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Innovation role in industrial development and high- tech exports growth: evidence from BRICS

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Abstract

We can see that technologically advanced nation, which hold the top spots in the innovation indicators, control the global markets, so all countries are accelerating in their adoption of technology and innovation. As a result, innovation has become an essential competitiveness goal for all economies that are developed and developing of these. As a result, it can lead to a huge production, new products, and decrease pollution; thus, it can achieve sustainable development in the world. using panel data econometric approaches, this study attempts to investigate the relationship between innovation as an independent variable, high-tech exports, the share of R&D expenditures in GDP (Gross Domestic Product), and total patents as a dependent variable in BRICS countries. Within the period 2020–2004 based on data at hand.

Keywords: *Innovation, Industrial development, high-tech Exports, panel Data, BRICS.*

1. Introduction

the developments of high-tech industries have become a critical economic indicator to long-term sustainable economic growth. especially, among higher-income countries (Ge, Y., 2022) .so, all countries compete in actively constructing science and technology innovation ecosystems to promote their science and technology innovation status; since innovation became a competitive advantage (Li, M, et al,2023, p: 1) .in addition to the ongoing challenges forced Developing Economies to establish their own high-value-added industries and Taking Innovation as a Weapon, as the spending on research and development promote innovation. (Ge, Y., 2022) spending on research and development in universities and institutes is one of the necessities for industrial innovation (Li, M, et al,2023, p: 5) so, U.S. R&D expenditures totaled $606.1 billion. In 2018, the national GDP to R&D spending ratio was 2.94%, which is greater than the 2.3% average GDP growth rate for the United States (Global Innovation Index 2021)

2. Research Questions:

According to the Industrial Development Report (IDR) 2020 10 economies PRODUCE 70% of all exports directly associated with these technologies. Another 40 economies the followers—actively engage in these technologies. The rest of the world fails to take part in the global creation and use of these technologies .so we can say that the problem of the study summarizes in one question: - can innovation and technology provide Industrial Development to increase high- tech exports in BRICS countries.

3. Research Importance

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The important of study indicated in the significant impact of innovation not only on industrial and economic development, but also on international trade; that technologically developed products increase comparative advantage in exports (Frankel and Romer, 1999) innovation and new technologies can lead to new products and big productions, resulting in the emergence of new industries, innovations are geared to reducing environmental impacts(co2) by introducing green manufacturing, which promote the environmental sustainability of the industrial process .

4. Research Hypotheses

This study revolves around a main hypothesis: -There is a relation between innovation and high- tic export in BRICS countries.

5. Research Limitation

There are two frames of this study: first, study applied on BRICS countries. And the Second: study period (2020-1990) according to available data.

6. Methodology

The researcher adopted the descriptive approach to review previous studies, using both the deductive approach and the inductive approach in analyzing the study variables, in addition to the modern scientific approach that relies on the use of econometrics in building and formulating a standard model by using the panel data econometric methods. Within the period (2020-2004) The researchers examined the relation between innovation as independent variable, and high- tech exports, Share of R&D Expenditures in GDP, and total Patents as a dependent variables in BRICS countries according to an available data.

7. Data Sources

The researcher relied on the data of:

- World Bank Economic Development indicators from 1990 until 2020 .
- United Nations reports until 2020.
- the World Economic Forum, Cornell University, INSEAD, and Portolan Institute.

8. Literature Review

because of the importance of innovation as mechanism to economic and trade growth; many studies had talked about it mentioned below:

This study (Gao, 2023) aims to investigate the relationship between enterprise technological innovation, export product quality, and the upgrading of the manufacturing value chain. Using panel data from Chinese manufacturing enterprises between 2000 and 2013, the study finds that technological innovation significantly promotes the upgrading of the manufacturing value chain. A 1% increase in enterprise technological innovation leads to a 0.28% increase in the upgrading of the manufacturing value chain. The study also finds that improving the quality of exported products has a significant positive impact on the manufacturing value chain.

Xu et al. (2023) found that two-way FDI has a significant positive impact on Chinese manufacturing innovation. They hypothesize that IFDI can promote the upgrading of the technology level, industrial linkage, technology demonstration, and finally promote the upgrading of the industrial structure in the host country.

Ge (2022) found that innovation activities have a significant positive impact on the expansion of high-tech enterprises. This suggests that industrial transformation is necessary for long-term, sustainable economic development.

Overall, these studies suggest that technological innovation is a key driver of the development of the high-tech industrial innovation ecosystem and the manufacturing sector in China

Study (de Oliveira, B. F. et al., 2022) also sought to investigate the relationship between the ability for innovation and the deindustrialization process. We make use of data gathered from 80 countries between 1995 and 2016. In order to measure the progress of deindustrialization, we also use a unique dependent variable linked to the quality of exports and industrial competitiveness. According to the data, there is a direct relationship between industrial GDP share, industrial employment as a proportion of total employment, and industrial export quality. As the income level rises in the estimations that take the income level into account, we found that the effect of the creative process on the dependent variables decreases.

Despite this, innovation has a positive effect on industrial strength. The results. Solovieva and Mingjun (2021) aimed to identify and analyze the systems of technology transfer in BRICS countries, in order to form special mechanisms for organizing innovative processes that provide effective and competitive high-tech products. Durmaz, Atakan, and Ümit Yıldız (2020) used panel data techniques to investigate the impact of innovation on high-tech exports in BRICS countries from 1999 to 2018. They found a significant positive relationship between the number of patents and high-tech exports in BRICS countries.

