

The measurement of green economic quality in the BRICS countries: Should they prioritize financing for environmental protection, economic growth, or social goals?

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Abstract

The study presents a Green Economy Index that evaluates the quality of green economies in the BRICS countries based on three pillars: environment, economic performance, and quality of green living. Research findings suggest that the BRICS nations are gradually shifting their focus from mere economic growth to encompassing environmental, social welfare, and equality concerns. Russia showcased the best balance among these three pillars from 2011 to 2020, while India and China made notable strides. Nevertheless, Brazil and South Africa face obstacles in improving their economies and increasing social welfare. The indicators highlight specific challenges each country must address, including high unemployment in Brazil and South Africa, low energy intensity in Russia and China, and air pollution and low Human Development Index in India, alongside shared issues like low government transparency. Based on the research significant findings, the study attempts to address whether the BRICS nations should prioritize financing environmental protection, economic growth, or social goals to maintain a balance among all the three pillars and achieve their green economy objectives.

Keywords: green economy, green economy index, three pillars of green economy, green financing, entropy weight method.

JEL classification: E00, E60, G00, G10.

1. Introduction

The COVID-19 pandemic, which occurred between 2019 and 2022, has left an indelible mark on the world, including the BRICS nations of Brazil, Russia, India,

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China, and South Africa. The pandemic's severe impact has caused significant harm to both the economy and the population. Given the scale of the damage, it is clear that a traditional approach to recovery will not be sufficient to restore pre-pandemic levels of growth. Instead, there is an urgent need to transform towards sustainable economic development, which can help the BRICS countries to build a more resilient and prosperous future.

The global community has recognized the urgency of transitioning to a green and sustainable economy, given the devastating effects of climate change and environmental degradation on economic and social progress. The United Nations Conference on Sustainable Development in Rio de Janeiro in 2012 endorsed this through "The future we want" outcome document, which identified the green economy as a crucial means of achieving sustainable development. The BRICS countries have implemented initiatives to promote sustainable development, such as investing in renewable energy and implementing environmental protection policies. They have also jointly pledged to work together to achieve sustainable development goals globally. In 2018, the BRICS countries adopted a set of action plans to promote sustainable development and the green economy. These plans included significant commitments such as promoting green and low-carbon development, increasing the use of renewable energy, improving energy intensity, protecting biodiversity and ecosystems, strengthening cooperation on sustainable development in their countries, and supporting the implementation of the United Nations' 2030 Agenda for Sustainable Development.

Moving forward, it is imperative to ensure that efforts to transition to a green economy as part of broader economic transformation remain on track. To this end, this paper proposes the Green Economy Index (GEI) as a tool to measure progress towards a green economy. The index utilizes carefully selected indicators that reflect the three pillars of the green economy, namely economic performance, the environment, and the quality of green living. This research also highlights the importance of measuring the quality of the green economy based on a balance between all the three pillars. Such measurements can help sustain the BRICS countries' green economy trajectory and expedite the implementation of low-carbon development and climate resilience programs, thereby facilitating a smooth transition to a green economy. By leveraging the GEI and emphasizing a balanced approach to measuring progress towards a green economy, the BRICS nations can work towards building a more sustainable and prosperous future for all.

2. Theoretical analysis

2.1. *The concept of green economy*

While there is no universal definition of green economy, many organizations and governments have proposed definitions that convey a similar central concept. The United Nations Environment Program (UNEP) defines the green economy as one that not only enhances human well-being and social equity but also substantially reduces environmental risks and ecological scarcities (UNEP, 2012). This definition of the green economy transcends a mere accounting of negative environmental impacts in a country's GDP calculation. It is a comprehensive framework that promotes sustainable development by investing in

capital, infrastructure, employment, and skills, with the goal of achieving both social welfare and environmental sustainability (UNEP, 2012). By embracing such a holistic understanding of the green economy, nations can build a more equitable, prosperous, and sustainable future for all.

The Organisation for Economic Co-operation and Development (OECD) defines the green economy as one that decouples economic growth from the depletion of natural capital and the degradation of the environment, while providing increased economic, social and environmental benefits. According to the OECD, the green economy requires investments in green infrastructure, development of green technologies and the creation of green jobs, as well as efforts to reduce the ecological footprint of economic activities. The OECD also emphasizes the need for inclusive growth and the reduction of environmental and social risks, and the promotion of sustainable consumption and production patterns. The Organisation advocates for market-based mechanisms and policy instruments that incentivize the transition to a green economy, such as carbon pricing, eco-taxation and subsidies for renewable energy (OECD, 2011).

The Asian Development Bank (ADB) insists the green economy is one that balances economic growth and environmental sustainability. According to the ADB, such an economy prioritizes the efficient use of natural resources, increased investment in renewable energy and environmental technologies, and the creation of green jobs. The ADB also views the green economy as one that promotes inclusive growth, social equity, and improved human well-being, while reducing poverty, inequality and environmental degradation. The Bank emphasizes the need for a transition to a green economy that is supported by policy frameworks, investments in green infrastructure, and the development of sustainable value chains. The ADB also promotes green financing and the integration of environmental considerations into national development strategies (ADB, 2012).

The BRICS countries have a collective vision of the green economy that prioritizes sustainable development and low-carbon growth. This includes a focus on the efficient use of natural resources, the promotion of renewable energy sources, and the adoption of green technologies and practices in various sectors. The BRICS nations also aim to promote international cooperation on environmental issues, such as climate change, to achieve a sustainable and inclusive global economy. In addition, they seek to leverage their economic and technological strengths to promote green finance and green investments. In other words, within the BRICS countries' vision, the green economy aims to address their environmental, social, and economic challenges, such as climate change, poverty, inequality, and sustainable development, with the main objective of promoting growth and development in a sustainable way, preserving the environment and the planet's resources, and promoting well-being of citizens.

