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The influence of macroeconomic infrastructure on supply chain smoothness and national competitiveness and its implications on a country's economic growth: evidence from BRICS countries

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A B S T R A C T

This study investigates the intricate relationships between macroeconomic infrastructure, supply chain smoothness, national competitiveness, and economic growth within the BRICS nations—Brazil, Russia, India, China, and South Africa. This study adopts a quantitative approach with cross-sectional data to examine the interrelationships. The research confirms that macroeconomic infrastructure significantly influences supply chain smoothness and a country's economic growth, underscoring the pivotal role of infrastructure development in enhancing supply chain efficiency and fostering economic expansion. However, rejecting hypotheses regarding the direct impact of supply chain smoothness and national competitiveness on economic growth highlights economic growth dynamics' complex and multifaceted nature within the BRICS context. This study emphasizes the need for nuanced, context-specific strategies to address each BRICS nation's unique challenges and opportunities. Theoretical implications call for a more comprehensive theoretical framework considering the contextual factors influencing economic growth within BRICS countries. Practical implications highlight the importance of strategic infrastructure investments and comprehensive policy approaches that extend beyond isolated factors. Despite its contributions, this study has limitations, including simplifying complex economic relationships and needing more country-specific analyses. Future research should explore broader variables, non-linear relationships, and country-specific nuances to understand economic growth in the BRICS group better.

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1. Introduction

Macroeconomic infrastructure plays a pivotal role in the economic growth of a nation (Jaiswal, 2023; Odongo & Kalu, 2016; Toader et al., 2018). This encompasses various facets such as transportation networks (Burlacu et al., 2022; Oeschger et al., 2020), energy systems (Crespo del Granado et al., 2018; Horak et al., 2022; Soltani et al., 2021), communication channels (H. Khan et al., 2020; Moller & Wacker, 2017; Ouyang, 2014), and other facilities that support the smooth flow of supply chains (Agyei et al., 2021; Koul et al., 2017; Melkonyan et al., 2019), production (Lang & Yang, 2019; Ryan-Collins, 2019; Schönberger et al., 2016), and international trade (Pechlaner et al., 2021; Pereira & Pereira, 2019; Shurong et al., 2022). In the context of the BRICS countries (Brazil, Russia, India, China, and South Africa), which constitute a group of emerging economies with significant global impact, macroeconomic infrastructure holds a distinctive role in influencing their economic competitiveness and overall economic growth (Maryam & Mittal, 2020). There are several reasons why it is imperative to undertake research on the influence of macroeconomic infrastructure on supply chain smoothness and the competitiveness of BRICS countries:

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- Rapid Economic Growth: BRICS nations have experienced rapid economic growth over the past few decades. Adequate infrastructure is essential to sustain this growth and ensure the seamless production and distribution of goods and services (Haji, 2021; Huang, 2016).
- Global Competitiveness: A nation's competitiveness in the global marketplace is highly contingent on its ability to provide efficient macroeconomic infrastructure. In the era of globalization, competitiveness can be a determining factor in attracting foreign investments and international business expansion (Khurshid et al., 2023).
- Efficient Supply Chains: Efficient supply chains are crucial for the manufacturing and trade sectors. Quality infrastructure enables companies to reduce logistical costs, expedite delivery times, and enhance customer satisfaction (Islam, 2014).
- Social and Environmental Impact: Macro-economic infrastructure also has significant social and environmental impacts. Infrastructure quality can affect the quality of life for citizens, while technology and energy resource choices can have substantial environmental repercussions (Ahmed et al., 2021; A. Iqbal et al., 2023; Sadiq et al., 2022).
- Comparative Analysis among BRICS Countries: Conducting comparative research on the influence of macroeconomic infrastructure in BRICS countries can provide valuable insights into the factors affecting economic growth and competitiveness in various economic contexts (Ioan et al., 2020; Kumar et al., 2023; Rasool et al., 2021).