9. Contribution of the Study.

The current study contributes to three main gaps:

The first gap is a temporal gap, as the relationship between the study variables is tested during the period from 1990 to 2020, which is a time period that was not addressed by previous studies.

The second gap is a spatial gap, as the BRICS bloc is chosen, while previous studies have addressed other regions and blocs.

The third gap is a gap in the study variables, called a metric gap, as the current study relies on the Global Innovation Index, which was not considered by previous studies, in addition to the R&D expenditure index, and patent applications for residents and non-residents, on the dependent variables represented in the added value of medium- and high-technology industries, and technological exports in BRICS countries.

10. Theoretical Frame

The concept of innovation:

Innovation can be defined as an introduction to new ways of doing things, and this definition includes aspects such as new organizational structures, products, or processes (

Prieto,2017:1). Oyedele also defined it as the ability to create and use the skill of imagination to reach a new space and invest in it, which is the process of converting the best creative ideas into reality, and then generating a series of innovative events that result in the creation of new value. (Oyedele,2018: 11)

In addition to the definition of Organization for Economic Cooperation and Development investment in innovation as spending on research and development and investment in software, which are indicators that affect productivity and then economic growth. (OECD,2003: 23)

Global Innovation Index (Gii):

The Global Innovation Index has been issued annually since 2008 by the International Business School, in partnership with the World Intellectual Property Organization and Cornell University. This index was also issued with the support of the Australian government on the side-lines of the Group of Twenty. It covers the global innovation index by measuring outputs and inputs in innovation processes and policies. Innovation, which shows the extent

of partnership between industry and science and the spread of knowledge. The Global Innovation Index is based on two main sub-indicators, which are inputs and outputs:

The input index refers to economic and legislative institutions, human capital institutions such as education, higher education, research and development, technology infrastructure, innovation-stimulating environment, markets and investment climate, and business sector intertwining in terms of creative links and knowledge absorption.

- As for the second sub-indicator, which is the output indicator, it includes knowledge and technology in terms of production, dissemination, knowledge impact, technology products, knowledge products and services, and information on networks.

The Global Innovation Index also helps governments evaluate innovation performance in their countries and achieve a better understanding of how to stimulate creative activity. The global intellectual property indicators analyze intellectual property activity and trends around the world, which helps policy makers to make more informed decisions.

the GII index, is a simple average of the scores along the input and output columns, where each of the columns is defined by several variables, sourced from international organizations such as the World Economic Forum, the World Bank and the International Telecommunication Union (Global Innovation). Index 08/09. P: 8) The Global Innovation Index provides detailed measures of innovation performance in 129 countries and economies around the world, and its 80 indicators explore a comprehensive vision of innovation in its various fields, including the political environment, education and infrastructure. and business development.

Innovation models:

There are several models for implementing innovation, including the linear innovation model, the dual (paired) innovation model, and the innovation activities model. We will list them in detail below.

Linear innovation

the early linear innovation model is one of the most significant prevailing models for innovation. According to these models, the process of innovation consists of a set of sequential actions that start with a scientific invention and are then pushed towards commercialization. Prevalent in most practices even now, the early linear innovation model is one of the most significant prevailing models for innovation. According to these models, the process of innovation consists of a set of sequential actions that start with a scientific invention and are then pushed towards commercialization. Still in use today, the early linear innovation model is one of the most significant dominant models for innovation. (Alaa El-Din,2012:4)

Innovation coupling models (CM)

The paired innovation model is a dynamic approach to innovation that recognizes the interaction between the different elements of the innovation process. It begins with a new need (demand), which leads to the creation of a new idea and then a new technology. Feedback and continuous evaluation occur at each stage, and there is interaction between the different stages of the innovation cycle, market needs, and modern production techniques. (Alaa El-Din,2012:6).

Innovation activities models:

The innovation cycle starts with an invention that is ready to be commercialized or applied to benefit society. An invention can be commercialized at any stage of its development, from prototype to product to applied research result, depending on a variety of factors such as the state of technology and consumer demand. Two other essential components for the successful commercialization of ideas and the creation of social and economic benefits are "innovation activities" and "innovation toolboxes." (Alaa El-Din, 2012:8).

types of innovation:

- Technological innovation: The creation of new products, services, or processes using new or significantly improved technology.
- Organizational innovation: Changes to a company's structure, processes, strategies, or policies that improve efficiency or effectiveness.
- Marketing innovation: New marketing strategies or tactics that improve the reach or effectiveness of marketing efforts.
- Business model innovation: The development of new or significantly improved business models that create new value propositions or generate new revenue streams.

About BRICS:

The BRICS economic alliance was first proposed by Goldman Sachs in a 2000 report on the world's most important emerging countries. The idea gained momentum in 2006, when the foreign ministers of Brazil, Russia, India, and China held a series of conferences and meetings. The BRICS Alliance was formally established in 2009, and South Africa joined the group in 2010. The BRICS countries are major emerging economies with a combined population of 3.2 billion people, which is over 40% of the world's population. Their combined GDP is over $27 trillion, which is about one quarter of the world's GDP. The BRICS countries are also members of the Group of 20, the world's most powerful economies.