Recent academic studies suggest that achieving carbon neutrality is dependent on transition towards a green, low-carbon, and circular economy to address ecological challenges (Attahiru et al., 2019). It is clear that carbon emissions and economic development are closely linked since economic growth requires energy consumption, which poses challenges for energy intensity (Lin et al., 2021). Therefore, developing the green economy is crucial for achieving a balance between energy security, environmental protection, and economic growth (Maclean and Plascencia, 2012; Weber and Cabras, 2017). By examining the factors that affect society's prosperity

and welfare, Egorova et al. (2015) highlight negative effects of the current economic model and present Japan's experience as evidence of the benefits of investing in green economy sectors and R&D to improve food production and increase life expectancy, ultimately positively impacting society's welfare. Transition to a green economy can, therefore, improve a nation's health and enhance factors that promote social and economic prosperity and welfare. Therefore, it is essential to recognize that the concept of green economy is grounded on three fundamental pillars: environmental conservation, sustainable economic growth achieved through reduced emissions and increased resource efficiency, and improvement of well-being and social equality. However, it is crucial to note that each country has unique natural conditions, economic resources, and cultural contexts, leading to diverse policies and strategies in achieving the UN Sustainable Development Goals (SDG).

2.2. *The measurement of the Green Economy Index*

Creating a method to assess the progress in the green economy transition is a complex task that necessitates a specific approach with clear, reliable, and precise indicators to measure it. This research aims to establish and evaluate the effectiveness of the quality of the GEI by utilizing various global practices and relevant research. UNEP (2012, 2014, 2015) released its Green Economy Index, which includes 40 indicators that fall under three categories: environmental, policy interventions, and well-being and equity. In 2017, the United Nations Program on the Global Environment (UN PAGE) introduced a framework for measuring the progress in moving to a green economy, which comprises three groups: economy, social, and environment, and a total of 13 indicators. This framework aimed to provide a comprehensive and holistic approach to assessing the corresponding progress by considering the economic, social, and environmental dimensions. The economy group includes indicators such as GDP, investments in renewable energy, and resource efficiency. The social group includes indicators such as poverty reduction, access to education and healthcare, and gender equality. The environmental group includes indicators such as air and water quality, biodiversity, and greenhouse gas emissions. These indicators were chosen to provide a comprehensive picture of the progress made in the green economy transition (PAGE, 2017).

There are different versions of the GEI developed by various entities, such as OECD's Green Growth and Dual Citizen's Global Green Economy Index. Under the framework of the OECD, it has introduced 26 green growth indicators that are grouped into four categories, such as productivity, natural asset base, quality of life, and policies (OECD, 2017). The Global Green Economy Index, created by Dual Citizen, offers a comprehensive view of the green economy through 18 quantitative and qualitative indicators. The index measures four essential dimensions: climate change and social equity, sector decarbonization, markets and Environmental, Social, and Corporate Governance (ESG) investment, and environmental health (Dual Citizen, 2022).

In China, recent studies have focused on developing a high-quality green economy, emphasizing critical factors such as resource utilization, environmental protection, social construction, economic performance, and sustainable living promotion. Zheng et al. (2022) emphasize the significance of these factors in forming a high-quality green economy.

2.3. A brief review of green economies of the BRICS nations from 2011 to 2020

Brazil. During the period of 2011–2020, Brazil made significant efforts to prioritize environmental protection, particularly in response to the threat of deforestation in the Amazon rainforest (OECD, 2015). The country implemented various initiatives to reduce deforestation and promote sustainable land use, including creating protected areas, increasing monitoring and enforcement efforts, and promoting sustainable agriculture and forestry practices (OECD, 2015, 2021). However, Brazil faced significant economic challenges during this period, with GDP declining for two consecutive years in 2015 and 2016 due to a combination of factors, including a decline in commodity prices, political instability, and fiscal imbalances (Vartanian and Garbe, 2019). Despite these challenges, the country remained committed to environmental protection as a top priority. Nevertheless, the economic and social goals were impacted, resulting in a decline in people's quality of life and an increase in unemployment. The COVID-19 pandemic has made it even more challenging for Brazil to recover from the crisis.

Russia. The Russian economy experienced a range of challenges and shifts between 2011 and 2020, with steady economic growth fueled by high oil prices and other commodity exports in the period 2011–2014 (Drobyshevsky, 2018; Kudrin and Gurvich, 2014). In 2015, the economy entered a recession due to falling oil prices, economic sanctions, and a decline in domestic demand. In 2017, the economy began to recover, with GDP growing by 1.5% (Drobyshevsky, 2018). In 2018, the economy grew by 2.3%, driven by a strong performance in the manufacturing and construction sectors. In 2019, the Russian economy continued to grow, with GDP expanding by 1.3%. In 2020, the COVID-19 pandemic had a significant impact on the Russian economy, with GDP contracting by 3% (Shirov, 2022). While Russia has made some efforts to promote environmental protection during the period of 2011–2020, it is not typically considered a key priority for the country. Russia's economy is heavily reliant on its natural resource industries, including oil, gas, and mining, which can have negative environmental impacts. Mitrova and Melnikov (2019) argue that, as a fossil energy power within the BRICS countries, Russia does not appear to have clear policies in its determination to increase the share of renewable energy. Instead, it wants to take advantage of this resource in order to revitalize the economy (Gaddy and Ickes, 2019). During the period of 2011–2020, Russia did prioritize social goals and addressing inequality as part of its policy agenda. However, the country faced significant social challenges during this time, including high levels of poverty, income inequality, and unemployment. According to Mareeva (2020), the population perceives current socio-economic inequality as excessive and illegitimate, and the resulting gap between expectations and reality has led to increasing demands for the state to address these disparities. This perception of social inequality is set against the backdrop of an objective situation where income equality has improved in the middle class but worsened between the wealthy elite and the rest of the population. In summary, although the Russian government increased social spending, including on healthcare, education, and housing, as well as setting environmental goals, in the period 2011–2020, it still tends to give priority to economic development over environmental and social goals.

