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Innovation and competitive industrial performance in BRICS economies

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Abstract---The study aimed to explore and measure the impact of innovation on competitive industrial performance (CIP) in the BRICS economies for the period 2011-2022, and the Global Innovation Index (GII) was used to measure the impact of innovation on the dependent variable, and some independent explained variables such as: the percentage of workers in industry of the total workforce, quality of regulation, rule of law, foreign direct investment and GDP, to test the relationship between these variables and competitive industrial performance (CIP). The study relied on data from a variety of sources: the World Intellectual Property Organization (WIPO), the United Nations Industrial Development Organization (UNIDO), and the World Bank, and the economic measurement of dynamic panel data was used, and the one-step GMM estimator was used for the Blundell-Bond system (1998). The results also indicate a significant positive impact of the

quality of the organization, the proportion of workers in industry, GDP and foreign direct investment on competitive industrial performance, while the study found that there is a negative impact of the rule of law on competitive industrial performance.

Keywords---Innovation, Competitive Industrial Performance, Quality of Regulation, Rule of Law, GDP, Foreign direct investment.

Jel Classification Codes: E01, F21, k2, L5, O32.

Introduction

Innovation serves as a cornerstone for enhancing competitive industrial performance, particularly within the rapidly evolving economies of the BRICS economies (Brazil, Russia, India, China, and South Africa). As these nations strive to cement their positions in the global economic landscape, the role of innovation in driving industrial competitiveness becomes increasingly pivotal. This study seeks to elucidate the relationship between innovation and competitive industrial performance, offering insights into how BRICS economies can leverage technological advancements and innovative practices to bolster their industrial sectors.

Competitive industrial performance is critical for sustainable economic growth and development. It reflects a country's ability to produce, add value, and export goods competitively on the global stage. A robust competitive industrial sector can lead to increased job creation, higher productivity, and improved standards of living. Moreover, it enhances a nation's capacity to adapt to global market changes, mitigate economic vulnerabilities, and achieve long-term economic stability (Değer et al., 2009).

Innovation is integral to competitive industrial performance as it drives productivity improvements, fosters the development of new products and services, and enhances operational efficiencies (fosso wamba & guthrie, 2019). Technological advancements and innovative practices enable industries to reduce costs, improve quality, and increase market share. By embracing innovation, countries can develop more sophisticated and diversified industrial bases, which are essential for competing in an increasingly interconnected global economy (Ivanová & Čepel, 2018).

In the context of the BRICS economies, innovation is particularly crucial due to their unique economic challenges and opportunities. These countries are characterized by rapid industrialization, significant economic growth, and a need to transition from resource-dependent economies to more diversified and technology-driven industrial sectors. Innovation can play a transformative role in this transition by enabling BRICS economies to enhance their industrial capabilities, increase value-added production, and integrate more effectively into global value chains (Caglar et al., 2024).

Additionally, the strategic implementation of innovation can help BRICS economies address pressing socio-economic issues such as income inequality, environmental sustainability, and the need for infrastructure development. By fostering a culture of innovation, these nations can develop more resilient and sustainable industrial sectors that contribute to overall economic and social well-being (hosseini & moradi, 2023).

Statistical data and comprehensive analysis, such as those provided by the Community Innovation Survey (CIS) in Latvia, show the importance of accurate and comparable innovation data for developing national innovation support strategies (Jesiļevska, 2016). The strategic use of public procurement for innovation is also crucial. Public procurement can drive sustainable development by selecting the most advantageous and sustainable innovation alternatives. This process involves evaluating proposals based on various criteria, such as quality, environmental impact, and social benefits, beyond just the lowest price, thus promoting effective use of public funds and fostering innovation (Babica & Sceulovs, 2019). Lessons from the global experience underscore the need for effective prioritization within national innovation strategies, focusing on the importance of intersectoral coordination and the alignment of national and international criteria. Furthermore, the coordination between national and international innovation systems plays a significant role in ensuring that BRICS countries can benefit from global knowledge and technology transfer, enhancing their competitive edge (Prokopenko & Omelyanenko, 2017).

The Global Innovation Index (GII) and the BRICS Competitive Industrial Performance (CIP) Index are crucial tools for understanding the impact of innovation on industrial competitiveness. The GI, published by the World Intellectual Property Organization (WIPO), provides a comprehensive ranking of countries based on their innovation capabilities and outputs. It assesses various indicators, including R&D investments, innovation linkages, and knowledge absorption, offering valuable insights into the innovation ecosystem of each country (WIPO, 2022).

Similarly, the BRICS Competitive Industrial Performance Index, developed by the United Nations Industrial Development Organization (UNIDO), evaluates the industrial performance of the BRICS economies. It measures factors such as manufacturing value added, industrial diversification, and export quality, providing a benchmark for comparing the industrial competitiveness of these countries. The index highlights the strengths and weaknesses of each nation, helping policymakers identify areas for improvement and formulate strategies to enhance industrial performance (UNIDO, 2022).

Despite the recognized importance of innovation for enhancing industrial performance, there remains a significant gap in understanding how different dimensions of innovation specifically affect the competitive industrial performance in BRICS economies. Each BRICS economies faces unique challenges and opportunities, and there is a need for a nuanced analysis that considers these distinct contexts. The lack of detailed empirical studies on this topic limits the ability of policymakers to design targeted strategies for fostering innovation-led

industrial growth in these countries, in light of this, we pose the following question:

To what extent does innovation impact competitive industrial performance in BRICS economies?

Goal and Significance of the Research:

This study is crucial for several reasons. First, it addresses a significant gap in the existing literature by providing an in-depth analysis of the relationship between innovation and industrial competitiveness in the BRICS economies. Second, by utilizing the Global Innovation Index and the BRICS Competitive Industrial Performance Index, this research offers a robust framework for assessing the innovation capabilities and industrial performance of these nations. Third, the findings of this study will provide valuable insights for policymakers and industry leaders in the BRICS economies, enabling them to design and implement effective strategies for promoting innovation-driven industrial growth. Through empirical analysis and advanced econometric modeling, this research aims to provide a comprehensive understanding of the dynamic interplay between innovation and industrial competitiveness.

