

Would the Bric Economies be Integrated or Assembled?

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Abstract

The objective of this work was to analyze the level of economic integration between the BRIC economies. From the WIOD input-output tables, a BRIC matrix was built which, using the hypothetical extraction method in Input-Output, made it possible to assess the impacts that each group economy generates on the others and the rest of the world. As a result, it was observed at first that the BRIC group had a greater degree of economic integration, but that this integration later lost strength due to the increase in the relationship of these countries with economies outside the group.

1. Introduction

The present study aims, from the World Input-Output Database (WIOD) matrices, to build an Input-Output Matrix of the BRIC (IOM-BRIC) countries (Brazil, Russia, India and China), in order to identify the degree of economic integration of the countries group, as well as interdependencies, convergences and divergences. Through the IOM-BRIC, it is possible to map the most important economic sectors, level of complementarity and global linkage of production.

The developed matrix is composed of five regions: Brazil, China, India, Russia and the rest of the world, both described in the tables respectively as BRA, CHN, IND, RUS and ROW, respectively. Each region will display purchases and sales from 56 sectors, as well as the final demand from these sectors fragmented into household spending, final consumption demand from non-profit organizations serving families (ISFLSF), government consumption, fixed capital formation and changes in inventory and valuables.

The term "BRIC", initially created by Goldman Sachs, carried out by O'Neill (2001), where the development of the economies of Brazil, Russia, India and China was comparatively studied, with the economies of the so-called G-7. According to the author, the 4 countries had relevant characteristics that made them economically important such as extensive oil production, economic representation on their continents, high economic growth, size, population and geographical potential.

To Wilson & Purushothaman (2003), in another Goldman Sachs study, the BRIC countries would have an economic performance superior to that of most developed countries by 2050. According to Kilic & Cankaya (2020), the BRIC economies formally met in 2006 and, starting in 2009, South Africa joined the group thus composing the BRICS economies, adding an "S" to the end of the original acronym representing "South Africa". All BRICS members are growing rapidly, with exception of Russia, which was once an economic power during the period of the USSR (Kalu et. al., 2020). To Arpuv & Uzma (2020), the BRICS countries have in common the standard of living and the per capita income comparable.

This economic group formed in the early 2000s represents a great potential for change in the world economy. The BRICS together represent 40% of the world population, approximately 30% of GDP and 17% of world trade. On the other hand, the G-7 countries represent 10% of the world population, approximately 39% of GDP and 32% of world trade (Kilic & Cankaya, 2020). To Kalu et. al. (2020), all BRICS nations are G-20 countries and represent a significant part of the world's GDP. However, according to the author, these

5 countries have different cultures, different geographical and political circumstances, and even different growth rates, which can interfere with the formation of a long-term strategic alliance.

Even so, in recent years, global markets have been rapidly integrating, and this integration process has been leveraged by technological advances in the areas of finance. This allows developing markets, especially emerging markets such as the BRICS, to mature more and more and at a greater pace (Panda, Vasudevan & Panda, 2020). Thus, this group of 5 countries deserves prominence in the economic plan due to the growth potential that they present, both individually and jointly.

The BRICS group has a relevant representation in the world economy. According to Isiksal (2020), the BRICS as a whole have a powerful influence on global and regional affairs. According to the author, Brazil, Russia, China and India are members of the G-20 and have a total population of more than 3 billion people, which represents approximately 40% of the entire world population. In addition, it is estimated that the nominal GDP of these countries is US\$ 18.6 trillion.

To Kalu et. al. (2020), the BRICS are among the main consumers of commodities, while they are the main recipients of global investment flows. Therefore, considering that financial development represents an important concern in the choice of investments, "international investors are especially interested in the joint movements of the BRICS stock markets with these global factors because investment opportunities, speculation and risk diversification may arise" (Kalu et. al., p. 2, 2020).

Panda, Vasudevan & Panda (2020) state that the BRICS countries are responsible for 16% of the world market capitalization, where Brazil, Russia and South Africa contribute 1% each, India contributes 3% and China has the largest contribution of 10%. Thus, the authors still mention that more than 43,000 companies are listed on the stock exchanges worldwide, where 10% are Chinese companies, 1% are Brazilian, 1% are Russian and 1% are South African. India deserves prominence for being the country that contributes the most with companies listed on the stock exchange, representing 13%, having 3% more than the United States, the second largest country with companies listed on the stock exchange, with a representation of 10% (Panda, Vasudevan & Panda, 2020).