India. During the period of 2011–2020, India was one of the fastest-growing major economies in the world, with an average annual growth rate of 7.5% between 2014 and 2019. However, despite this impressive growth, there were signs of a slowdown in India's economy beginning in the third quarter of 2019, as reported by Nagaraj (2020). The COVID-19 pandemic further exacerbated the situation, leading to economic challenges for the country. Despite these challenges, India has been making efforts to address environmental issues, and the Climate Action Tracker rates India's nationally determined contribution (NDC) as "2°C compatible," meaning that it is a reasonable contribution to global efforts based on India's historical responsibility and present capacity (Climate Action Tracker, 2020). In fact, India's NDC outperforms any other G20 country, according to Picciariello et al. (2021). India's commitment to clean and renewable energy is noteworthy, with the country investing a minimum of \$35.37 billion from its fiscal stimulus package towards clean energy, including renewable energy sources such as solar power, and energy intensity, in response to the COVID-19 pandemic. Furthermore, India has demonstrated its dedication to promoting low-carbon development by providing further support for environmentally friendly transportation, afforestation, and other initiatives (IISD et al., 2020; Climate Transparency, 2020). Despite persistent issues related to gender, income, healthcare, and access to clean water, India's efforts to improve the quality of life of its citizens are commendable, with the Human Development Index (HDI) rising from 0.57 to 0.64 and nearly 99% of the population having access to electricity (Chawla et al., 2022; Anand and Thampi, 2021). India has made significant strides in achieving sustainable development between 2011 and 2020, and while much more needs to be done, the country has taken concrete steps to balance the three pillars of environment, economic growth, and social goals.

China. From 2011 to 2020, China's economy underwent remarkable growth and transformation, continuing to expand rapidly with an average annual GDP growth rate of around 7.5%. Despite some fluctuations, China remained one of the fastest-growing major economies worldwide. The government's policies, a growing middle class, increasing urbanization, technology and innovation, and an export-oriented economy were the primary drivers of China's high economic growth rate between 2011 and 2020 (Liu and Hu, 2020). Although China faced significant environmental challenges during this period, such as air pollution, water pollution, and soil contamination, the government implemented measures to mitigate these problems and made considerable progress in improving environmental conditions. Despite some cities' ongoing struggles with pollution, China's air quality, as evidenced by a 33% reduction in PM2.5 (fine particulate matter) concentrations from 2013 to 2020, improved significantly overall (Lu et al., 2020). Moreover, to meet its energy demands while fulfilling its commitment to reduce carbon emissions, the Chinese government encouraged and supported renewable energy projects, investing a record-breaking \$83.4 billion in 2019, the most of any country worldwide (Gurol, 2022, p. 138). Additionally, between 2013 and 2020, approximately 100 million people in China were lifted out of poverty, as per the World Bank's (2022) report. This period, which saw China's political leadership devoting substantial financial resources to social welfare and inequality reduction objectives, is similar to India in that it did not prioritize economic growth at any cost but instead invested in environmental and social goals.

South Africa. From 2011 to 2020, South Africa had to deal with a lot of inequality and slow economic growth. Despite the government's efforts to promote economic growth and reduce poverty, the country continued to experience significant challenges in these areas. South Africa's GDP growth rate averaged only 1.6% per year during the period of 2011–2020, which is below the average growth rate for other middle-income countries. This slow growth has been attributed to a range of factors, including structural weaknesses in the economy, high levels of unemployment, and low levels of investment. South Africa has one of the highest levels of income inequality in the world, with a Gini coefficient of 0.63 in 2011 and 0.60 in 2020. This has been attributed to a range of factors, including historical legacies of apartheid, persistent poverty, and unequal access to education and healthcare (Adjaye-Gbewonyo et al., 2016; Burns et al., 2017). According to the UNDP (2019), South Africa's HDI was 0.666 in 2011 and 0.710 in 2019, indicating a modest improvement in human development. This increase was primarily driven by the growth in life expectancy, while the progress in education and income remained relatively stagnant. The South African government's efforts to protect the environment and increase social well-being should be recognized, as evidenced by the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) in 2011 and the National Development Plan (NDP) in 2012, as well as the implementation of a carbon tax in 2019 and the National Health Insurance (NHI). Based on the above empirical evidence, we do not expect South Africa to see an improvement in its economic index. However, implementing programs that protect the environment and promote social well-being can help the country to improve scores in the pillars of environment and social goals (the quality of green living).

3. Material and methods

3.1. Data sources

For this study, data from the BRICS countries for the period of 2011 to 2020 was selected. The analysis of this data required consulting a variety of sources, including the World Bank, IQAir, the World Health Organization, and statistical yearbooks of all five BRICS countries, etc. Gathering and analyzing data from multiple sources allowed for a comprehensive and nuanced understanding of trends and patterns in the BRICS countries over the past decade.

