10	-0,28
Chemical, rubber, plats	-0,10	1,00	-0,33	-0,61	4,03	-0,13	-0,10	-0,11
Mineral products neck	0,17	-0,29	-0,57	-2,23	-0,85	-0,01	0,09	0,11
Ferrous metals	0,16	-0,18	-1,08	-0,46	0,90	-0,13	-0,02	-0,01
Metals neck	-0,08	-2,14	-0,48	20,12	3,39	-0,27	-0,14	-1,14
Metal products	0,55	-1,25	-1,82	-3,24	-2,94	-0,06	0,09	0,08
Manufactures nec	-0,25	0,88	-1,57	-1,29	-3,20	0,25	0,32	0,17

Source: Simulation results

4.2.2 Impacts of trade opening by removing import tariffs associated with trade facilitation in long run

The main objective of this article is not only to determine the impact of trade opening on carbon emission but also it is to determine the impacts of trade flow and capital movement across BRICS countries on carbon emission. To do this, we assumed that capital is mobile across BRICS countries in terms of convergence of growth rates in capital stocks in the steady state. We investigate the combined effects of trade opening and capital movements across borders.

Therefore, long run closure is used in this simulation so that the model is able to capture long run effects of capital movements. In this case, sufficient time passes for changes in investment to result in changes in the regional capital available for production. Endogenously determined capital stocks adjust to changes in capital demand. The long run macroeconomic effects of trade opening and capital movements in the context of BRICS thesis are reported in Table-7.

Table-7: Percentage change in macroeconomic variables for policy scenario-2

	BRICS countries					USA	EU	Row
	China	India	Russia	Brazil	S. Africa			
I-Price variable								
GDP price index	0.87	-0.33	-1.10	-0.59	-0.12	-0.12	-0.16	-0.12
Import price	-0.13	-0.02	-0.00	0.00	-0.04	-0.01	-0.10	-0.05
Export price	0.63	-0.33	-0.32	-0.24	0.31	-0.13	-0.14	-0.13
Terms of trade	0.76	-0.31	-0.32	-0.24	0.35	-0.12	-0.05	-0.08
Trade Balance	6,723	-2,830	-1,983	-1,594	-1,112	-205	-424	1,427
Price of capital	0.82	-0.55	-0.69	-0.89	-0.21	0.04	0.03	0.05
II-Quantity variable								
Real GDP	0.17	0.77	0.30	0.63	2.27	-0.07	-0.16	-0.18
Output of capital	0.26	1.40	0.36	1.36	4.15	-0.25	-0.38	-0.40
Import volume	2.51	4.44	3.87	8.22	10.56	-0.33	-0.28	-0.38
Export volume	1.62	5.46	3.16	7.35	9.50	-0.36	-0.24	-0.26
Investment	0.32	1.49	0.45	1.44	4.27	-0.05	-0.20	-0.27
Private cons	0.27	0.49	0.37	0.67	2.29	-0.09	-0.17	-0.19
Government Cons	0.15	0.22	-0.10	0.17	1.11	-0.04	-0.09	-0.13
III-Carbon variable								
Carbon emissions	0.23	0.70	0.52	0.76	2.23	-0.18	-0.34	-0.39

Source: Simulation results

As a result of tariff removals and reduction of non-tariff trade barriers among BRICS countries under enhancing investment flows with capital movements, the growth of trade and investment, which stimulates economic growth of the between these countries, will increase. The results are reasonably consistent over the long run, however the simulations based on the steady state databases tend to result in larger gains in capital stocks and real GDP as a result of the tariff removals with facilitation. As shown in Table-7, larger changes in real GDP for S. Africa stem from larger increases in capital stocks for a member under the steady state simulations. In the steady state simulations all BRICS members experience increases in their capital stocks and hence improvements in real GDP. A comparison with the short run results in previous scenario shows that these improvements in real GDP tend to be greater in the long run with the indigenization of capital. In the case of the non-BRICS regions (USA, EU and rest of World) the decrease in the long-run real GDP becomes significant in the steady state case.