Projections suggest that the BRICS countries will continue to grow rapidly in the coming decade, and that their combined GDP could overtake the combined GDP of the G-7 countries (the United States, Britain, France, Japan, Germany, Canada, and Italy) by 2030.The BRICS countries are important players in the global economy, and their growing influence is likely to have a major impact on the world in the years to come

Economic importance of the BRICS:

The BRICS growing importance for the world economy is reflected by various economic and demographic indicators. These include, but are not limited to, their increasing share in world GDP; share in world trade; trade openness and increasing forex reserves; and their foreign direct investment (FDI) inflows and outflows. Regional/common market and share in global GDP The BRICS economies, if viewed collectively over the last two decades, have emerged as a force to be reckoned with. This is duly reflected by the increasing share of BRICS in the world GDP. From a share of a little over 10% of the world GDP in 1990, BRICS now commands a share of more than 25%. This implies that the economic size of BRICS in terms of its share in world GDP expanded by 150% in the two-decade periods.

The group had sought to establish an organization called the New Development Bank (NDB) in 2015 with a capital of $50 billion and equal shares among the five countries. The Bank aims to support infrastructure projects in these countries, and over the last five years it has supported 70 infrastructure projects with over $25 billion

11. The Reality of the Global Innovation Index

Over the years, INSEAD has established itself as a leading reference in the field of innovation, and has become a "tool for action" for decision-makers who want to improve their country's innovation performance since 2007 (Dutta,2019:36). According to the 2007 Global Innovation Index report, the United States topped the world's list of innovation with a score of 5.80 points out of 107 countries, followed by Germany in second place with 4.89 points, the United Kingdom with 4.81 points, Japan in fourth place with 4.48 points, and France in fifth place with 4.32 points. The ranking changed in 2009, with Iceland topping the list of 130 countries with 4.86 points, followed by Sweden with 4.85 points, Hong Kong with 4.83 points, Denmark in fifth place with 4.72 points, and Finland with 4.66 points. (The Global Innovation Index,2008/2009:1)

Since 2007, INSEAD has positioned itself as a prominent innovation resource and a "work tool" for decision-makers seeking to improve innovation performance in their nations (Dutta, 2019:36). According to the globe Innovation Index Report 2007, the United States leads the globe in the innovation index with a balance of 5.80 points at 107 nations, followed by Germany in second place with a balance of 4.89 points, and the United Kingdom in third place with a balance of 4.81 points. Japan is placed fourth with a balance of 4.48 points, followed by France with a balance of 4.32 points, while Iceland was ranked top among 130 nations with a balance of 4.32 points in 2009. (the Global Innovation Index,2008/2009:1)

According to the 2022 Innovation Report, Switzerland topped the list of 132 countries with a score of 64.6 points, followed by the United States with 61.8 points, Sweden in third place with 61.6 points, the United Kingdom with 59.7 points, and the Netherlands and Korea in fifth and sixth place, respectively, with 58.0 and 57.8 points, respectively.

12. Analysis of the Reality of Innovation in BRICS Countries:

In 2001 Goldman Sachs report predicted that China would become the world's largest economy by the middle of the century, and that India, Brazil, and Russia would become among the top ten countries. Despite not being global innovation leaders, they have achieved a high ranking in the Global Innovation Index, with China, India, Brazil, and Russia ranking 29th, 23rd, 40th, and 54th in the world, respectively, in 2007. However, innovation output measures are much better than input measures, with India and China ranking fifth and ninth in the world in competitiveness, respectively, in addition to their progress in innovation infrastructure.

India is ranked second, with significant progress in the Innovation Index, with its scores rising from 42nd in 2007 to 46th in 2022. This progress is attributed to several factors, including: increased investment in research and development, infrastructure development, and growth of the technology sector.

Brazil is ranked third, with significant progress in the Innovation Index, with its scores rising from 55th in 2007 to 59th in 2022. This progress is attributed to several factors, including increased investment in research and development, improved education and training, and infrastructure development. Russia has made the least progress in the Innovation Index, with its scores rising from 54th I 2007 to 60th in 2022. This progress is attributed to several factors, including: the economic sanctions imposed by the United States and Western countries on Russia after the invasion of Ukraine. South Africa has made the least progress among BRICS countries in the Innovation Index, with its scores rising from 38th in 2007 to 61st in 2022. This progress is attributed to several factors, including: political and economic instability in South Africa.

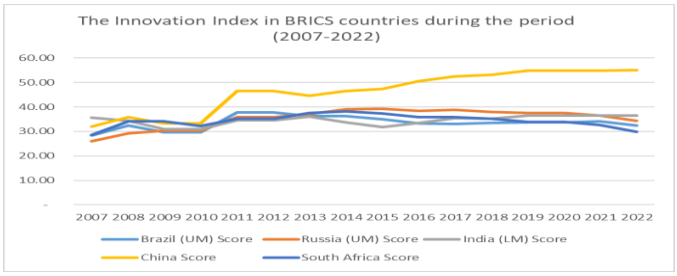


Figure 1*: *innovation indicator in BRICS countries

Source: World Bank Income Group Classification (June 2021). Year-on-year GII rank changes are influenced by performance and methodological considerations; some economy data are incomplete.

The figure also shows the ranking of BRICS countries in the Global Innovation Index during the period (20072022).The figure shows that the ranking of BRICS countries in the index has generally increased during this period, with China ranking 12th globally in 2022, compared to 29th in 2007.Despite this increase, BRICS countries still face challenges in the field of innovation, including: weak cooperation between the public and private sectors, brain drain, and lack of intellectual property protection.