3.2. Indicators selection

This study aimed to develop a comprehensive Green Economy Index that takes into account the unique features of an inclusive green economy. In order to achieve a balance between social welfare, environmental sustainability, and economic growth, the definition of green economy adopted in this report promotes investment, capital, infrastructure, employment, and skills. This means prioritizing low carbon natural capital, resource efficient physical capital, and human capital with green skills (PAGE, 2017). Drawing on research by Zheng et al. (2022) and the Ministry of National Development Planning of Indonesia (2022), the GEI was constructed from three pillars: environment, economic performance, and the quality of green living. The 16 indicators selected to measure these pillars

were carefully chosen based on three criteria: alignment with the United Nations' SDG, complete historical data, and yearly reporting to ensure future calculation of the GEI. A detailed description of the selected indicators can be found in Table 1. This comprehensive approach ensures a more accurate and meaningful measurement of the green economy and can be used to guide policy and decision making towards a more sustainable and inclusive future.

3.3. The entropy weight method

Based on the works by Zheng et al. (2022), and Li and Zou (2018), the entropy weight method is employed to compute the weight of each indicator. In this method, the evaluation is set up with m indicators and n samples, and the measured value

Table 1
Construction of the Green Economy Index (GEI).

First level indicators	Basic indicators	Indicators explanation	Unit	Property	Weight
Environment	Forest coverage	Comparison between forest cover with total land area	%	Positive	0.1227
	Share of renewable energy	The share of energy from renewable sources against the total primary energy	%	Positive	0.4539
	Air quality	Based on annual average PM2.5 concentration	$\mu\text{g}/\text{m}^3$	Negative	0.2176
	Land protection	Share of land area that is protected	%	Positive	0.1353
	Wastewater management	Proportion of safely treated household wastewater	%	Positive	0.0706
Economic performance	Energy intensity	Energy consumption per unit of GDP	$\text{kW}\cdot\text{h}/\text{\$}$	Negative	0.2054
	CO ₂ emissions per unit value added	The kilograms of CO ₂ emitted per US\$ of GDP	$\text{Kg CO}_2/\text{\$}$	Negative	0.3138
	GDP per capita	GDP per capita (PPP \$2017)	\$1000	Positive	0.2892
	Share of medium and high-tech industry	The proportion of medium and high-tech industry value added as a percentage of total manufacturing value.	%	Positive	0.1178
	Employment rate	The share of the labor force that is employed	%	Positive	0.0221
	Government transparency	Corruption Perception Index (0–100)	–	Positive	0.0516
	The quality of green living	HDI	Human Development Index	–	Positive
Health worker density		Number of physicians/1000 people	physicians	Positive	0.7867
Safe sanitation and hygiene		Share of population using safely managed sanitation facilities	%	Positive	0.0983
Access to electricity		Share of the population with access to electricity	%	Positive	0.0124
Inequality		GINI coefficient	–	Negative	0.0875

Source: Compiled by the authors.

of the i -th indicator in the j -th sample is recorded as X_{ij} . Let P_{ij} be the standardized value of the i -th indicator in the j -th sample, its calculation is as follows:

$$P_{ij} = \frac{X_{ij}}{\sum_{j=1}^n X_{ij}}; \quad i = 1, 2, \dots, m. \quad (1)$$

The entropy value E_i of the i -th indicator is calculated by the following equation:

$$E_i = -\frac{\sum_{j=1}^n P_{ij} \ln(P_{ij})}{\ln(n)}; \quad i = 1, 2, \dots, m. \quad (2)$$

The weight of the i -th indicator (w_i) is calculated as in equation 3. The weights of all 16 indicators and their properties are presented in Table 1.

$$w_i = \frac{1 - E_j}{\sum_{i=1}^m (1 - E_j)}. \quad (3)$$

Therefore, the value of an index is calculated as follows:

$$I_j = \sum_{i=1}^m w_i X_{ij}; \quad j = 1, 2, \dots, n. \quad (4)$$

Three separate indices are measured in this study using the entropy weight method: the environment index (*env.index*), the economic performance index (*eco.index*), and the quality of green living index (*qgl.index*). The GEI evaluates the progress toward an inclusive green economy by combining the progress made in the three pillars and considering the number of indicators within each pillar to acknowledge that all indicators are of equal importance. As a result, the a -th country's GEI in b -th year is calculated as follows:

$$\begin{aligned} \text{Green economy index}_{ab} &= \\ &= \frac{\text{env.index}_{ab} \times 5 + \text{econ.index}_{ab} \times 6 + \text{qgl.index}_{ab} \times 5}{16}. \end{aligned} \quad (5)$$

3.4. Min-max scaling method

To accurately assess the balance of three pillars, this study does not rely on the entropy value as each index is made up of different indicators. Instead, we utilize the min-max scaling method to normalize the values of all indices within the range of [0, 1]. This method ensures that all the indices can be compared with one another to provide a comprehensive green economy evaluation. The formula for min-max scaling is:

$$\text{Normalized Value}_{ab} = \frac{\text{Value} - \text{Value}_{\min}}{\text{Value}_{\max} - \text{Value}_{\min}}. \quad (6)$$

It should be noted that the min-max scaling method is utilized solely for assessing the balance of three pillars of the green economy. To determine its quality between 2011 and 2020, and future potential, we recommend employing equations (4) and (5).