We see in Ganda (2021) that there is a high expectation of rapid economic development compared to other emerging economies in recent decades. Due to this presented economic and financial relevance, the BRICS countries have been the subject of several studies in this area in recent years. Panda, Vasudevan & Panda (2020), Kalu et. al. (2020), Kanvinde (2020) and Hung (2020), developed studies with an emphasis on the BRICS financial and stock market. Kilic & Cankaya (2020) studied the price of oil. Ganda (2021) addressed the environmental impact of human capital in the countries of this group.

In turn, it is in Ganda (2021) that the existence of a high expectation of rapid economic development is understood, when compared to other emerging economies in recent decades. Due to this presented economic and financial relevance, the BRICS countries have been the subject of several studies in this area in recent years.

In another spectrum, in the field of the state economy, Apurv & Uzma (2020) studied the relationship between investment in infrastructure and economic growth, Evenett (2020) addressed state regulation and governance in the BRICS, while Gregory (2020) addressed political risk and financial flexibility in these countries. In fact, what seems common to the countries of the group of economies is the fact that they see themselves as future large economies, and in this sense, the objectivity of cooperation in the sectors of infrastructure and supply of raw materials overrides the low economic integration that is required as a criterion in the composition of economic blocks. Integration is more a desire that is seen in the future than a reality that is presented in the present.

2. Method And Database

The input-output model, and its extensions, are important tools for economic analysis, since it is possible to analyze a large set of economic information for a given production system, as well as the interdependence between sectors and different regions (Cabral, Cabral & Oliveira, 2017). Its operation is an adaptation of the neoclassical theory of general equilibrium for the empirical study of the interrelationships between economic sectors, which must work under the hypothesis of equilibrium, in which the demanded quantities of goods and services are identical to those produced. The input-output model presents the following premises; (i) constant technological coefficient; (ii) constant returns to scale; (iii) exogenously defined final demand; and (iv) rigid prices.

The flows of intersectoral relations of goods and services in a given region, which has n sectors, can be represented as shown in (Leontief, 1986):

$$Z_{11} + Z_{12} + \dots + Z_{1280} + y_1 = X_1$$

⋮

1

$$Z_{2801} + Z_{2802} + \dots + Z_{280280} + y_{280} = X_{280}$$

Where vector z represents intra and intersectoral sales (the lines), to 280 sectors existing in the studied regions (BRIC) for the different countries and the representative of the rest of the world (5 regions that form the macro-region, and each of them presents 56 sectors, $56 \times 5 = 280$), the vector y represents the final demand of the sectors (which is composed of gross fixed capital formation, exports, government consumption and household consumption) and the X represents the gross value of the production of sectors (Annex I).

You can rewrite the first equation in matrix notation:

$$Z + Y = X$$

2

Where, Z is a matrix (280x280), representing the intra and intersectorial relation coefficients (in intermediate consumption), and Y is a vector of (280x1), where the final demand of the four studied national economies is presented (Brazil, Russia, India and China) and for the rest of the world (for all these regions, the 56 sectors previously presented are presented). X is a vector (280x1), in which its values represent the gross value of production for the sectors of a given region.

Equation (2) can be represented in terms of a matrix of technical coefficients (A), also called a matrix of direct coefficients, where A would be:

$$A = \hat{Z}(X)^{-1}$$

3

We have that \hat{X} is the diagonalized matrix of the vector X (gross value of production). And each element of the technical coefficient matrix (A) is defined as follows:

$$a_{ij} = \frac{z_{ij}}{x_j}$$

4

Since a_{ij} is called a technical coefficient ratio, direct requirement coefficient or input-output ratio; then a_{ij} refers to the direct effects of an exogenous variation in final demand. Through Eq. (4), it is verifiable that the ratio of technical coefficients is the fixed relationship between the inputs used in production and the total produced by each sector (gross value of the production of this particular sector).

The matrix A of an input-output model can be illustrated as follows:

$$A = \begin{bmatrix} a_{11} \cdots a_{1280} & \vdots & \vdots & a_{2801} \cdots a_{280280} \end{bmatrix}$$

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With the matrix represented above, we have the intrasectorial technical coefficients on the main diagonal, while on the secondary diagonal, we have the direct intersectorial coefficients. Approaching the conclusion of the presentation of the model, replacing Eq. (3) in Eq. (2), we have:

$$AX + Y = X$$

6

Now, putting Eq. (6) in function of Y (final demand), it becomes:

$$X = (I - A)^{-1}Y$$

We define I as an identity matrix (280x280) and $(I - A)^{-1} = B$ a matrix of direct and indirect coefficients, or an inverse Leontief matrix. Thus, by Leontief's inverse, we can determine the vector of total sectoral production by means of the key matrix equation of the input-output model, which is the following:

$$X = BY$$

This is Leontief's basic model, with an emphasis on the sector x sector relationship and the sectors of their respective countries and with the sectors of foreign countries.