Theoretical Framework:

Joseph Schumpeter's theory of economic development emphasizes innovation as a pivotal force in economic growth. According to (Schumpeter, 1934) innovation generates new markets and sectors through the introduction of novel goods, services, or technological advancements. Schumpeter's concept of "creative destruction" underscores how innovation replaces outdated sectors with more productive ones, driving overall economic progress (Freeman & Soete, 1997). This theoretical perspective is crucial in understanding how BRICS economies can leverage innovation to transform their industrial bases, enhance value-added production, and improve their global competitiveness.

Michael Porter's theory of competitive advantage provides a framework for understanding how nations achieve economic success through industrialization and innovation. (Porter, 1990) argues that a nation's capacity for innovation and productivity improvement is fundamental to gaining a competitive edge. Four essential factors that determine a country's competitive advantage are outlined by Porter's "diamond model": linked and supporting sectors, factor and demand circumstances, firm strategy, structure, and rivalry. This model is particularly relevant for analyzing how BRICS economies can harness their unique resources and capabilities to enhance industrial competitiveness through innovation.

Moreover, Endogenous growth theory, as articulated by economists such as Paul Romer, contends that internal causes, as opposed to external ones, are what largely drive economic growth. (Romer, 1990) emphasizes the importance of knowledge, human capital, and innovation in driving sustained economic growth. According to this theory, investments in research and development (R&D) and technological advancements are critical for industrialization. In BRICS economies,

policies that promote innovation and enhance human capital can lead to sustained industrial growth and economic diversification.

Integrating Schumpeter's, Romer's, and Porter's theories provides a comprehensive framework for understanding the impact of innovation on industrial performance in BRICS economies. Schumpeter's focus on creative destruction complements Romer's emphasis on endogenous growth drivers, while Porter's competitive advantage theory offers practical insights into how innovation can be strategically leveraged to enhance industrial competitiveness.

The theoretical framework outlined combines key economic theories to elucidate the multifaceted impact of innovation on industrial performance in BRICS economies. By leveraging innovation, these economies can drive industrial growth, enhance value-added production, and achieve a competitive edge in the global market. The integration of Schumpeter's, Romer's, and Porter's theories provides a robust foundation for analyzing and promoting innovation-driven industrial development within BRICS nations.

Literature Review:

In light of global economic transformations and rapid technological development, the BRICS economies (Brazil, Russia, India, China, South Africa) have become an increasingly important economic force on the world stage. Industrial competitiveness is a critical element in achieving sustainable growth and economic prosperity for these countries. Innovation plays a pivotal role in enhancing competitive industrial performance, as it can provide new technologies and innovative procedures that contribute to improving production efficiency and increasing added value.

This paper aims to explore the role of innovation in enhancing the industrial competitiveness of BRICS countries. The literature review was structured to provide a comprehensive overview of current studies, arranged in key thematic areas. The first section examines the impact of policy and innovation on competitiveness, highlighting key drivers and indicators of competitiveness performance as identified in previous research. This is followed by a review of the impact of industrial performance and technology, with a focus on how advances and technology adoption contribute to competitiveness. The final section presents case studies from Specific regions and countries, providing insights into the unique challenges and opportunities faced by different BRICS countries in their pursuit of competitive industrial growth.

By analyzing these studies, this review aims to illustrate the complex interplay between innovation and industrial competitiveness in BRICS economies, providing a foundation for understanding the strategic implications for policymakers and industry leaders alike. In addition, these studies help identify appropriate study variables and statistical methods, and highlight research gaps that require further investigation and treatment.

To shed light on the different dimensions of innovation and its impact on competitive industrial performance, we review in this section a set of studies that

dealt with this topic from multiple angles. First, we begin by addressing research that explored the impact of policy and innovation on competitiveness in different industrial contexts.

Impact of Policies and Innovation on Competitiveness

Sirikrai & Tang (2006), proposed an AHP-based model for evaluating industrial competitiveness, applied to the automotive components industry in Thailand. Their model helps identify key performance indicators and drivers critical for industrial competitiveness, providing a comprehensive framework for analysis. Similarly, (chen et al., 2007) develop novel patent indicators to assess technological innovation competitiveness, demonstrating their effectiveness in evaluating high-tech industries in Taiwan. On the other hand, (Alkahtani et al. 2021) conduct a systematic review of the literature on value innovation, highlighting its role in achieving superior performance, competitive advantage, and sustainable growth. Their work synthesizes the results of multiple studies and proposes a conceptual framework for understanding value innovation in different contexts.

Moreover, (Ivanová & Čepel , 2018) assess the impact of innovation performance on the competitiveness of Visegrad 4 countries. They conclude that innovation significantly affects global competitiveness rankings, with the Czech Republic performing the best among the four. Likewise, (Le & Ikram , 2022) explore the relationship between sustainable innovation and corporate competitiveness in the SME sector in Viet Nam. Their study reveals that sustainable innovation positively impacts organizational competitiveness, which in turn enhances financial, environmental and operational performance. This underscores the importance of integrating sustainability into business strategies to improve outcomes. Furthermore, (Hajighasemi et al., 2022) investigate the impact of welfare state systems on innovation and competitiveness in the EU, using the European Innovation Panel (EIS). They find that inclusive welfare systems, especially in northern countries, support innovation goals and do not hinder competitiveness, demonstrating the complex interplay between social policies and economic performance.

Additionally, (Zhang et al., 2022) explore the role of innovation in sustainable performance among SMEs practicing circular economy principles. They find that R&D and patents are positively correlated with social and environmental performance, highlighting the critical role of innovation in achieving sustainable goals. Complementarily, (fosso wamba & guthrie, 2019) explore the impact of blockchain adoption on competitive performance in supply chains. They find that blockchain not only enhances competitive performance directly but also indirectly through process and relational innovations.