4. Results and discussion

4.1. Characteristic indicators analysis

Table 2 displays Brazil's remarkable performance in environmental indicators compared to other BRICS countries. Brazil has 60% forest coverage and an increasing share of renewable energy, from 43.9% in 2011 to 49.5% in 2020, with a decrease in PM2.5 dust from 15.8 $\mu\text{g}/\text{m}^3$ to 12.7 $\mu\text{g}/\text{m}^3$. Brazil's commendable energy intensity and low CO₂ emissions per unit value added reveal its commitment to environmental protection, emission reduction, and energy efficiency. Nonetheless, Brazil's GDP per capita and employment rate have declined from 2011 to 2020, which presents a challenge. China has made significant progress from 2011 to 2020, as reflected in its positive indicators, despite its air quality remaining in the unhealthy range, especially in industrial cities. India has also made progress in air quality, reducing the air quality index to 51.9 $\mu\text{g}/\text{m}^3$ in 2020 from 84.2 $\mu\text{g}/\text{m}^3$ in 2011, and boasts an impressive energy intensity of 1.19 kW·h per USD of GDP, the same as South Africa. Russia's indicators in all the three pillars remain mostly

Table 2

The change in indicators in the period 2011–2020.

Country	Environment											
	Forest coverage		Share of renewable energy		Land protection		Air quality		Wastewater management			
	2011	2020	2011	2020	2011	2020	2011	2020	2011	2020		
Brazil	61.0	59.4	43.90	49.5	28.9	30.3	15.8	12.7	31	33		
China	21.6	23.4	7.08	14.2	17.1	15.6	60.7	38.7	61	65		
India	23.5	24.3	7.50	9.7	6.0	7.5	84.2	51.9	25	27		
Russia	49.8	49.8	5.58	7.1	9.7	11.5	19.1	16.2	27	27		
South Africa	14.3	14.1	0.69	3.2	14.1	8.7	26.7	25.1	61	61		
Country	Economic performance											
	Energy intensity		CO ₂ emissions per unit value added		GDP per capita		Share of medium and high-tech industry		Employment rate		Government transparency	
	2011	2020	2011	2020	2011	2020	2011	2020	2011	2020	2011	2020
Brazil	1.07	1.09	0.17	0.14	15.3	14.0	36.3	33.7	93.1	86.3	43	38
China	2.48	1.75	0.63	0.44	9.7	16.3	41.4	41.4	95.4	95.0	39	42
India	1.48	1.19	0.30	0.27	8.6	11.5	41.1	41.3	94.5	92.0	36	40
Russia	2.35	2.25	0.40	0.35	25.0	26.6	24.7	25.6	93.5	94.4	28	30
South Africa	2.45	2.23	0.44	0.40	13.7	12.8	24.4	24.5	75.4	70.8	43	41
Country	The quality of green living											
	HDI		Health worker density		Safe sanitation and hygiene		Access to electricity		Inequality			
	2011	2020	2011	2020	2011	2020	2011	2020	2011	2020		
Brazil	0.72	0.76	1.85	2.31	40.3	48.7	99.3	100.0	0.53	0.49		
China	0.69	0.76	1.46	1.98	38.5	69.7	99.8	100.0	0.42	0.38		
India	0.57	0.64	0.74	0.93	27.4	45.9	67.6	99.0	0.36	0.36		
Russia	0.79	0.83	6.45	4.50	58.4	60.8	100.0	100.0	0.40	0.36		
South Africa	0.67	0.72	0.72	0.80	27.4	45.9	83.6	84.4	0.63	0.60		

Source: Compiled by the authors from various sources.

unchanged, except for a decrease in the number of physicians per 1,000 people. It is noteworthy that the Russian government has made efforts to maintain growth in the indicators from 2011 to 2020. Among the BRICS countries, South Africa appears to be the weakest performer, with most indicators remaining largely unchanged compared to others. South Africa's employment rate and GDP per capita decreased from 2011 to 2020, and its GINI coefficient stands at 0.6, indicating the country still has much work to do in the period from 2021 to 2030.

4.2. The changing trend of the Green Economy Index

Table 3 shows the results of the environment index, the economic performance index, the quality of green living index, and GEI calculations. The trends of these indices are depicted in Figs. 1, 2, 3, and 4 respectively.

The environment. The study acknowledges the impressive efforts made by the BRICS nations to enhance the quality of the living environment. Table 3 and Fig. 1 showcase the noticeable increasing trend of the environment index in the BRICS countries from 2011 to 2020. Brazil stands out with its impressive values of forest coverage, land protection, and share of energy from renewable sources against total primary energy. In 2011, China and Russia had comparable

Table 3

The changing trend of the three pillars and the Green Economy Index in 2011–2020.

Country	Environment index (Pillar 1)									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	33.66	32.80	31.76	31.29	32.07	33.44	33.30	34.55	35.20	36.17
China	12.75	13.42	13.65	14.23	14.53	14.67	14.97	15.32	15.67	16.03
India	8.98	8.64	8.92	8.94	8.88	8.81	9.05	9.24	9.68	10.30
Russia	11.86	11.84	12.13	11.99	11.94	12.12	12.10	12.07	12.14	12.77
South Africa	8.28	8.11	8.13	8.33	8.51	7.85	8.21	8.36	8.39	8.63
Country	Economic performance index (Pillar 2)									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	12.70	12.63	12.79	12.57	12.23	11.77	11.87	11.67	11.71	11.63
China	11.10	11.32	11.61	11.65	11.95	12.38	12.71	12.88	13.23	13.37
India	10.89	10.90	10.78	11.07	11.65	11.73	11.86	12.04	12.18	11.97
Russia	13.04	13.57	13.47	13.48	13.77	13.73	13.69	13.60	13.89	13.78
South Africa	10.09	10.13	10.17	10.27	10.22	10.27	10.17	10.19	10.17	9.68
Country	The quality of green living index (Pillar 3)									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	6.61	6.69	6.81	6.90	7.00	7.09	7.41	7.51	7.72	7.81
China	6.14	6.53	6.95	7.34	7.77	8.21	8.68	9.06	9.46	9.62
India	4.09	4.41	4.66	4.89	5.15	5.39	5.65	5.82	6.23	6.45
Russia	12.03	10.39	10.39	10.54	10.36	10.47	10.59	10.66	10.68	10.74
South Africa	4.25	4.48	4.69	4.92	5.14	5.31	5.54	5.74	5.95	6.14
Country	Green Economy Index									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	17.35	17.08	16.85	16.65	16.79	17.08	17.18	17.52	17.80	18.11
China	10.07	10.48	10.79	11.11	11.45	11.79	12.16	12.45	12.82	13.03
India	8.17	8.16	8.29	8.47	8.75	8.84	9.04	9.22	9.54	9.72
Russia	12.36	12.03	12.09	12.10	12.13	12.21	12.23	12.20	12.34	12.51
South Africa	7.70	7.73	7.82	7.99	8.10	7.97	8.11	8.23	8.29	8.25