Despite the wealth of research on the impact of macroeconomic infrastructure on economic growth, supply chain efficiency, and competitiveness, there remains a gap in research specifically focusing on BRICS countries as a group. These emerging economies exhibit contextual differences and policy variations that may result in significant disparities in how macroeconomic infrastructure influences their supply chain smoothness and competitiveness. Hence, there is a need to fill this knowledge gap with more in-depth research. The novelty of this research lies in its comparative approach centered on the BRICS countries. This research will foster a better understanding of the role of macroeconomic infrastructure in the context of this group of nations and explore differences and similarities in its impact on supply chain smoothness and competitiveness. Furthermore, this research will endeavor to identify unique factors that may influence the impact of macroeconomic infrastructure in BRICS countries. This research holds significant importance as it can provide deeper insights into how macroeconomic infrastructure affects economic growth, supply chain smoothness, and competitiveness of BRICS countries. The outcomes of this research can offer guidance to governments and economic stakeholders in formulating more effective policies to enhance their economic infrastructure, consequently promoting sustainable economic growth and global competitiveness. The primary motivation for this research is to enhance our understanding of the factors influencing the economic performance of BRICS countries, which play a crucial role in the global economy. Macro-economic infrastructure is a key element in this process, and this research is motivated by the desire to contribute to knowledge in this area.

The primary objectives of this research are to identify the influence of macroeconomic infrastructure on supply chain smoothness and competitiveness in BRICS countries and to analyze its implications on their economic growth. This research will strive to fill the knowledge gap by investigating differences and similarities among BRICS countries concerning macroeconomic infrastructure and its impact. Additionally, the research aims to provide policy recommendations that can assist BRICS countries in improving their infrastructure and enhancing their overall economic performance.

2. Literature Review and Hypothesis Development

2.1 Macroeconomic Infrastructure and Supply Chain Smoothness

According to Pradhan et al. (2017), Macroeconomic Infrastructure refers to the fundamental physical and organizational structures, facilities, and systems that underpin and support the overall functioning of a country's economy at a national or regional level. This infrastructure includes transportation networks (such as roads, railways, ports, and airports), energy generation and distribution systems, communication and information technology networks, and various public utilities. Macroeconomic infrastructure plays a pivotal role in facilitating economic activities, trade, and production within a nation (Zhai, 2018). The relationship between Macroeconomic Infrastructure and Supply Chain Smoothness is intertwined (Xu et al., 2021). Macroeconomic infrastructure provides the essential backbone for the smooth operation of supply chains (Awan & Ali, 2022). Efficient transportation networks (roads, railways, ports, etc.) are critical for the timely movement of goods within and across borders (Kaewunruen et al., 2016). Well-maintained roads and modern transportation facilities reduce transportation times and costs, contributing to smoother supply chain operations (Kulagovskaya et al., 2021). Reliable energy infrastructure is essential for manufacturing and distribution processes (Wolsink, 2020). A stable energy supply ensures that factories and distribution centers can operate without interruptions, reducing downtime and enhancing supply chain smoothness (Debnath et al., 2022). Effective communication networks facilitate real-time information sharing among supply chain partners, enabling better coordination and responsiveness to changing demands and conditions (Manfredi & Capik, 2022). Joash and Rose (2020) assert that advanced IT infrastructure supports digital supply chain management, allowing for better demand forecasting, inventory management, and order processing. It contributes to smoother supply chain operations. In addition, Venkatesh et al. (2020) assess that infrastructure in the form of public services (such as healthcare and education) can indirectly impact the supply chain by ensuring a healthy and skilled workforce, which can improve productivity and labor availability. Macroeconomic infrastructure serves as the foundational framework upon which supply chains operate. The quality and efficiency of this infrastructure can significantly impact the smoothness and effectiveness of supply chain

processes, which, in turn, have implications for a country's national competitiveness and economic growth. Efficient infrastructure reduces bottlenecks, lowers operational costs, and enhances the overall competitiveness of businesses operating within a country, contributing to its economic growth and development. Thus, the hypothesis is as follow:

H_1: *Macroeconomic infrastructure influences supply chain smoothness.*

2.2 Macroeconomic Infrastructure and National Competitiveness

Well-developed and efficient macroeconomic infrastructure, such as modern transportation networks and reliable energy systems, reduces operational costs for businesses (Hawker & Bell, 2020). It makes products and services more competitive in terms of pricing and availability in domestic and international markets (Camagni, 2017). A strong and reliable infrastructure network enables smoother trade within a country and across its borders (Ramasamy & Yeung, 2019). Efficient transportation, logistics, and communication infrastructure make it easier for businesses to access global markets and participate in international trade, enhancing national competitiveness (Gani, 2017). Countries with robust infrastructure are often more attractive to foreign investors (Donaubauer et al., 2016). Adequate infrastructure reduces operational risks and costs for foreign companies, making the host country more competitive in the eyes of international investors (An et al., 2021). Access to advanced technology and communication infrastructure fosters innovation and boosts productivity (Iqbal et al., 2023). A competitive edge in technology and innovation can significantly enhance a nation's competitiveness on the global stage. Macroeconomic infrastructure, such as educational and healthcare facilities, indirectly contributes to national competitiveness by ensuring the development of a healthy, skilled, and productive workforce. A well-prepared and adaptable infrastructure can help a nation weather economic challenges and crises more effectively, thus maintaining its competitiveness even in challenging times. In summary, macroeconomic infrastructure is a cornerstone of national competitiveness. A country's ability to compete in the global economy is closely tied to the quality, efficiency, and adequacy of its infrastructure. Robust infrastructure supports economic growth, attracts investment, reduces costs, and facilitates trade, all of which are critical components of national competitiveness. Therefore, investing in and maintaining a strong macroeconomic infrastructure is essential for a country's long-term competitiveness and economic success. Therefore, the hypothesis is as follows:

H_2: *Macroeconomic infrastructure influences national competitiveness.*

2.3 Macroeconomic Infrastructure and Country's Economic Growth

According to Khan et al. (2021), Country's Economic Growth refers to the sustained increase in the production and consumption of goods and services within a nation over a specified period. It is often measured by the growth in a country's Gross Domestic Product (GDP) and is a key indicator of a nation's overall economic health and development. The relationship between Macroeconomic Infrastructure and a Country's Economic Adequate infrastructure, such as well-maintained roads and transportation systems, enables businesses to operate efficiently (Razzaq et al., 2021; Wekesa et al., 2016). This efficiency leads to increased productivity, which is a significant driver of economic growth. Modern and efficient infrastructure helps reduce production costs for businesses (Ojah et al., 2022). Lower costs can lead to higher profit margins, which can, in turn, fuel investment, job creation, and overall economic growth (Dellink et al., 2017). A well-connected transportation and logistics network facilitates domestic and international trade. Easier access to markets can boost exports and imports, contributing to economic growth (Mohamad et al., 2015). Countries with robust infrastructure are often more attractive to domestic and foreign investors (M. A. Islam et al., 2020). Investments in infrastructure projects can create jobs, stimulate economic activity, and drive economic growth. Advanced technology and communication infrastructure support innovation and technological advancement. A nation's capacity for innovation can boost productivity and competitiveness, leading to economic growth. Infrastructure that includes education and healthcare facilities helps develop a skilled and healthy workforce, which is crucial for economic growth. Roach & Al-Saidi (2021) assert that a well-maintained and adaptable infrastructure can help a nation withstand economic shocks and adapt to changing circumstances, promoting long-term economic growth. Infrastructure development in rural and underserved regions can help reduce regional disparities and promote more inclusive economic growth. Macroeconomic infrastructure and a country's economic growth are intimately linked. Adequate and efficient infrastructure provides the foundation for economic activities, reduces costs, enhances productivity, and fosters innovation, all of which are critical factors in promoting economic growth. Investment in infrastructure projects and their maintenance is a strategic way for countries to stimulate and sustain economic development over the long term. Therefore, the hypothesis is as follows:

H_3: *Macroeconomic infrastructure influences country's economic growth.*

2.4 Supply Chain Smoothness and Country's Economic Growth

Shah and Naghi Ganji (2017) assess that Supply Chain Smoothness, refers to the efficiency and effectiveness of the processes involved in the procurement, production, distribution, and delivery of goods and services from suppliers to end consumers. A smooth supply chain is characterized by minimal disruptions, delays, and bottlenecks in the flow of materials, information, and products. It ensures that products are available when and where they are needed, reducing costs and improving customer