13. The Experiments of BRICS Countries in Innovation, and Challenges

1- Brazilian experience in supporting and adopting innovation:

Innovation has played a key role in Brazil's transformation from a poverty-stricken to a developed country. The government has implemented a number of policies and programs to promote innovation, and Brazilian companies have responded by developing new technologies and products. Brazil has a large and entrepreneurial population, which has also contributed to the country's success in innovation. Some notable examples of Brazilian innovation include Petrobras, a pioneer in offshore oil exploration, Ambrair, the world's leading producer of jet aircraft, and Brazil's ethanol industry, which produces more than 33% of the world's ethanol

Brazil ranked 40 globally out of 107 countries according to the Global Innovation Index 2007 by a balance of 2.84 points, then declined in ranking to 50 in 2008 by a balance of 3.25 out of 130 countries, then declined in ranking in 2009 to 68 worlds by a balance of 2.97 out of 132 States, then advanced in 2011 to 47 out of 125 States, with a balance of 37.75 and again in ranking 64 in 2013 by a balance of 36.33. It continued to oscillate between improvement and deterioration during the time, reaching position 54 in 2022 with a balance of 32.5 points out of 132 nations.

2- The Indian experience in supporting and adopting innovation

India is a lower-middle-income country in Central and Southern Asia, with about 1.4 billion inhabitants and an absolute GDP of $2950 trillion in 2022. According to the Global Innovation Index (GII), it has excelled its peer group in terms of innovation capability for the past four years.

India's dominance in innovation is the result of a long-term policy shift from science to technology to innovation and entrepreneurship. This shift has been backed by years of planning and implementation. Following independence, Indian policymakers focused on economic expansion through industrialization and scientific advancement. Initially, industrial growth was centered on establishing and empowering public-sector enterprises. The 1956 Industrial Policy Resolution established policies that granted the state monopoly over all heavy industries. The Industrial Policy Statement of 1977 emphasized decentralization, whereas the Industrial Policy Statement of 1980 emphasized the need to stimulate domestic competition while also updating technology.1 The 1983 technological Policy Statement emphasized technological development in the country, turning away from the previous emphasis on scientific development.

During the 1990s, science and technology policy began to coincide with the country's general economic policy framework, which encouraged industry R&D, the identification of technological requirements, and technology development. According to the Ministry of Science and Technology's most recent statistics (updated through 2009-10 and forecast for the next two years), gross R&D expenditure (GERD) in the country has been steadily growing throughout the years. It increased by roughly 45% from 24,117.24 crore Indian rupees () in 2004-05 to 53,041.30 crore in 2009-10. The ratio of R&D to GDP grew dramatically from 0.81% in 2004-05 to 0.87% in 2009-10. These figures pointed to India's rapid increase in R&D over the previous decade when compared to its nearest competitors.

India ranked 23rd out of 107 countries in the Global Innovation Index (GII) in 2007, with a score of 3.57 . However, its ranking declined in the following years, reaching 56th in 2009 with a score of 3.10. This prompted the Indian government to announce its support for innovation by adopting the "India Vision 2020-2010", which it called the "Decade of

Innovation". This vision began to bear fruit in 2016, when India ranked 66th in the GII with a score of 33.61. India continued to progress in the following years, reaching 40th in the world in 2022 among 132 countries.

Incentives of innovation:

- the establishment of the National Council for Innovation.
- A new and creative science and technology strategy aiming at encouraging initiative and scientific-led solutions for inclusive and sustainable growth and manufacturing.
- Raise total research and development spending to 2% of GDP.
- The Indian government has established a national scientific and technology institution and is working to promote innovation as a public-private collaboration effort. Innovation is concentrated in industrial sectors, with more than half of research and development spending going to three industries: pharmaceuticals, automobiles, and computer software.

3- South Africa's Experience in Industrial Innovation to Support Exports

South Africa is a developing country that seeks to boost its economy through industrial innovation. The South African government has adopted a number of policies and programs to support industrial innovation, including :

- The "Made in Africa" program, which aims to promote local manufacturing and increase exports.
- The "Africa 2063" program, which aims to build a prosperous and sustainable African economy.
- The "Innovation and Industrial Growth" program, which aims to boost innovation in the industrial sector.

These policies and programs have resulted in some successes in the field of industrial innovation in South Africa, including:

- Cybro, a financial technology company that offers innovative products and services to small and medium-sized enterprises.
- African Black Stanley, a mining company that offers innovative technologies to increase productivity.
- African River, an agricultural company that offers innovative technologies to improve productivity and resource efficiency.

However, there are still a number of challenges facing industrial innovation in South Africa, including:

- Weak research and technological infrastructure
- Lack of investment in innovation by small and medium-sized enterprises
- Weak business environment

The South African government is working to address these challenges through a number of policies and programs, including:

- Investments in research and technological infrastructure.
- Incentives to stimulate investment in innovation by small and medium-sized enterprises.
- Reforms to improve the business environment.

It is expected that South Africa will continue to boost its efforts in the field of industrial innovation in the coming years, which will help it achieve its economic and social goals.