Source: Authors' calculations.

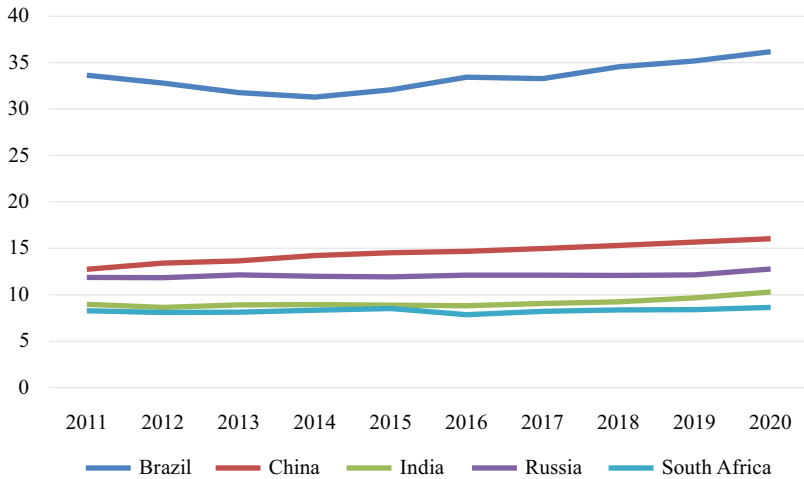


Fig. 1. The changing trend of the environment index of the BRICS countries in 2011–2020.

Source: Authors' calculations.

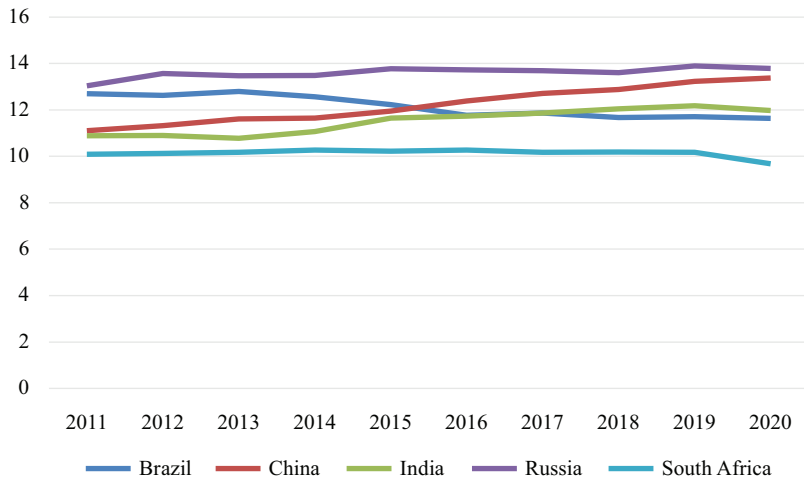


Fig. 2. The changing trend of the economic performance index of the BRICS countries in 2011–2020.

Source: Authors' calculations.

environmental indices, with China at 12.75 and Russia at 11.86. However, by 2020, China had raised its index to 16.03, while Russia had only reached 12.77. In contrast, India and South Africa had the lowest environmental indices of 8.98 and 8.28, respectively, in 2011. By the end of 2020, India's index had increased by 1.32 points to 10.30, while South Africa's index had increased by only 0.35 points to 8.63. Despite variations in financial support and accomplishments, all the BRICS countries appear to be focused on environmental objectives, as analyzed in subsection 2.3.

The economic performance. The economic performance of India, Russia, and China showed marked improvement between 2011 and 2020, while Brazil and South Africa saw declines. China's economic performance index was on par with

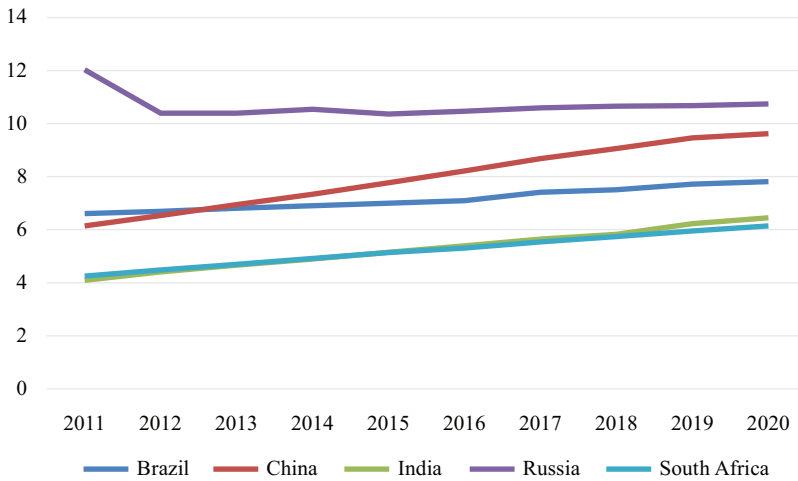


Fig. 3. The changing trend of the quality of green living index of the BRICS countries in 2011–2020.