Industrial Performance and Technology Impact

(drucker, 2013) examines the relationship between regional industrial structure and competitive industrial performance in the U.S. from 1987 to 1997. His findings highlight the importance of economic diversity, industrial specialization, and competitive structure in regional employment changes and industrial

development, reinforcing the idea that industrial competitiveness is multifaceted. In a more recent study, (Wagire & Kulkarni, 2024) examines the impact of Fourth Industrial Revolution (I4.0) technologies on the industrial performance of manufacturing organizations in India. They find that adopting I4.0 technologies enhances operational performance and can improve product flexibility, work-life balance, and sustainability after achieving operational improvements. These findings contribute to an understanding of how new technologies can enhance competitiveness in emerging markets. Similarly, (Caglar et al., 2024) examines the impact of economic growth, trade openness, renewable energy, human capital, and industrial competitiveness on environmental sustainability in EU countries from 1995 to 2018. They find that while economic growth and trade openness may harm environmental quality, renewable energy and human capital improve it. This study provides insights into how industrial competitiveness can be aligned with sustainability goals. Likewise, (Caglar et al., 2023) analyze BRICS economies, examining the relationship between industrial competitiveness, renewable energy consumption, urbanization, and load capacity factor from 1990 to 2018. They find that higher industrial competitiveness enhances.

In another recent study, (hosseini & moradi, 2023) evaluate Iran's competitive industrial performance using CIP data from 1990 to 2020. They find that Iran's industrial competitiveness is weak compared to global and regional benchmarks, with significant regression in high-tech manufacturing.

Additionally, (Caglar & Askin, 2023) Examine how renewable energy and competitive industrial performance (CIP) can improve the load capacity factor in the top ten CIP economies between 1990 and 2018. The results show that while competitive industrial performance and economic expansion may have a detrimental impact on environmental quality, human capital and the use of renewable energy have a beneficial impact on the load capacity factor.

In a comparative analysis, (Değer et al., 2009) conduct a comparative analysis of Turkey's industrial competitiveness relative to 33 countries between 1985 and 2002. Their study reveals that Turkey lags behind in industrial competitiveness, pointing to significant challenges for sustainable development. Similarly, (Zhao & Zhang, 2007) assesses China's industrial competitiveness using the Competitive Industrial Performance (CIP) index developed by UNIDO. They identify key drivers such as skills, technological efforts, inward FDI, royalty and technical payments abroad, and modern infrastructure. Their findings suggest that China's significant jump in competitiveness is closely linked to its participation in international production networks. However, they also caution that low domestic value added and the need for upgrading industry and domestic innovation remain significant challenges. Additionally, (Zhang, 2014) explores the impact of FDI on China's industrial competitiveness using an AHP-based model. Zhang's findings underscore the importance of FDI in enhancing industrial competitiveness, particularly in the automotive components industry in Thailand.

(Iweriebor et al., 2015) analyze the effects of public spending on Nigeria's industrial sector, suggesting a need for better fiscal management to enhance industrial performance. (ahmad, khattak, khan, & Rahman, 2020) investigates the effects of domestic consumption spending and technological innovation on

South Africa's industrialization, finding positive impacts of both variables. Similarly, (Gholami & Sameei, 2019) examine the impact of government consumption expenditures on economic growth in D-8 countries, finding negative effects of increased government spending. In addition, (Omankhanlen et al., 2021) analyze the impact of government expenditure on Nigeria's industrial development, highlighting the need for effective fiscal management. In Nigeria, (Ozuzu & Isukul, 2021) find that government capital expenditure, taxation, and monetary policy rates positively impact the industrial sector's growth. Finally, (Wiryawan & Otchia, 2022) explore the impact of local government capital expenditure on industrial development in Indonesia, highlighting the need for improved central-local collaboration for effective industrialization.

Results and Discussion

Descriptive statistics, variables, and datasets

This experimental study was conducted using panel data from the founding BRICS countries (Brazil, Russia, India, China, and South Africa) over a 12-year period (2011-2022). These countries were chosen as they all ranked highly in the Global Innovation Index 2022, showing outstanding performance in innovation. The dependent variable is the Competitive Industrial Performance (CIP) index, which is an instrument used by the United Nations Industrial Development Organization (UNIDO, 2022) to measure the competitiveness of industries in different countries. The index aims to evaluate the ability of countries to produce and export manufactured goods competitively, as well as to develop industrial sectors with high added value and advanced technological content. The CIP index includes three main components: production capacity, which measures the ability to efficiently produce manufactured goods; technological depth, which assesses the extent of advanced technology use in industrial processes; and global market presence, which measures the ability of countries to compete in global markets through the export of manufactured goods. Combined, these components provide a comprehensive assessment of countries' capabilities to achieve sustainable industrial growth and global economic competitiveness.

The Global Innovation Index (GII) is developed and published annually by the World Intellectual Property Organization (WIPO) in collaboration with Cornell University and INSEAD. This index aims to measure the innovation environment in various countries and compare their innovation capabilities. It is a comprehensive measure reflecting the ability of countries to innovate. A study by (Caglar et al., 2023) confirmed a positive relationship between innovation and industrial competitiveness, indicating that countries with higher GII levels tend to perform better in the CIP index. Innovation enhances industrial capacity by developing new technologies and improving production efficiency, thereby increasing industrial competitiveness.

Furthermore, an effective intellectual property protection system enhances the GII, as laws and regulations that protect inventors' rights encourage innovation. An effective IP protection system increases confidence in the investment environment, encouraging companies and individuals to invest in

innovation(Caglar et al., 2023), which boosts industrial growth and competitiveness (Wang et al., 2024).

In Brazil, the government seeks to improve the level of innovation by supporting research projects and increasing investments in research and development to stimulate innovation, in addition to enhancing IP protection laws to encourage local inventors. In Russia, the economy heavily relies on technological and scientific innovations, with significant investments in scientific research, especially in technical fields, and an advanced legal system for IP protection. In India, the country relies on a broad base of human skills and seeks to enhance investments in the technology and innovation sector, in addition to improving laws to protect IP rights. China features a strong innovation environment supported by substantial government backing and significant investments in R&D focusing on advanced industries, along with a developed legal system to support and protect innovations. In South Africa, innovation in small and medium-sized industries is encouraged, with increased support for scientific research to enhance innovation capacity and an improved IP protection system to bolster confidence in the innovation environment.