2.1. Hypothetical Extraction Method

Proposed by Dietzenbacher et al. (1993), this method is applied to the input-output matrix seeking to identify sectors strategically important for economic development, since this method helps in the identification of sectors with greater capacity to influence the production of other productive sectors, the detection of these sectors is important for the formulation of economic policy.

This method consists of the hypothetical (imaginary) extraction of a given sector of the input-output structure, with the possibility of removing more than one sector and in the case of an input-output structure with several regions, an entire region can be removed, that is, all sectors of a region. The objective of this extraction is to be able to quantify how much of the total production, of this evaluated region, would reduce if there were the removal of the j -th sector, or of the (j -th) chosen sectors. Thus, it is possible to know the relevance of this or these sectors for total production in the other sectors.

In this work this was done from the assignment of zero value to the rows and columns j 's of the matrix A^f , being j 's the sectors corresponding to the country under analysis (all sectors in one country, and after another). Using $A^f_{-(j's)}$ to denote the matrix without the sectors of a given nation of dimension $(n-56) \times (n-56)$ and considering that $Y^f_{-(j's)}$ corresponds to the vector of final demand minus the sectors of a nation, with this, the key equation of the input-output model becomes as follows:

$$X^f_{-(j's)} = (I - A^f_{-(j's)})^{-1} Y^f_{-(j's)}$$

As a way of measuring the economic loss given the hypothetical extraction, it is evaluating the economic loss in a given sector of another country given the gross value of its production (VBP) without the extraction of a given country, subtracted by the value of the VBP in the same sector, however, with the

hypothetical extraction of the country, in practical terms, the difference between the VBP before the extraction by the VBP with the extraction. Representing this in an equational structure that is able to ascertain the total loss in the model given the withdrawal of a country, we expose the following equation:

$$T_{j's} = i'X^f - i'X^f_{-}(j's)$$

10

Where i' refers to a column vector transposed into dimension (1x281). It should be noted that the higher the value of $T_{j's}$, the greater the interdependence of the sectors of the economy studied with the productive sectors of the other regions under analysis, therefore, the greater the importance of this country's economy for the growth of the others.

As a sequence, we can divide Eq. (10) by the original VBP $i'X^f$ and multiply it by 100, which provides an aggregate measure of economic loss in percentage terms, as follows:

$$T_{j's} = \left[\frac{(i'X^f - i'X^f_{-}(j's))}{i'X^f} \right] 100$$

11

In addition to the calculation that measures the country's relevance to the total VBP of the regions, it is convenient to assess the country's relevance to the VBP of each sector in each region, that is, what is the impact on the VBP of the sector in each region (of those that do not are being extracted) given a hypothetical extraction from a given country (this evaluation which we will use later in the evaluation of the research results), the following equation is used:

$$T_{j's}^i = \left[\frac{(X^f - X^f_{-}(j's))}{X^f} \right] 100$$

12

Through this equation, it is possible to verify which sectors are most dependent on such countries and, therefore, to identify the dependency system between countries. At this point, it is possible to assess how sectors of one economy impact sectors of other interconnected economies. In this sense, it is possible to assess what a national economy has of the capacity to influence the production of other productive sectors in other countries.

By the method described, it will be possible to investigate both the interrelationships between the sectors of the BRIC economies, but also the interrelationship that a national economy has with other economies and their respective sectors. In this way, with a relevant detection of possibly converging or contradictory

interests among the studied nation states, an aid to the formulation of economic policy that requires the identification of the national position outside its territory is possible.

2.2. Database

The input-output matrices (MPIs) provided by WIOD were used as a database, representing the interrelationship between 43 countries and the rest of the world. The matrices are arranged with 56 sectors for each of the 43 countries plus 56 sectors for the rest of the world. In order to study the interdependencies, convergences and divergences between the countries of the group (Brazil, Russia, India and China) and the other countries, all 39 other nations were added together with the rest of the world, forming a single region, maintaining the economies of BRIC separated, allowing their respective analyzes.

3. Results

In order to identify the degree of economic integration between the BRIC countries, this chapter presents the main results obtained through the hypothetical extraction methodological framework implemented in an input-output matrix developed especially for this study, for the years 2000 and 2014. With these two points of comparison, it is possible to intuit whether the level of interdependence between the group's economies has increased or not.