Source: Authors’ calculations.

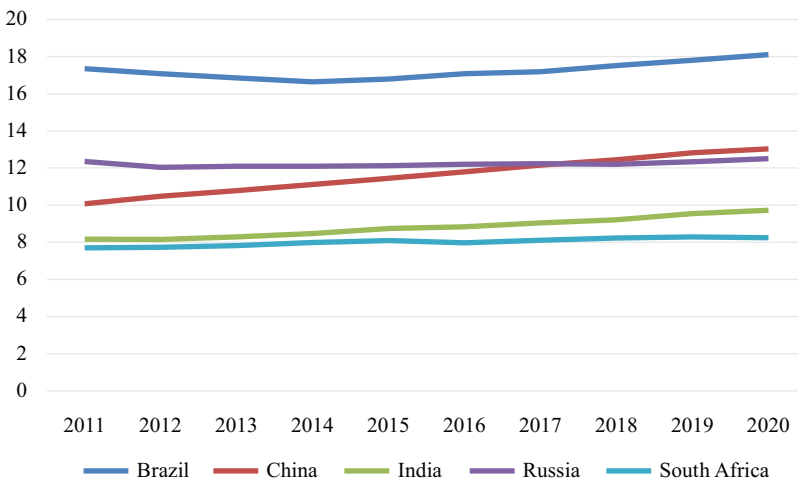


Fig. 4. The changing trend of the Green Economy Index of the BRICS countries in 2011–2020.

Source: Authors’ calculations.

India’s at 10.89 in 2011, but by 2020, it had risen by 2.27 points to 13.37, nearly matching Russia’s 13.78. Unfortunately, based on the analysis in subsection 2.3, it is unlikely that Brazil and South Africa will experience growth in their economic performance index. As shown in Fig. 2, Brazil’s index fell from 12.70 in 2011 to 11.63 in 2020, while South Africa’s index declined from 10.09 in 2001 to 9.68 in 2020, largely due to political instability, rising unemployment rates, and a decrease in GDP per capita, as demonstrated in Tables 2 and 3.

The quality of green living. The study highlights the progress made by the BRICS countries in improving the quality of green living, as analyzed in subsection 2.3. All the countries, except Russia, have experienced growth in the quality of green living index. Russia’s decline in this index was primarily due to a drop in

the number of physicians in 2011–2012. However, from 2012–2020, the country maintained a physician-to-population ratio of around 4.5, which is higher than the OECD average of 3.2. Overall, Russia stands out in the quality of green living index and has maintained an HDI above 0.8 from 2012–2020. The other countries have also made significant strides in improving the index, especially China, which is rapidly catching up with Russia (see Table 3 and Fig. 3).

The Green Economy Index. The study shows that Brazil leads in the overall quality of green economy due to its superior environmental index, followed by China, Russia, India, and South Africa, in that order. India and China have made remarkable progress between 2011 and 2020, while South Africa has made little progress. However, the study emphasizes that to fully understand the state of green economy, it is crucial to consider the status of all the three pillars and their corresponding indicators.

4.3. *The balance of three pillars in the BRICS countries' green economy from 2011 to 2020*

After normalizing all indices with the min-max scaling method, which scales values to the range [0, 1], radar charts are utilized in this study to evaluate the balance of three pillars of the green economy (see Figs. 5, 6, 7, 8, and 9). Russia has done the best job of maintaining the quality of its economy equally distributed among the three pillars, although the country has shown little progress from 2011 to 2020. We found that, in addition to economic development efforts, Russia's environmental pillar scores increased while social goals slightly increased, shifting the equilibrium of the green economy towards environmental and economic objectives. Compared to China, Russia should improve its energy intensity and increase the transparency of its government management system. China has performed significantly better than Russia in these areas (see Figs. 6 and 8).

China has made impressive progress in all areas and is a clear leader in transition to a green economy. The study acknowledges China's commitment to improving both the environment and the well-being of its citizens, in addition to its high-quality economic development policies. The growth trend of the quality of green living index further highlights China's efforts to balance all the pillars of the green economy. As shown in subsection 2.3, China is fulfilling its environmental obligations and social objectives. Fig. 6 confirms that China is making progress in achieving a balanced green economy, thanks to increased funding for environmental and social initiatives.

Along with China, India shows the obvious progress in all the three pillars. As analyzed in subsection 2.3, the study noted India's efforts in improving air quality, HDI, and the proportion of households with access to electricity. According to the study, India's economy, like China's, tends toward the balance of all the pillars (see Fig. 7).

It is worth noting that Brazil's green economy is primarily focused on the environmental pillar, which is not surprising. However, we commend Brazil's efforts to improve the quality of green living despite facing economic and political instability. Brazil is currently going through a challenging phase, characterized by a stagnant economy and political turmoil. Despite this, we recommend that Brazil should continue to prioritize environmental protection while simultaneously working towards

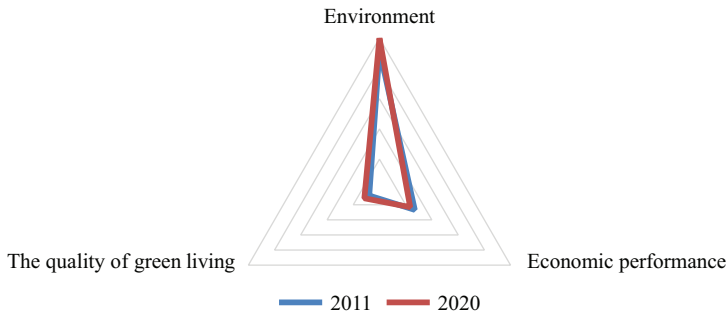


Fig. 5. The balance of three pillars of the green economy in Brazil in 2011–2020.