The percentage of industrial workers out of the total workforce is an indicator expressing the share of the workforce employed in the industrial sector, including manufacturing, mining, construction, and utilities, compared to the total workforce. This indicator is crucial for measuring the degree of industrialization, reflecting the role of the industrial sector in economic development and job creation. A higher percentage indicates a strong industrial base, which enhances productivity and economic growth and contributes to improving the country's industrial competitiveness (UNIDO, 2022).

The capacity of the government to create and carry out sensible laws and regulations that support and encourage the growth of the private sector is referred to as regulatory quality. This indicator reflects the efficiency of laws and regulations and their impact on improving the business environment and facilitating economic operations. The components of regulatory quality include economic policies indicating the effectiveness of government policies in regulating markets and reducing bureaucracy, property rights protection including laws protecting IP rights and encouraging innovation, and transparency and accountability measuring the extent of transparency in law enforcement and the accountability of government institutions.

Regulatory quality positively affects industrial performance competitiveness. Effective laws and regulations enhance the efficiency of industries and increase their competitiveness by improving the business environment and reducing operational costs. Studies indicate that countries with good regulatory quality achieve higher growth rates in manufacturing industries (Mishra & Kumar, 2021).

The degree to which members of society uphold the laws and norms of society, especially those pertaining to contract enforcement, property rights, law enforcement, and the prevention of crime and violence, is referred to as the rule of law (Kaufmann et al., 2002). The components of the rule of law include the

effectiveness of the judiciary in enforcing contracts and protecting the rights of contracting parties, protecting intellectual and physical property rights, ensuring fair use, and the level of public security and crime control. Rule of law positively affects industrial performance competitiveness. A strong and effective legal system increases confidence in the business environment, encouraging local and foreign investments. Protecting property rights also fosters innovation and creativity in the industrial sector, increasing competitiveness (Acemoglu & Johnson, 2005).

Foreign Direct Investment (FDI) refers to investments made by an investor from one country in business activities in another country, aiming to obtain a lasting interest and significant influence in the management of those activities (Adabor et al., 2023). This is typically achieved by the investor owning at least 10% of the voting rights in the foreign company. FDI is a key component of international economic integration as it creates stable and long-term links between economies, contributes to technology and knowledge transfer (Dempere et al., 2023), enhances international trade by providing access to foreign markets, and can be a vital means for economic development.

FDI enhances industrial performance competitiveness in several ways. First, FDI helps transfer modern technologies and advanced knowledge from investing countries to host countries, enhancing the efficiency of local industries (Kenh & Wei, 2023). Second, FDI improves productivity by introducing new management practices and advanced production techniques (Abor et al., 2024). Third, FDI creates new jobs, increasing individual income and promoting economic growth. Finally, FDI can increase the host country's production capacity, enhancing its ability to export and compete in international markets.

Gross Domestic Product (GDP) is the total monetary value of all final goods and services produced within a country's borders during a specific period, usually a year or a quarter. GDP is used as a comprehensive measure of a country's economic health, providing an overview of the size and growth rate of the economy. It has a strong positive impact on the CIP index, as an increase in GDP indicates a rise in overall economic activity, leading to improved industrial competitiveness through enhanced infrastructure, increased investments in R&D, and improved workforce quality (Caglar et al., 2023) (Bate et al., 2023). In particular, increased government and private investment can improve industrial efficiency and productivity, boosting the competitiveness of local industries.

Table 1: Study Variables and Data Sources

Variable	Symbol	Expected Sign	Source
Dependent Variable			
Competitive Industrial Performance Index	CIP		United Nations Industrial Development Organization (UNIDO) https://stat.unido.org/analytical-tools/cip?country=012
Independent Variables			
Global Innovation	GII	+	World Intellectual Property Organization (WIPO)

Variable	Symbol	Expected Sign	Source
Index			https://www.wipo.int/global_innovation_index/en/
Percentage of Industrial Workers	EMPi	+	World Bank World https://data.worldbank.org/
Regulatory Quality	rqu	+/-	Worldwide Governance Indicators (WGI) https://www.worldbank.org/en/publication/worldwide-governance-indicators
Rule of Law	rll	+/-	Worldwide Governance Indicators (WGI) https://www.worldbank.org/en/publication/worldwide-governance-indicators
Foreign Direct Investment	FDI	+	World Bank World https://data.worldbank.org/
Gross Domestic Product	GDP	+	World Bank World https://data.worldbank.org/

The Econometric Model and Estimation

1. Descriptive Statistics

Table 2: Descriptive Statistics of Study Variables

Variable	Obs	Mean	Std. dev.	Min	Max
CIP	60	.1439033	.1212857	.0479444	.4012663
GII	60	38.50667	6.536323	29.8	55.3
EMPi	60	24.84359	3.923726	17.24874	32.15201
FDI	60	2.136558	1.497118	-1.776443	9.677949
GDP	60	3.191719	3.726867	-5.963358	9.550832
rqu	60	56.26126	9.125115	21.22642	75.35545
rll	60	34.70922	12.63467	6.132075	53.36538

Source: Prepared by researchers based on the outputs of the statistical program STATA17