14.The Role of Innovation in Achieving the Sd8 Goal of Suitable Development Indicators

Innovation is one of the main drivers of sustainable development. It contributes to creating new job opportunities, improving the quality of life, and protecting the environment. Our industry and infrastructure also need to be modernized to meet upcoming challenges. In order to achieve this, we must work to develop new sustainable technologies and ensure fair and open access to information and financial markets. By doing so, we will ensure that societies around the world are secure and prosperous, and we will also achieve prosperity and job opportunities.

There is a difference between innovation and invention. Invention is a first step in the innovation process. An invention is the discovery of a new idea or the development of a new technology. Innovation, on the other hand, is the application of an invention in the form of a new product, service, or way of working. Karol Sledzik (2015) also distinguished between invention and industrial innovation. Schumpeter defined invention as the discovery of a new technology and its practical application, and innovation as the introduction of new technologies in products and forms of industrial organization. (R. Ingles, Lotz)

The Global Goals may be achieved with the support of everyone. Utilize these eight objectives to drive inclusive and sustainable industrialization, create resilient infrastructure, and foster innovation. There is a significant impact of innovation not only on industrial and economic development, but also on international trade; that technologically developed products increase comparative advantage in exports (Frankel and Romer, 1999)

1- The importance of innovation for sustainable development:

Innovation is essential for achieving sustainable development. It contributes to achieving the following goals:

- Creating new job opportunities: Innovation can create new job opportunities in various sectors, such as technology, manufacturing, and services.
- Improving the quality of life: Innovation can improve the quality of life by providing new products and services that meet people's needs.
- Protecting the environment: Innovation can help protect the environment by developing more sustainable products and services.
- Develop Sustainable, Resilient and Inclusive

Infrastructures.

- Promote Inclusive and Sustainable Industrialization.
- Increase Access to Financial Services and Markets.
- Upgrade All Industries and Infrastructures for

Sustainability.

By 2030, all nations should take action in accordance with their own capacities to modernize infrastructure, remodel industries, boost resource use efficiency, and increase the adoption of clean, ecologically sound technology and industrial processes.

- Enhance Research and upgrade Industrial

Technologies.

Enhance scientific research, modernize the industrial sectors' technological prowess in all nations, especially developing nations, and, by 2030, encourage innovation by upping both public and private spending on research and development as well as the ratio of workers engaged in it per million people.

- Facilitate Sustainable Infrastructure Development.

Improved financial, technological, and technical assistance to African nations, least developed nations, landlocked developing nations, and small island developing States will enable the construction of sustainable and resilient infrastructure in emerging nations.

- Support Domestic Technology Development and

Industrial Diversification.

Support domestic technological advancement, research, and innovation in emerging nations, notably by establishing favourable regulatory conditions for, among other things, industrial diversification and commodity value addition. Brazil has made commendable progress in sustainable development with an overall SDG Index Score of 73.689. It has a Goal 9 Score of 68.969, showcasing substantial advancement in industry, innovation, and infrastructure. Brazil excels in road infrastructure with a score of 90.519 and mobile phone usage with a score of 95.842. University access is also impressive at 86.366, but research and development (R&D) activities show room for growth with a score of 32.649.

China is strongly committed to sustainable development, as evidenced by its high SDG Index Score. It has excelled in SDG9, which focuses on industry, innovation, and infrastructure. China has a well-developed road infrastructure, ubiquitous mobile phone usage, and exemplary logistics and transport efficiency. University access is also outstanding, and China invests heavily in research and development, contributing significantly to global research. Russia Russia has made impressive strides towards sustainable development, with a strong overall SDG Index score. It has excelled in SDG 8, which focuses on industry, innovation, and infrastructure. Internet usage is high, road infrastructure is excellent, and mobile phone use is widespread. However, there is room for improvement in research and development (R&D), despite Russia's high level of education and scientific research. India India has made impressive strides towards sustainable development, with a moderate overall SDG Index score. It has shown significant progress in SDG 9, which focuses on industry, innovation, and infrastructure. However, there is room for improvement in internet access, mobile phone access, and research and development.

South Africa South Africa has made commendable progress towards sustainable development, with a strong overall SDG Index score. It has excelled in SDG 9, which focuses on industry, innovation, and infrastructure. Internet usage is high, road infrastructure is excellent, and mobile phone use is widespread. However, there is room for improvement in research and development (R&D).

15. Economic Analysis of Study Variables in BRICS Countries

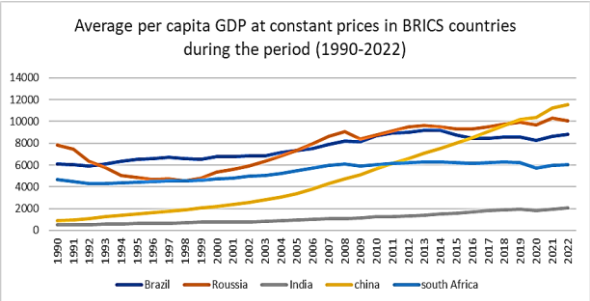


Fig.2 *Average per capita GDP at constant prices in BRICS countries during the period (1990-2022)*

Source*: World Bank Economic Development indicators* https://data.albankaldawli.org/

The previous figure shows the average GDP per capita in constant US dollars in BRICS countries, Brazil, Russia, India, China, and South Africa, during the period (1990-2022). It generally increased during this period, which indicates that BRICS countries have made significant progress in improving the living standards of their citizens in the past two decades. It increased from about $2,000 in 1990 to about $14,000 in 2022.The data shows that China had the highest average GDP per capita in BRICS countries, reaching about