Source: Authors' calculations.

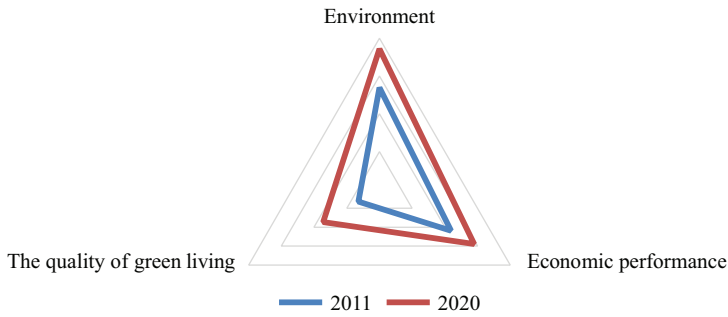


Fig. 6. The balance of three pillars of the green economy in China in 2011–2020.

Source: Authors' calculations.

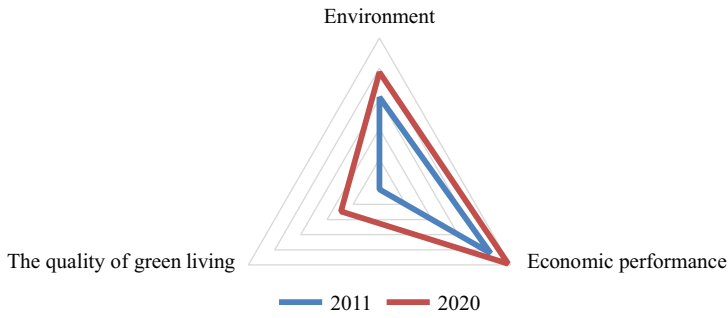


Fig. 7. The balance of three pillars of the green economy in India in 2011–2020.

Source: Authors' calculations.

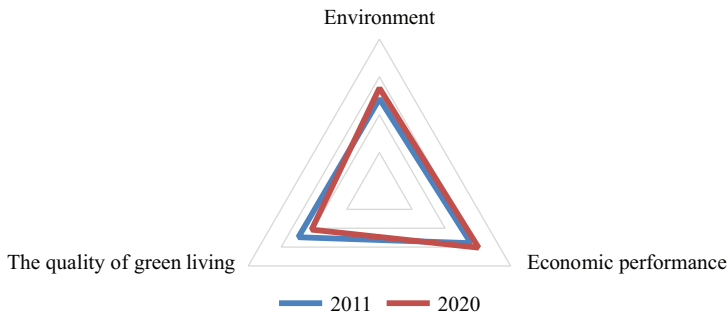


Fig. 8. The balance of three pillars of the green economy in Russia in 2011–2020.

Source: Authors' calculations.

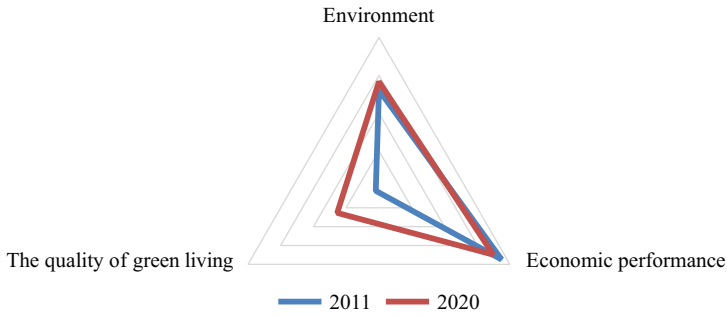


Fig. 9. The balance of three pillars of the green economy in South Africa in 2011–2020.

Source: Authors' calculations.

resolving political conflicts. By doing so, Brazil can unify its economic recovery efforts and make progress towards its goals of promoting well-being of its citizens and reducing income inequality.

South Africa's performance between 2011 and 2020 is the least impressive among the nations considered (see Fig. 9). This study proposes that South Africa needs to address not only political instability, rising unemployment, and decreasing GDP per capita but also social issues such as low access to electricity (in contrast to the other BRICS nations that have reached 100 percent) and income inequality.

In summary, we can conclude that the BRICS countries aim to maintain a balance between the environment, economic growth, and the quality of living. All the pillars of the green economy are interrelated, and their interaction is essential for reaching equilibrium. In order to achieve such a balance, a country must have a stable political system, consistently reinforce its economic potential, implement green development policies, and allocate more financial resources towards environmental and social goals.

5. Conclusion

Our study reveals that the BRICS nations are moving towards a green economy that strives for a harmonious balance between environmental conservation, economic growth, and high standards of green living. A successful transition to a sustainable and green economy is only possible by aligning a nation's strategy with the United Nations' Sustainable Development Goals.

The findings also highlight that the BRICS countries face common challenges such as social inequality, corruption, and low transparency levels that need to be addressed. Russia must prioritize reducing its reliance on oil and gas exports and promoting renewable energy, while China and India should focus on improving rural health and addressing environmental pollution. Brazil and South Africa need to find political stability solutions to revive their economies and achieve their social goals.

This study suggests the Green Economy Index as a tool for the BRICS countries to assess the quality of their economies from 2011 to 2020 and make necessary policy adjustments. However, the index has limitations due to the lack of historical data on other sustainable development goals during the period 2011–2020. Thus, there is a need to continually add relevant indicators to ensure the accuracy of assessments and forecasts.

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