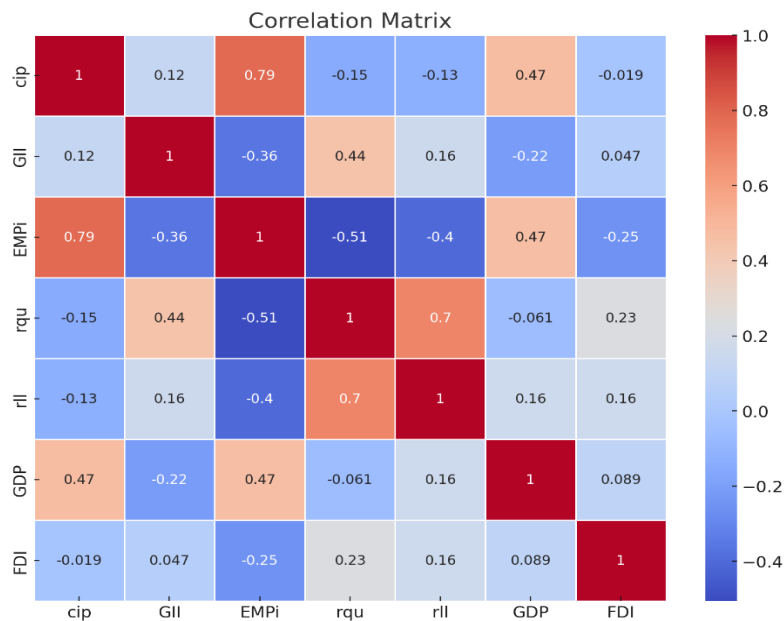
The table above presents the descriptive statistics for the study variables, showing significant variation among BRICS economies in industrial competitive performance, innovation levels, regulatory quality, and the rule of law. The average Competitive Industrial Performance (CIP) index is 0.1439, with a standard deviation of 0.1213, and values ranging from 0.0479 to 0.4013, reflecting substantial differences in industrial competitiveness among countries. The Global Innovation Index (GII) has an average of 38.5067 with a standard deviation of 6.5363, and values ranging from 29.8 to 55.3, indicating clear disparities in innovation capabilities among the countries. The percentage of industrial workers (EMPi) averages 24.8436, with a standard deviation of 3.9237, and ranges from 17.2487 to 32.1520, showing variation in the reliance on the industrial sector among the countries. The average Foreign Direct Investment (FDI) is 2.1366 with a standard deviation of 1.4971, ranging from -1.7764 to 9.6779, reflecting considerable differences in FDI inflows. The average Gross Domestic Product

(GDP) is 3.1917 with a standard deviation of 3.7269, and values ranging from -5.9634 to 9.5508, indicating variations in GDP growth. The average regulatory quality (rqu) and rule of law (rll) are 56.2613 and 34.7092, respectively, with standard deviations of 9.1251 and 12.6347, and ranges from 21.2264 to 75.3554 for regulatory quality and from 6.1321 to 53.3654 for rule of law, highlighting the disparity in the efficiency of laws, regulations, and legal systems among countries. This variation directly impacts the competitiveness of industries in BRICS countries.

2. Correlation Matrix

With a range of -1 to 1, the correlation matrix displays the strength of the association between two or more variables. Whereas a negative correlation shows that as one variable rises, the other falls, a positive correlation shows that as one variable rises, the other variable also rises. There may be little to no association between the variables if the correlation value is near to 0.

Table 3: Correlation Matrix of Study Variables



Source: Prepared by researchers based on the outputs of the statistical program STATA17

The correlation matrix shows that there is significant variation among the economic variables influencing the industrial competitive performance of BRICS countries. The strong positive correlation between the Competitive Industrial Performance (CIP) index and the percentage of industrial workers (EMPI) (0.7876) reflects the importance of the industrial sector in enhancing industrial competitiveness. Additionally, the moderate positive correlation between CIP and Gross Domestic Product (GDP) (0.4716) indicates that GDP growth boosts the competitiveness of industries. On the other hand, the negative correlation

between regulatory quality (rqu) and the percentage of industrial workers (-0.5063) and rule of law (rll) (-0.4043) highlights the impact of legal regulation and governance on competitiveness. Moreover, the positive correlation between the Global Innovation Index (GII) and regulatory quality (rqu) (0.4413) underscores the importance of innovation in improving industrial performance. Regarding Foreign Direct Investment (FDI), the moderate correlations with other variables reflect its role in enhancing competitiveness through technology transfer and infrastructure improvement. Overall, the results indicate that improving regulatory quality, strengthening the rule of law, and increasing investment in innovation and industrial infrastructure are key to enhancing the industrial competitiveness of BRICS countries.

3. Multicollinearity Test

The Variance Inflation Factor (VIF) (Belsley et al, 1980) measures multicollinearity in regression analysis due to the presence of correlated variables in the model. A VIF value of 1 indicates no multicollinearity, while values greater than 1 indicate increasing levels of multicollinearity. To conduct a VIF test, VIF values are calculated for each predictor variable in the regression model. A VIF value greater than 5 or 10 may indicate significant multicollinearity, but the threshold values can vary depending on the specific application.

Table 4: VIF Test Results

Variable	VIF	1/VIF
rqu	2.70	0.3703
rll	2.46	0.4062
EMPi	2.17	0.4603
GDP	1.69	0.5920
GII	1.39	0.7205
FDI	1.16	0.8593
Mean VIF	1.93	

Source: Prepared by researchers based on the outputs of the statistical program STATA17

The mean VIF value is 1.93, which reinforces the absence of significant multicollinearity among the explanatory variables in the model. The highest VIF value for regulatory quality (rqu) is 2.70, which is still within acceptable limits, indicating that the explanatory variables do not exhibit levels of multicollinearity that could affect the accuracy of the results and con.

Therefore, the results obtained from the regression model can be relied upon without concern for the effects of multicollinearity on the coefficient estimates. This enhances the reliability of the results and conclusions related to the impact of innovation, regulatory quality, GDP growth, and foreign direct investment on the industrial competitive performance of BRICS countries.

4. Cross-Sectional Independence Test

Cross-sectional dependence is a form of correlation and is one of the common problems that often arise in panel data estimates. It refers to the possibility that cross-sections in panel data are correlated, which can be due to factors such as spatial effects, omitted common effects, social effects, and economic network interactions (Chudik & Pesaran, 2013).

The presumption of cross-sectional independence really forms the basis of the features of first-generation panel unit root tests and cointegration tests. The estimates produced and the conclusions reached are affected by the assumption of cross-sectional independence since an increase in the covariance matrix with the number of cross-sections would result in incorrect parameter estimations. The following cross-sectional independence tests will be applied:

- **Pesaran's CD Test (2004)** (Pesaran, 2004)

Pesaran's CD test (2004) is a first-generation test for detecting strong cross-sectional dependence. It is particularly useful when the number of time periods (T) and the number of cross-sections (N) are both large.

$$CD = \sqrt{\frac{2}{N(N-1)}} \sum_{i=0}^N \sum_{j=i+1}^N T_{ij} \hat{p}_{ij}^2 \rightarrow N(0, 1)$$

- **Pesaran's CD Test for Weak Cross-Sectional Dependence (2015)** (Pesaran, 2015)

Pesaran's CD test for weak cross-sectional dependence (2015) is a second-generation test that detects weak or mild cross-sectional dependence. This test is valid for panel data where $N < T$ and is robust to a variety of cross-sectional dependence structures.