In the year 2000, the less globalized character of these economies is clear, when compared to the year 2014. There is a significant integration between the members of the BRIC, where their economy for them is much more significant than the importance of these countries for the rest of the world, this statement is shown in red in the following table:

Table 1
How much each economy impacts and is impacted – 2000

		Impact on GDP				
		Brazil	Russia	India	China	RW
Extracted Countries	Brazil	-	-0.21%	-0.09%	-0.06%	-0.18%
	Russia	-0.09%	-	-0.06%	-0.04%	-0.09%
	India	-0.19%	-0.31%	-	-0.09%	-0.17%
	China	-0.24%	-1.46%	-0.22%	-	-0.61%
Source: Research results.						

Here we see how the hypothetical extraction of any member of the group impacts the economy of other countries. Table 1 shows that Russia is the country that most depends on the economy of the other BRIC

countries, its economy is the most affected when any of the other economies is extracted. Thus, Russia is the country that loses the most with the hypothetical extraction of the other members of the group (red cells). China, on the other hand, is the economy that generates the greatest absolute impact on the other economies, with Russia being the economy most dependent on the group; China is the economy that causes the greatest variation in production in other countries.

This greater relevance is accompanied by less dependence on other members, since China is the least affected country in all situations of extraction, even when compared with the result for the rest of the world. The main result of this analysis is that the Russian economy is the most dependent on members of the BRIC, while the Chinese economy, in the opposite direction, is the least dependent on any member of the group. Finally, we can say that Brazil is the second economy of the group with the greatest dependence on the other countries under analysis and India is the third with the greatest dependence, or, the second with the greatest independence.

In the year 2014, the scenario is completely reconfigured, in which the biggest impacts of hypothetical extractions from the economies of Brazil, Russia and China were on the output of the rest of the world, with the exception of China, which would impact Russia more severely, showing that the Russian economy maintains a great productive relationship with China, which suffers much more from the hypothetical extraction of China than the rest of the world.

Table 2
How much each economy impacts and is impacted – 2014

		Impact on GDP				
		Brazil	Russia	India	China	RW
Extracted Countries	Brazil	-	-0.26%	-0.27%	-0.25%	-0.37%
	Russia	-0.08%	-	-0.09%	-0.22%	-0.29%
	India	-0.31%	-0.41%	-	-0.31%	-0.50%
	China	-1.71%	-2.49%	-0.79%	-	-2.47%
Source: Research results.						

When comparing these results with the results of 2000, the change in the structure of interdependence between countries is evident, where they start to present a greater importance in the international scenario than within the group. This shows a reduction in the level of interdependence between members when compared to the rest of the world. However, this result is not due to a reduction in the impact generated in the countries under evaluation, by their extraction, since this impact grows in all scenarios, with the exception of the impact in Brazil, given the hypothetical extraction of Russia, which presents a slight decrease.

This indicates that although there is an increase in the relationship between countries, these countries have greater relations with countries outside this group, since it is possible to infer that external countries suffer much greater impacts than the members of the group, given the hypothetical extraction of the economy Brazilian, Russian and Indian. The same can be said for China, when comparing the impact of its extraction, for Brazil, India and the rest of the world, since the magnitude of the impact in the rest of the world, it demonstrates that there are countries, outside the ones analyzed above, that suffer impacts much more significant given its extraction.

Thus, it is understood that the importance of each BRIC economy for their output increased from 2000 to 2014, however this increase was no more relevant than the increase in the impact suffered by the rest of the world, thus, the Hypothetical extraction from Brazil, Russia and India have a greater impact on the rest of the world, implying that the importance of the BRIC to the world has increased. In addition, in this 15-year period, the expressive increase in the importance of the Chinese economy for the output of the economies of the BRIC and the rest of the world is visible, when in 2000 it was the economy that had the greatest impact on the others, when in 2014 maintained this position with significant increases.

After assessing the more aggregated scenario of impacts, it is important to detail the impacts generated in the economic sectors of the group's countries and the rest of the world.

3.1. Sectoral impact given Hypothetical Extraction in 2000 and 2014

Through the data presented in Annexes II, III, IV and V, it is possible to create a temperature map that demonstrates the impacts of the extraction of a given country in the sectors of the other BRIC countries and the rest of the world. The temperature map is read as follows: the darkest cells demonstrate the greatest impacts, and the lightest cells demonstrate the least impacts on the sectors of economies.