Table-8: Percentage change in decomposition of welfare for policy scenario-2

	Allocation	Endowment	Technology	Terms of trade	Investment-Saving	Welfare
China	4,496	6,104	2,866	14,341	-1,819	25,987
India	3,738	8,160	2017	-1,118	-676	12,122
Russia	591	2,566	1538	-1,264	561	3,993
Brazil	3,685	9,783	1381	-670	279	14,458
S. Africa	2,384	5,613	593	387	1	8,977
EU-28	-7,939	-17,285	0	-3,167	537	-27,855
USA	-2,503	-6,130	0	-2,449	-147	-11,230
ROW	-9,658	-30,121	0	-6,127	1,276	-44,630
Total	-5206	-21311	8395	-68	11	-18178

Source: Simulation results

The welfare effects of the second simulation for the BRICS countries are given in Table-8. According to the decomposition of welfare effects, the highest welfare gain or loss stems from endowment effects resulting from capital movements across BRICS countries. In addition to the endowment effects, they would experience gain in locative efficiency as resources will divert from inefficient sectors to the more efficient sectors.

As for change in carbon emissions, comparing second scenario with the first, trade opening with capital movement on carbon emission has negative effects for all BRICS countries. As shown in the last row of Table-7, the largest percentage changes occurs in emission of carbon for S. Africa(2.23%) and smaller increases for China (0.23%). The increase in carbon emissions accompanied by an increase in output of energy (scale effect) and energy intensive sector (composition effect) as shown in Table-9. The changes in output of all energy sectors in S.Africa, Russia, and India increase, with the largest percentage change in output of petroleum products, there are also rises in almost all energy intensive sector outputs.

Table 9: Percentage change in the outputs of energy and energy intensive sectors for policy scenario-2

	BRICS countries					USA	EU	Row
	China	India	Russia	Brazil	S. Africa			
Energy sectors								
Coal	0.07	0.27	0.96	0.55	0.46	0.04	-0.01	0.07
Oil	-0.44	0.17	-0.08	0.36	0.38	-0.08	-0.09	-0.44
Gas	-0.58	0.11	-0.91	0.35	0.3	-0.06	-0.05	-0.58
Electricity	0.34	0.98	3.66	0.75	0.99	-0.33	-0.2	0.34
Gas manufacture. dist.	0.12	1.28	-5.82	0.97	0.62	-0.34	-0.22	0.12
Petroleum products	0.64	1.24	1.65	0.82	0.56	-0.37	-0.18	0.64
Energy intensive sectors								
Minerals nec	-0.31	0.54	-0.08	1.76	0.65	-0.22	-0.23	-0.31
Chemical.rubber. plastic	0.04	1.90	1.38	4.6	0.30	-0.30	-0.21	0.04
Mineral products nec	0.31	0.58	-0.11	-0.63	0.18	-0.21	0.00	0.31
Ferrous metals	0.29	0.92	1.23	1.34	-0.28	-0.34	-0.15	0.29
Metals nec	0.02	-0.81	28.24	4.00	0.76	-0.61	-0.39	0.02
Manufactures nec	-0.14	1.73	1.04	-3.00	-0.93	0.03	0.19	-0.14

Source: Simulation results

5. Conclusion

This paper analyzes the economic and environmental impacts of trade opening associated with trade facilitation and factor capital movement on carbon emissions in the context of BRICS thesis. To do this, standard GTAP-E model and database may be adjusted to address economic policies results from the climate change issues. From the two policy scenarios, the following conclusions can be reached; in the short run scenario, trade opening among BRICS countries have a positive impact on economy by increasing, trade volume (exports and imports), and welfare for all members and have positive effects on environment by decreasing carbon emission for Brazil and South Africa due to the composition effects, and these are more powerful than scale effects. It is considered that scale effects are more powerful than other two effects in carbon emissions for China and Russia. It also needs to be noted that the model does not cover technique effects of trade opening on carbon emissions.

In the second policy scenario, the comparative static long-run simulation is utilized in this article through treatment of capital movements. In the closures used in the model, capital is assumed to be mobile depending on capital stocks and return rates across countries in the long run. In comparing the short- and long-run effects of intra-BRICS trade opening, it was found that the BRICS economies experienced greater increases in real GDP in the long run. These larger increases in real GDP were primarily due to the increases in capital stocks within the BRICS economies. Accordingly, grater increase in real GDP results in increase in carbon emissions depending on the strength of scale effects.

It is known that the BRICS today are amongst the largest carbon emitters of the world. China, India, Russia are also among the top 10 emitters based on their total carbon emissions. Despite the fact that climate change mitigation for BRICS countries will be very difficult in the near future, important positive steps in renewable energy sector are already taken: China, for example, is not only the largest carbon emitter, but the world's leading producer of wind turbines and solar panels. India has various initiatives to promote solar power and reduce India's emission intensity in the context of national Action Plan.

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