Table 5: Table of Cross-Sectional Independence Tests

Variables	Pesaran (2004) CD test		Pesaran (2015) CD test for weak cross-sectional dependence	
	CD	P-Value	CD	P-Value
cip	8.04	0.00	9,458	0.00
GII	-1.46	0,444	9,458	0.00
EMPi	-0.21	0,837	9,469	0.00
FDI	-0.62	0,533	7,319	0.00
GDP	6.86	0.00	5.976	0.00
rqu	0.85	0,395	9.443	0.00
rll	-0.04	0,971	9,307	0.00

Source: Prepared by researchers based on the outputs of the statistical program STATA17

The results of the (Pesaran, 2004) CD test and the (Pesaran, 2015) CD test show variation in cross-sectional dependence among the different variables. The (Pesaran, 2004) CD test indicates that there is no strong and statistically significant correlation in some variables, such as regulatory quality (rqu), rule of law (rll), percentage of industrial workers (EMPi), and the Global Innovation Index (GII). This suggests that these variables may be more independent and less influenced by external factors between countries.

Conversely, the (Pesaran, 2015) CD test shows weak correlation among the variables across countries, indicating that there are mild interdependencies between the countries in the sample. The results of the cross-sectional independence tests reject the null hypothesis of no cross-sectional independence at the 1% significance level in the applied tests. This means that there is correlation between cross-sections, implying that any shocks in one country within the study sample can easily be transmitted to other countries.

Since there is cross-sectional dependence, albeit weak based on the (Pesaran, 2015) test, it becomes necessary to use panel data techniques that account for this dependence. In this study, the one-step Generalized Method of Moments (GMM ONE STEP) estimator was used to address this issue. Using the one-step GMM system is appropriate for handling cross-sectional dependence as it deals with autocorrelation and fixed effects, providing reliable and meaningful estimates of the economic relationships between the variables (Roodman, 2009a). (Windmeijer, 2005) (Blundell & Bond, 1998a) (Arellano & Bond, 1991).

Given that the (Pesaran, 2015)CD test results showed the presence of cross-sectional dependence, using the one-step GMM method is a suitable choice for the dynamic panel data analysis. This enhances the accuracy of the estimates and reduces biases arising from cross-sectional dependence among the countries in the studied sample.

5. Estimation of One-Step Generalized Method of Moments (GMM ONE STEP)

Estimating dynamic panel data models is an effective technique for addressing the effects of explanatory variables and their homogeneity, as well as fixed country effects that cannot be observed (Yerdelen Tatoğlu, 2018). To deal with the issue of endogeneity among explanatory variables, (Arellano & Bond, 1991b) proposed the use of the Difference GMM method, where lagged variables are used as instruments to derive the corresponding moment conditions. This method involves taking the first difference in the regression equation to remove individual fixed effects and then using lagged variables as effective instruments for endogenous variables in the differenced equation.

While the Difference GMM method is effective in mitigating the endogeneity problem, it suffers from the "weak instruments" problem in the case of limited samples, leading to low accuracy in estimates (Bond et al., 2001). To address this issue, (Blundell & Bond, 1998). (Arellano & Bover, 1995) proposed the use of the System GMM estimator. The System GMM method allows for addressing the endogeneity problem in addition to reducing omitted variable bias, multicollinearity issues, unobserved cross-sectional heterogeneity, and

measurement errors commonly encountered in pooled ordinary least squares (OLS) and fixed effects regression methods. Furthermore, the System GMM can provide better and more accurate estimates compared to other GMM estimators (Blundell & Bond, 1998).

The dynamic model used in this study relies on an equation that combines both difference and level equations:

$$y_{i,t} = \sum_{j=1}^p a_j y_{i,t-j} + x_{i,t}\beta_1 + w_{i,t}\beta_2 + v_i + \epsilon_{i,t} \quad ; i = 1, \dots, N \quad t = 1, \dots, T$$

The System GMM estimator is used in the study to evaluate dynamic panel data. Even though System GMM findings are usually reliable, it's important to evaluate the estimates' consistency by looking at the validity of the instruments and making sure there isn't any second-order serial correlation. When the error term and the instruments do not correlate, as determined by the Sargan and Hansen tests, the instruments are deemed legitimate. (Teixeira & Queirós, 2016) state that the Arellano-Bond tests are used to test for second-order serial correlation.

System GMM comes in two flavors: one-step and two-step estimate techniques, which vary according on whether the weighting matrix is heteroscedastic or homoscedastic. Two-step estimators are considered more efficient as they reduce the bias in the standard errors of the estimates with limited samples. However, System GMM can produce numerous instruments as the number of periods increases, potentially leading to model overfitting and reduced model specification (Roodman, 2009b). Therefore, the one-step System GMM is recommended for models with a small number of countries and a longer time period (Teixeira & Queirós, 2016). The one-step GMM estimator is particularly robust in small samples and is less sensitive to instrument proliferation compared to the two-step GMM. In contrast, the two-step System GMM is preferred for models with a large number of countries and a shorter time period.

Based on our analysis involving data from BRICS countries, we preferred to use the results of the one-step System GMM over the two-step System GMM. Consequently, the model was estimated using the one-step System GMM estimator as proposed by (Blundell & Bond, 1998). As shown in the table below.

$$CIP_{i,t} = a_i + a_1 CIP_{i,t-1} + a_2 GII_{i,t} + a_3 rqu_{i,t} + a_4 rll_{i,t} + a_6 EMPi_{i,t} + a_7 GDP_{i,t} + a_8 FDI_{i,t} + \epsilon_{i,t}$$

The dynamic model used in this study is based on an equation that combines both difference and level equations:

Where $cip_{i,t}$ is the Competitive Industrial Performance index, $cip_{i,t-1}$ is the lagged Competitive Industrial Performance index from the previous year, $gii_{i,t}$ is the Global Innovation Index representing innovation in this study, and $rqu_{i,t}$, $rll_{i,t}$, $EMPi_{i,t}$, $GDP_{i,t}$, $FDI_{i,t}$ are control variables. Moreover, (i) refers to the BRICS countries, t refers to the years 2011-2022, a_i represents country-specific fixed effects that are heterogeneous across countries, and a_1 to a_8 are coefficients, while $(\epsilon_{i,t})$ is the error term.