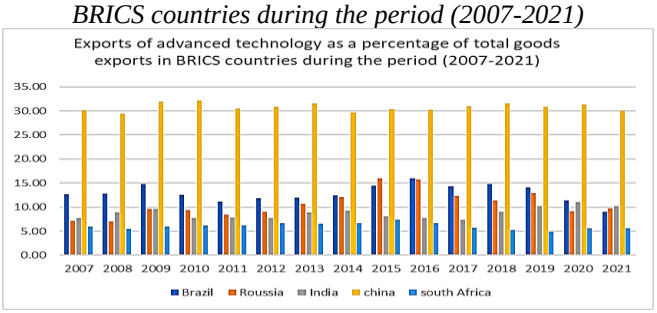
$10,000 in 2022. India followed with an average GDP per capita of about $7,000, Brazil with an average GDP per capita of about $6,000, and Russia and South Africa had the lowest average GDP per capita in BRICS countries, reaching about $4,000 and $3,000, respectively.

This increase is due to several factors, including the rapid economic growth in these countries and the improvement of living standards.

The value added of the industry sector as a percentage of GDP in BRICS countries during the period (1990-2022)

The figure shows the value added of the industrial sector as a percentage of GDP in BRICS countries, Brazil, Russia, India, China, and South Africa, during the period from 1990 to 2022. It is observed from the figure that the value added of the industrial sector as a percentage of GDP in BRICS countries has increased significantly during this period, from about 40% in 1990 to about 60% in 2022. This increase is due to several factors, including the rapid economic growth in these countries, the transition from industrial economies to service economies, and the increasing demand for services from the growing population. The data shows that China had the highest value added of the services sector as a percentage of GDP in BRICS countries, reaching about 70% in 2022. India followed with an average value added of the services sector as a percentage of GDP of about 50%, followed by Brazil with an average value added of the services sector as a percentage of GDP of about 40%. Russia and South Africa had the lowest average value added of the services sector as a percentage of GDP in BRICS countries, reaching about 30% and 20%, respectively. In general, the figure indicates that the industrial sector has become more important in the economies of BRICS countries in the past two decades.

Fig.*3 Exports of advanced technology as a percentage of total goods exports in BRICS countries during the period (2007-2021)*

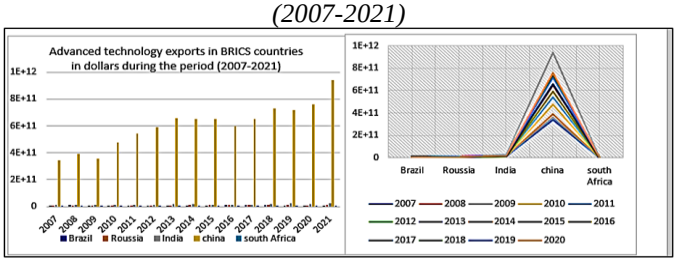


Source*: World Bank Economic Development indicators* https://data.albankaldawli.org/

The figure shows that exports of advanced technology as a percentage of total goods exports in BRICS countries, which are Brazil, Russia, India, China, and South Africa, have not increased significantly between 2007 and 2021. Rather, they have fluctuated between increases and decreases around the same values as in 2007. The data shows that China is the country with the highest exports of advanced technology as a percentage of total goods exports in BRICS countries, reaching about 20% in 2021. India follows with an average of exports of advanced technology as a percentage of total goods exports of about 12%, followed by Brazil with an average of exports of advanced technology as a percentage of total goods exports of about 10%. Russia and South Africa, on the other hand, record the lowest average exports of advanced technology as a percentage of total goods exports in BRICS countries, reaching about 5% and 7%, respectively.

In general, the figure suggests that BRICS countries have become more important in the production and export of advanced technology over the past two decades. This increase is due to several factors, including rapid economic growth in these countries, increased spending on research and development, increased adoption of innovation, and increased demand for high-tech products and services from advanced economies.

Fig.4 *advanced technology in BRICS countries in dollars during the period (2007-2021)*



Source*: World Bank Economic Development indicators* https://data.albankaldawli.org/

The figure shows the exports of advanced technology in BRICS countries in dollars during the period (2007-2021). It is noted from the figure that the exports of advanced technology in BRICS countries have increased significantly during this period, from about 10% in 2007 to about 15% in 2021.

This increase is due to several factors, including:

- Rapid economic growth: The rapid economic growth in these countries has led to increased demand for high-tech products and services.
- Increased investment in research and development: BRICS countries have increased their investment in research and development, which has led to increased production of advanced technology.
- Increased demand for high-tech products and services from advanced economies: The increased demand for high-tech products and services from advanced economies has led to increased exports of advanced technology from BRICS countries.

The data also shows that China is the country with the highest exports of advanced technology in BRICS countries, reaching about $9.42 trillion in 2021. India follows with an average of exports of advanced technology as a percentage of total goods exports of about 27446653652, followed by Brazil with an average of exports of advanced technology as a percentage of total goods exports of about 6.35E+09. Russia and South Africa, on the other hand, record the lowest average exports of advanced technology as a percentage of total goods exports in BRICS countries, reaching about 1.06E+10 and 1.84E+09, respectively.