When Brazil is extracted, the sector most impacted in 2000 is *Architectural and engineering activities; technical testing and analysis* (46) from India, with a loss of 4.58%, which in the subsequent period ceased to be the most affected, with a contraction of 1.15%. In 2014, the highlight was the Russian *Manufacture of chemicals and chemical products* (11) sector, which would have lost 2.36% of its production (Annex II).

Analyzing the results of Annex III on the hypothetical extraction of the Russian economy, in the year 2000, it mainly affected the *Wholesale and retail trade and repair of motor vehicles and motorcycles* (28) sector in India, with an impact of 0.67%. For 2014, the most impacted sector was ROW's *Fishing and aquaculture* (3), with an impact of 2.13%.

Extracting the Indian economy, for the year 2000, the sector most affected was that of *Architectural and engineering activities; technical testing and analysis* (46) in Brazil, suffering a reduction of the order of 7.79% (Annex IV). Despite the reduction in the degree of dependence, the pattern was maintained in 2014, when the Brazilian sector continued to be the most impacted, with the distinction that for this year the

degree of dependence decreased to 6.38%. We see that for the year 2000, there is a strong interdependence between India and Brazil, in which the extraction of any of these economies affects mainly the same sector (46).

Finally, based on Chinese economy to the year 2000, the most affected sector is the Russian *Manufacture of paper and paper products* (8) sector, with a drop of 10.42% of the production. In the following period, we see the sector most affected is the *Manufacture of computer, electronic and optical products* (17) sector of the ROW, with a drop of 16.28% of the output in this sector (Annex V).

It is observed that in this period the relationship between the countries of the group did not decrease, in some cases it even increased (the relationship of the countries with the Chinese economy), however, we see the relationship of these countries with the ROW has increased in terms of magnitude and in relative terms, more than their relationship with the other members of the group, thus, the analyzed economies became less related, not because of a gap between them, but due to a more significant increase in the participation of economies outside the group, present in the ROW, in the economic relations between the BRIC. The only exception is the Russian's case, which continued suffering the greatest impacts from a group member, China.

A point common to all the results on the heat map presented in the annexes is that the darkest bands (those most impacted) are concentrated between sectors 1 to 20, which are precisely agricultural, extractive and manufacturing activities. Thus, it is identified that the sectors of greatest interdependence between the countries of the group, and even with the rest of the world, are those with the lowest added value.

4. Final Remarks

The present work was able to verify a convergent relationship between the Brazilian and Indian economies, as well as to verify the greater distancing of the Indian economy from the global process of high interaction and dependence with the Chinese economy. We also see the character of high interaction of the Russian economy with the Chinese, as we have seen, of course, the structural change in the relationship between Brazil and China, boasting a significant increase in the importance of the Chinese economy to Brazil from the year 2000 to the year 2014.

The economic importance of China to the rest of the world was evident, where the country represented a very relevant impact on the economy of the studied nations and the rest of the world, with the occurrence of its extraction. It can also be seen that in the early 2000s Russia had an economy much more distant from the interactions between countries, and we see a possible approximation of this country with the so-called Global Value Chains, due to its greater interaction with other economies in the year 2014.

The process observed for Russia, described above, was also observed for all economies studied, where they showed an increase in their interactions on the international stage, with emphasis on Chinese and later on Indian activities, which showed significant importance. We can also verify that the Chinese and

Indian economies presented a basket of similar demands, focusing on natural resources and their derivatives, possibly due to the scarcity of these in their territories.

Finally, we can say that the study does not complete the interpretation of all the results available in it, however it indicates, through the heat map, the most significant and most relevant results, which, at least, should tend to guide the discussions prevailing economic conditions for these countries in the international scenario and, therefore, situate the economies (in our case, Brazil), in face of this scenario. It is believed that the scenario seen has not had major changes, however, an update is needed to verify the changes for the most recent years.

Declarations

Availability of data and materials

The baseline datasets generated and analysed during the current study are available in the World Input-Output Database (WIOD) matrices repository, [<https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release>], but the datasets that makes up the modified matrix (BRIC) are not publicly available due to the lack of place to do so, but are available from the corresponding author on reasonable request.

Competing interests

'Not applicable' for that section

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Author's contributions

FR collected the data, developed theoretical framework, designed and performed computation, developed the matrix (BRIC) used in the research, performed the hypothetical extraction and evaluated the results. EM supervised the research throughout the process, assisting in data collection, in the methodological part, in the projection and interpretation of results. JC assisted with methodological issues. DC assisted in contextualizing the BRIC economies. MJ assisted in translating the text into English.

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