We adapt our econometric framework considering the study's objective and the type of data available. We use a dynamic panel model because the Competitive Industrial Performance index is significantly influenced by its historical values. The model is estimated using the one-step System GMM estimator.

Table 6: One-Step System GMM Estimation Results

Variables	Coefficient	P-Value
GII	0.0006872	0.080
EMPi	0.0027373	0.001
FDI	0.0011146	0.059
GDP	0.0008902	0.000
rqu	0.000557	0.021
rll	-0.0005261	0.062
AR (1)	-1.52	0.128
AR (2)	-0.96	0.339
Sargan test	41.9	0.196
Hansen test	0.00	1.000
Pesaran (2015) CD test	2.054	0.140

Source: Prepared by researchers based on the outputs of the statistical program STATA17

In the final table, the results indicate that the variables included in the model are statistically significant, at least at the 5% level. The discussion of the results of the BRICS economies (Brazil, Russia, India, China, and South Africa) was as follows?

Impact of the Global Innovation Index (GII):

Increasing the Global Innovation Index (GII) by 1% leads to an increase in competitive industrial performance by 0.06872%, this effect is attributed to the fact that innovation plays a crucial role in enhancing the competitiveness of industries by improving efficiency and productivity and developing new products and services. Innovation can help companies gain competitive advantages, both in terms of cost and quality, thereby enhancing the overall industrial performance of the BRICS countries.

Previous studies such as Sirikrai and Tang (2006) and Chen et al. (2007) confirm that innovation enhances industrial competitiveness by improving production efficiency and creating new products and services. Economic theories strongly support the study's findings on the role of innovation in enhancing competitive industrial performance. Schumpeter's theory of economic growth, which focuses on "creative destruction," asserts that innovation is the primary driving force for the growth of new markets and sectors through the introduction of new products, services and technologies. This theory highlights how innovation can replace old sectors with more productive ones, promoting inclusive economic progress. These ideas support findings that suggest that innovation enhances the industrial competitiveness of BRICS economies.

Impact of Industry Employed Rate (EMPi):

On the other hand, an increase in the proportion of workers in industry (EMPi) by 1% enhances competitive industrial performance by 0.27373%, this significant impact indicates the importance of the industrial workforce in enhancing the industrial performance of BRICS economies. A trained and skilled workforce is one of the most important assets of any industrial economy, contributing to increased productivity and improved product quality, leading to the competitiveness of companies and industries in BRICS economies.

Previous literature such as the Ivanová and Čepel study (2018) and the Hosseini and moradi study (2023) support the importance of a skilled workforce in enhancing industrial performance. This finding is consistent with Michael Porter's theory of competitive advantage, which asserts that the availability of skilled labor and good human resources is one of the decisive factors in achieving competitive advantage. The human factor is a key element of Porter's diamond model, boosting innovation and productivity within industries. This theory supports the idea that investment in education and training contributes to improved industrial performance. The findings of the study support that increasing the proportion of people employed in industry enhances the competitive industrial performance of the BRICS economies.

Impact of Organization Quality (rqu):

Improving regulation quality (rqu) by 1% boosts competitive industrial performance by 0.0557%, this result reflects the importance of a good regulatory framework in supporting industries. Good regulation can facilitate industrial processes, reduce bureaucratic costs, increase investments, and enhance corporate confidence in the market, improving the industrial performance of BRICS economies.

Studies such as Hajighasemi et al. (2022) suggest that a good regulatory environment supports innovation and enhances competitiveness. Porter's theories of competitive advantage, especially the "diamond" model, highlight the importance of strong regulatory conditions in supporting innovation and enhancing competitiveness. The findings of your study that improving the quality of regulation lead to enhanced industrial performance are in line with this theory, as regulatory conditions are among the factors that determine national competitive advantage. A good regulatory framework contributes to the creation of a stable and innovation-stimulating business environment.

Impact of Gross Domestic Product (GDP):

In addition, an increase in gross domestic product (GDP) by 1% enhances competitive industrial performance by 0.08902%, economic growth boosts demand for products and services, and provides financial resources for investments in the industrial sector. In addition, economic growth can spur innovation and technological development, enhancing the competitiveness of industries in the BRICS economies.

Studies such as Ahmad et al. (2020) support the idea that economic growth boosts industrial performance by increasing demand for goods and services. Traditional economic theories, such as the theory of economic growth presented by Robert Lucas and Paul Romer, support the study's findings on the importance of GDP in boosting industrial performance. These theories suggest that economic growth enhances competitive industrial performance by increasing demand for goods and services and stimulating investments in technology and infrastructure. Economic growth also leads to improved productive capacity and increased innovation.

Impact of the Rule of Law (rll):

On the other hand, increasing the rule of law (rll) by 1% reduces competitive industrial performance by 0.05261%, this result may seem unexpected, but it can be explained that in some cases, the application of strict laws may impose restrictions on industrial processes and increase regulatory costs. This can happen if the laws are inflexible or do not take into account industry-specific challenges, which can lead to a negative impact on industrial performance in BRICS economies.

While the previous literature has not provided a strong affirmation of the negative relationship between the rule of law and industrial performance, there can be negative effects in some contexts where strict laws increase costs. However, this does not necessarily contradict overarching economic theories, some of which suggest that a regulated and stable business environment boosts investor confidence and stimulates growth. However, there may be cases where strict regulations increase costs for companies, which explains the study's potential negative findings.

Impact of Foreign Direct Investment (FDI):

Increasing foreign direct investment (FDI) by 1% enhances competitive industrial performance by 0.11146%, FDI brings with it capital, technology and management knowledge, contributing to improved industrial efficiency and enhanced competitiveness. In addition, foreign investment can open new markets and improve supply chains, supporting the industrial growth of BRICS economies.