In general, the figure suggests that BRICS countries have become more important in the production and export of advanced technology over the past two decades.

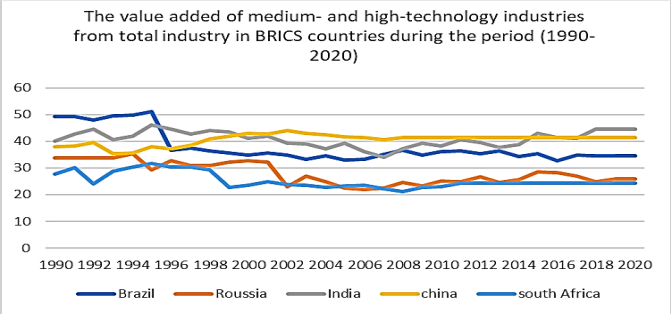
- It is also noted that the increase in exports of advanced technology from BRICS countries has been uneven. China, India, and Brazil have recorded a significant increase in exports of advanced technology, while Russia and South Africa have recorded a smaller increase.

This difference may be due to several factors, including:

- Differences in industrial structure.
- Differences in levels of investment in research and development.
- Differences in government policies.

It is expected that the growth of exports of advanced technology from BRICS countries will continue in the future. Projections have indicated that exports of advanced technology from BRICS countries could reach $100 billion by 2030.

Fig.*5 The value added of medium- and high-technology industries from total industry in BRICS countries during the period (1990-2020)*



***Source**: World Bank Economic Development indicators* https://data.albankaldawli.org/

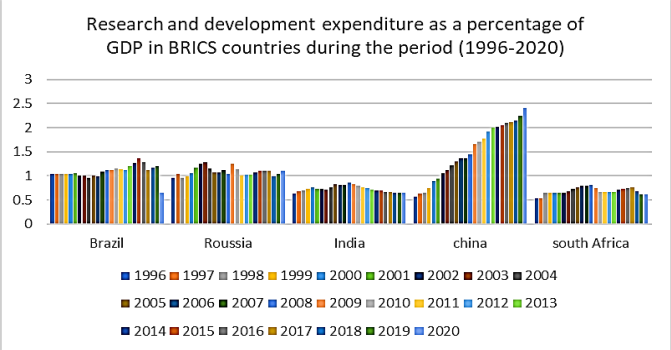
The chart shows the value added by medium- and high-tech industries during the period 1990-2020.

It can be seen that all five countries have experienced significant economic growth during this period. China is the country with the fastest economic growth, with the value added by medium- and high-tech industries growing at an average rate of 10.4% per year. India follows with an average growth rate of 7.3%. Brazil, Russia, and South Africa experienced slower economic growth, with their economies growing at average rates ranging from 2.5% to 4.5%.

However, the economic growth rates of Brazil, Russia, and South Africa have declined in recent years. This may be due to a variety of factors, including the global recession and political instability in some countries.

In general, the figure shows that global economies have grown significantly in the past three decades. China is the only country that has experienced annual economic growth of 10% or more in every year of the past 30 years. India is the only other country that has experienced annual economic growth of 7% or more in every year of the past 30 years. In addition, Brazil, Russia, and South Africa have all experienced periods of strong economic growth, but it appears that these growth rates have begun to slow in recent years.

***Fig.6** R&D spending as a percentage of GDP in BRICS countries.*



***Source:** World Bank Economic Development indicators* https://data.albankaldawli.org/

The figure shows the R&D spending as a percentage of GDP in BRICS countries, which are Brazil, Russia, India, China, and South Africa, during the period from 1996 to 2020. It is noted from the figure that the R&D spending as a percentage of GDP in BRICS countries has increased significantly during this period, from about 0.5% in 1996 to about 1.5% in 2020.

This increase is due to several factors, including:

- Rapid economic growth: The rapid economic growth in these countries has led to increased financial resources available for R&D.
- Increased awareness of the importance of R&D: The awareness of the importance of R&D in promoting economic growth and innovation has increased.

• Government support for R&D: Governments in BRICS countries have provided financial and organizational support for R&D.

The data shows that China is the country with the highest R&D spending as a percentage of GDP in BRICS countries, reaching about 2.5% in 2020. India follows with an average R&D spending as a percentage of GDP of about 1.7%, followed by Brazil with an average R&D spending as a percentage of GDP of about 1.2%.

Russia and South Africa record the lowest average R&D spending as a percentage of GDP in BRICS countries, reaching about 1% and 0.7%, respectively.

In general, the figure suggests that BRICS countries have become more committed to R&D over the past two decades.

• It is also noted that the increase in R&D spending in BRICS countries has been uneven. China, India, and Brazil have recorded a significant increase in R&D spending, while Russia and South Africa have recorded a smaller increase.

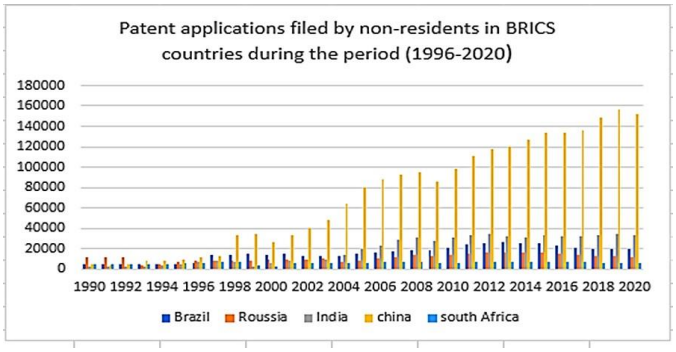


Fig.7 *the number of patent applications filed by non-residents in BRICS countries.*
Source*: World Bank Economic Development indicators* *https://data.albankaldawli.org/*

The figure shows the number of patent applications filed by non-residents in BRICS countries, which are Brazil, Russia, India, China, and South Africa, during the period from 1996 to 2020.