Studies such as Zhang (2014) suggest that FDI plays an important role in enhancing industrial competitiveness by bringing in capital, technology and management expertise. Schumpeter's theory as well as Paul Romer's new growth theory emphasize the importance of FDI in technology and knowledge transfer and the promotion of innovation. These theories support the results of the study, which found that foreign direct investment enhances competitive industrial performance, so foreign direct investment is a catalyst for economic growth and enhances industrial competitiveness by improving production efficiency and increasing exports.

The final part of the table presents the diagnostic test results for the dynamic panel data model. All pre- and post-diagnostic tests confirm that the model is

statistically valid, and all variables included in the model are significant at the 5% level. The Sargan (1958) and Hansen over-identification restriction tests ($p > 0.10$) indicate that the instruments are well-specified and valid in the estimated model. The (Arellano & Bond, 1991b) test for second-order serial correlation in the differenced errors ($p > 0.10$) suggests that the residuals do not exhibit serial correlation.

The results of the (Pesaran, 2015) CD test for cross-sectional independence, which is suitable for detecting weak or mild correlations and is valid for panel data where $N < T$, indicate that the errors in the model are not highly correlated across cross-sections, meaning that cross-sectional dependence is weak. This enhances the reliability of the estimates obtained using the one-step GMM. Consequently, the estimated model using the one-step System GMM estimator proposed by (Blundell & Bond, 1998) is valid.

Conclusion

This study analyzes the impact of innovation, regulatory quality, GDP growth, and foreign direct investment on the industrial competitive performance of BRICS economies during the period 2011-2022 using dynamic panel data estimation, which takes into account the dynamic lag effects of industrial performance. The dynamic panel data model includes explanatory variables such as the percentage of industrial workers (EMPi), regulatory quality (rqu), rule of law (rll), gross domestic product (GDP), and foreign direct investment (FDI), with the Global Innovation Index (GII) as the main explanatory variable. This study examines the relationship between these variables and industrial competitive performance, using the one-step System GMM estimator proposed by (Blundell & Bond, 1998). Which provides robust results when the lagged dependent variable is included in the dynamic panel data model. All diagnostic tests confirm that the econometric model is valid and that all variables included in the model are statistically significant at the 5% level.

The results indicate that an increase in innovation levels enhances industrial competitive performance, reflecting the importance of investing in research and development and supporting innovative environments. An increase in the percentage of industrial workers improves industrial performance, emphasizing the importance of training and developing the industrial workforce. Improving regulatory quality plays a crucial role in enhancing the competitive environment for industries, while overall economic growth boosts countries' ability to improve industrial performance through investments in infrastructure and technology. Foreign direct investment flows positively contribute to enhancing industrial performance by transferring technology and increasing production efficiency. On the other hand, a strong rule of law may have complex effects, requiring a delicate balance in its application to ensure the enhancement of industrial competitiveness.

Regarding policy implications, if BRICS economies (Brazil, Russia, India, China, and South Africa) adopt policies that promote innovation, improve regulatory quality, increase investments in economic infrastructure, and enhance the attraction of foreign investment, they can enhance their industrial competitive

capabilities and achieve sustainable economic growth. Recommendations include focusing on supporting research and development, improving education and vocational training, simplifying bureaucratic procedures, and improving the business environment to attract foreign investments. These policies can enhance the industrial competitive performance of BRICS countries and drive economic growth and technological advancement in the region.

Recommendations:

Based on the findings, the study recommends the following:

Boosting investment in research and development (R&D):

Investment in R&D is essential to foster innovation and increase industrial competitiveness. Governments and the private sector in the BRICS countries (Brazil, Russia, India, China, South Africa) should increase funding for R&D activities, especially in high-tech and emerging industries. This can be achieved through tax incentives, grants, and subsidies for R&D projects.

Improving vocational education and training:

To develop a skilled industrial workforce and boost productivity, invest in STEM-focused education systems and vocational training programs. Partnerships between educational institutions and industries in Brazil, Russia, India, China, and South Africa should be encouraged to ensure that curricula are relevant to market requirements.

Improving the quality of organization:

BRICS governments should streamline regulatory processes to reduce bureaucratic barriers and create a business environment conducive to industrial growth. Implementing clear, consistent and fair regulations that support business operations and innovation, and encouraging transparency and accountability in regulators is critical.

Promotion of Foreign Direct Investment (FDI):

To benefit from FDI in technology transfer and industrial development, an attractive investment climate must be created by ensuring political stability, offering incentives to foreign investors, and protecting intellectual property rights. The establishment of special economic zones with favorable conditions for foreign companies can have a significant impact in Brazil, Russia, India, China, and South Africa.

Supporting Economic Growth:

Economic growth can boost industrial performance by increasing demand for products and services and providing financial resources for investments in the industrial sector. Macroeconomic policies in BRICS countries should promote stable and sustainable economic growth, with a focus on developing

infrastructure such as transport, energy, and digital infrastructure to support industrial activities.

Balancing the rule of law with flexibility:

While the rule of law is essential to ensure a stable legal environment, excessive regulatory costs must be avoided. Strengthening the enforcement of property rights and contracts to build investor confidence is essential, but laws that may impose undue burdens on industries should also be reviewed and amended, ensuring that they are flexible and supportive of industrial innovation in Brazil, Russia, India, China, and South Africa.

Encouraging public-private partnerships:

Public-private partnerships are an effective tool for fostering collaboration for industrial innovation. These partnerships should be facilitated in key sectors to drive innovation and industrial competitiveness. Partnerships can focus on joint R&D projects, infrastructure development, and technology transfer initiatives in the BRICS countries.

Focus on Sustainable Industrial Practices:

To align industrial performance with environmental sustainability, sustainable industrial practices must be promoted by encouraging the adoption of green technologies and renewable energy. Implementing policies that support the principles of circular economy and reduce industrial waste and emissions is important to ensure sustainable industrial growth in Brazil, Russia, India, China, and South Africa.

By adopting these recommendations, BRICS economies can enhance their competitive industrial performance through innovation. A strategic focus on research and development, education, quality regulation, foreign direct investment, economic growth, rule of law, public-private partnerships, and sustainability will enable these countries to achieve long-term industrial growth and competitiveness on the global stage.

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