It is noted from the figure that the number of patent applications filed by non-residents in BRICS countries has increased significantly during this period, from about 20,000 applications in 1996 to about 180,000 applications in 2020. This increase is due to several factors, including:

• Rapid economic growth: The rapid economic growth in these countries has led to increased demand for new products and services and innovation.

• Increased awareness of the importance of patents: The awareness of the importance of patents in protecting intellectual property and innovation has increased.

• Trade liberalization: Trade liberalization has led to increased flow of technology between countries around the world.

The data shows that China is the country with the highest number of patent applications filed by non-residents in BRICS countries, reaching about 100,000 applications in 2020. India follows with an average of 50,000 applications, followed by Brazil with an average of 20,000 applications.

Russia and South Africa record the lowest average number of patent applications filed by non-residents in BRICS countries, reaching about 10,000 applications and 5,000 applications, respectively.

In general, the figure suggests that BRICS countries have become more attractive to foreign investment in research and development in the past two decades.

16. The Role of Innovation in Industrial Development and Technological Export Growth.

The relationship between innovation and economic growth has been thoroughly studied worldwide. Feldman and Massard 2002) emphasize the complex relationship between institutions and the geography of innovation, emphasizing the spatial aspects of knowledge generation. Similarly, Hilpert [2](2003) directs attention towards regionalizing global innovation, highlighting the variations in participation observed among several geographical areas. The relevance of this issue has notably increased for the BRICS nations, which encompass a diverse range of innovation pathways.

The topic of interest pertains to the concept of innovation within the context of China. The significance of China within any discourse about BRICS is unquestionable. In his comprehensive study, Wu 2011) extensively examines the factors contributing to innovation within the Chinese economy, drawing upon empirical evidence derived from province statistics. Uzagalieva et al. (2012) provide a novel approach to examining the connection between industrial bilateral trade flows, which serve as indicators of technical advancement, and expenditures on innovation in a time characterized by extensive global commerce. When examining the relationship between innovation and commerce, the authors highlight the importance of employing appropriate instrumental factors to address the potential endogeneity issue.

The significance of innovation in industrial development and high-tech exports becomes increasingly relevant as the BRICS nations continue to progress in the global economy. The literature that has been examined emphasizes the complex and diverse aspects of this relationship, highlighting the importance of taking into account the distinct paths, difficulties, and possibilities that each of these countries offers.

17. Method & Results.

The study variables are the innovation index, the R&D expenditure index as a percentage of GDP, and patent applications by residents and non-residents. The dependent variables are the added value of medium- and high-technology industries, technological exports in dollars, and technological exports as a percentage of total exports. The impact of innovation and the variables that represent it on industrial development and technological exports will be measured using panel data for BRICS countries during (1990-2020).

TABLE RESEARCH VARIABLES

Variable	Definition	Resources
rdex	Share of R&D Expenditures in	World Bank Database
GII	Global Innovation Index	Cornell University, INSEAD
patent	patent Total Patents	WIPO
addv	added value of medium- and	World Bank Database
Htech	Share of HTI in Total	World Bank Database
tecex	technological exports	World Bank Database

The variables used in the analyses were chosen based on the literature and economic theory. Two types of panel data models were used in the study: panel fixed effects models and panel random effects models. In random effect models, changes that happen over time or within units are included in the model as part of the error term. This is done to prevent the loss of degrees of freedom that can occur in fixed effect models. The following equations show the fixed effects model and the random effects model: On the other hand, in this study, the model designed and estimated for panel data is as follows:

$$tecex = \beta 0 + \beta 1\ GII + \beta 2\ rdex + \beta 3\ patent + uit \quad (1)$$

18. Results.

The results of the unit root test show that the series of advanced technology exports is stationary at the level, while the other series are stationary in first difference. Here, the trend-free model is used as the reference for the variable representing the share of R&D expenditures in GDP. The non-stationary series were stabilized by taking the difference of series and including them in the analysis. The panel fixed effects and panel random effects estimation results also show that the estimated coefficients are robust estimators resistant to diagnostic problems. When analyzing the estimation results, we note that the coefficients β3, B2, and B1 are statistically significant at the 5% level, with positive signs. This means that there is a statistically significant and accurate relationship between the number of patents, the innovation index, and R&D expenditure, which represent innovation, and high-tech exports in BRICS countries. This is in line with the results of economic theory.

19. Recommendations

− Support the research process by Increasing R&D spending: This will provide more resources for researchers to develop new ideas and technologies .

− Supporting and improving infrastructure: This includes providing adequate facilities and equipment for researchers, as well as strengthening the research and innovation ecosystem .

− Increasing the incentives for innovation outputs: This can be done through a variety of mechanisms, such as tax breaks, grants, and prizes .

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Linking the educational process to industry: This will help to ensure that students are trained in the skills that are needed in the workforce.

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