satisfaction. A smooth supply chain reduces operational inefficiencies and costs for businesses. This cost reduction can lead to improved profitability, increased investments, and overall economic growth. In addition, Kano et al. (2020) assert that businesses operating within a country with a smooth and efficient supply chain can produce goods and services more competitively, both domestically and internationally. Enhanced competitiveness can drive export growth, contributing to economic expansion. According to Uzir et al. (2021), A smooth supply chain ensures that products are consistently available to consumers. Higher product availability and on-time delivery can lead to increased customer satisfaction and loyalty, driving demand and economic growth. Efficient supply chains help companies optimize inventory levels. This reduces working capital tied up in inventory and improves cash flow, which can be invested in other growth initiatives. A well-functioning supply chain can enhance investor confidence in a country's business environment. This can attract domestic and foreign investments, fostering economic growth. A smooth supply chain can facilitate the timely introduction of new products and technologies to the market. Subhashini & Preetha (2018) explain that innovation can lead to increased productivity and revenue generation, driving economic growth. As supply chain activities expand and become more efficient, they often create jobs in transportation, logistics, warehousing, and related sectors. Job creation can boost consumer spending and contribute to economic growth. Improving supply chain infrastructure in less-developed regions can reduce regional disparities and promote balanced economic growth across the country. A smooth supply chain can be more resilient in the face of disruptions, such as natural disasters or supply chain disruptions. Enhanced resilience can help maintain economic stability and growth during challenging times. In summary, the smoothness of a country's supply chain is a critical factor in its economic growth. An efficient and well-managed supply chain can reduce costs, enhance competitiveness, boost customer satisfaction, attract investments, foster innovation, and create jobs—all of which contribute to overall economic growth and development. Therefore, policymakers and businesses often focus on improving supply chain operations as a strategic means to promote economic growth and sustainability. Therefore, the hypothesis is as follows:

H_4: *Supply Chain Smoothness influences country's economic growth.*

5.6 National Competitiveness and Country's Economic Growth

National Competitiveness refers to a country's ability to effectively participate in the global marketplace by producing goods and services efficiently, attracting investments, and sustaining economic growth (Camagni, 2017). It involves a combination of factors, including a skilled workforce, innovation capacity, business environment, and infrastructure (Kotabe & Kothari, 2016). According to Götz (2020), a competitive business environment that is conducive to entrepreneurship and investment can attract domestic and foreign businesses. This, in turn, leads to increased economic activity, job creation, and higher economic growth. Competitive nations often prioritize innovation and technology development. Investments in research and development, coupled with a culture of innovation, can lead to the creation of new industries and higher productivity, contributing to economic growth (Spigel & Harrison, 2018). Yue et al. (2021) and Göçer et al. (2022) argue that infrastructure that is well-developed and efficient, such as transportation networks and energy systems, reduces production costs, enhances logistics, and attracts businesses. This infrastructure can significantly impact a country's ability to compete globally and stimulate economic growth. A skilled and educated workforce is a critical component of national competitiveness. Education and training programs that produce a capable workforce contribute to higher productivity and, consequently, economic growth. Furthermore, Cooper's explain (2019) that competitive countries can more effectively participate in international trade. Export growth can stimulate economic expansion, as it leads to increased production, job opportunities, and foreign exchange earnings. Competitive nations tend to attract more foreign direct investments (FDI) due to favorable business environments, which can boost economic growth through capital infusion, technology transfer, and job creation (Gutola & Milos, 2022). In accordance with Howarth & Norgaard (2017), competitive countries often allocate resources more efficiently, ensuring that capital and labor are used optimally. This efficient allocation contributes to higher economic output and growth. Therefore, Rodrik (2018) assert that competitive nations are better equipped to adapt to economic challenges and crises. They can recover more swiftly from setbacks and maintain economic growth, even in adverse conditions. Promoting competitiveness in all regions of a country reduces regional disparities and promotes inclusive growth. This balanced growth can positively impact overall economic performance. National competitiveness allows countries to access a wider range of global markets. Enhanced access can lead to increased exports and foreign exchange earnings, further contributing to economic growth. In summary, national competitiveness and a country's economic growth are intrinsically linked. A competitive nation is more likely to experience sustained economic growth due to its ability to attract investments, foster innovation, develop infrastructure, and efficiently allocate resources. Policymakers often focus on enhancing national competitiveness as a strategic approach to drive economic growth and improve the overall quality of life for their citizens. Therefore, the hypothesis is as follows:

H_5: *National competitiveness influences country's economic growth.*

5.7 Supply Chain Smoothness and National Competitiveness as mediator

Macroeconomic infrastructure significantly impacts supply chain smoothness. Efficient infrastructure enables seamless logistics, reduced transportation times, and minimized disruptions in the supply chain. Smooth supply chains, in turn, lead to cost reductions, faster delivery times, and improved customer satisfaction for businesses. This increased efficiency and

customer satisfaction can translate into higher economic growth, as businesses become more competitive and profitable. Mediation by National Competitiveness: Macroeconomic infrastructure also plays a crucial role in a country's national competitiveness. An efficiently developed infrastructure reduces operational costs, enhances connectivity, and attracts investments, all of which enhance a nation's competitiveness on the global stage. Competitive countries are better positioned to engage in international trade, foster innovation, and stimulate economic growth. Therefore, the hypothesis is as follows:

H_6: *Supply chain smoothness mediates the relationship between macroeconomic infrastructure and country's economic growth.*
H_7: *National competitiveness mediates the relationship between macroeconomic infrastructure and country's economic growth.*

3. Methodology

The research methodology will employ a cross-sectional data analysis approach to investigate the influence of macroeconomic infrastructure on supply chain smoothness, national competitiveness, and economic growth in the BRICS countries within the data range of 2010 to 2022 (Suseno & Basrowi, 2023). Firstly, we will select relevant key variables, including macroeconomic infrastructure indicators (infrastructure investment), supply chain smoothness, national competitiveness, and economic growth indicators (Suseno et al., 2018). Data sources will be sourced from various international institutions and government data sources that have compiled this data within the specified time frame (Mustofa et al., 2023). The cross-sectional data analysis will involve collecting data at a single point in time (cross-section) for each BRICS country within the same time frame (Basrowi & Maunnah, 2019). This data will be collected from various sources such as economic databases, statistical reports, and other open data sources (Marwanto et al., 2020). Subsequently, cross-sectional regression analysis will evaluate the relationships between these variables. Factors such as macroeconomic variables and policy changes will be considered in the analysis to ensure the validity of the results. This research will enable comparisons among the BRICS countries at a single point in time to understand differences and similarities in the impact of macroeconomic infrastructure (Soenyono & Basrowi, 2020). The analysis results will be interpreted and used to conclude the relationships between macroeconomic infrastructure, supply chain smoothness, national competitiveness, and economic growth at the specified point in time (Suwarno et al., 2020). Furthermore, the research findings will serve as the basis for formulating policy recommendations to assist the BRICS countries in enhancing their infrastructure, supply chain smoothness, national competitiveness, and economic growth within the context of the cross-sectional data used in this study (Basrowi & Utami, 2020).

4. Results

4.1 Descriptive analysis

The primary objective of conducting descriptive analysis within the framework of the study is to systematically and comprehensively explore and present critical data about macroeconomic infrastructure, supply chain efficiency, national competitiveness, and economic growth in the context of the BRICS nations – Brazil, Russia, India, China, and South Africa. Descriptive analysis serves as a fundamental step in this research endeavor, with several specific aims:

Firstly, it strives to enhance data comprehension. By undertaking descriptive analysis, the researchers aim to develop a profound familiarity with the dataset, allowing for a nuanced understanding of the intricacies associated with macroeconomic infrastructure, supply chain dynamics, competitiveness indicators, and economic growth metrics in each of the BRICS countries. Secondly, descriptive analysis involves data description. It entails the systematic summarization and portrayal of the dataset's central attributes. Researchers calculate and present various descriptive statistics for the dataset's variables, including metrics related to the quality of infrastructure, efficiency within supply chains, rankings that reflect national competitiveness, and economic growth indicators. These statistical summaries concisely represent the data's central tendencies, variability, and distribution.

Additionally, data visualization forms an integral part of descriptive analysis. By creating visual representations such as charts, graphs, and tables, the researchers make the dataset more accessible, enabling stakeholders to discern patterns and variances within the data readily. These visual aids serve as powerful tools for identifying initial relationships and trends. Furthermore, descriptive analysis facilitates cross-country comparisons. Conducting descriptive analyses for each of the BRICS nations permits a comprehensive assessment of the state of macroeconomic infrastructure, supply chain performance, national competitiveness, and economic growth across these countries. This comparative analysis helps highlight both commonalities and disparities among them. Descriptive analysis offers preliminary insights into potential associations or correlations between macroeconomic infrastructure, supply chain smoothness, national competitiveness, and economic growth within the BRICS countries. These initial findings lay the groundwork for more in-depth inferential analyses, further exploring the causal relationships and nuanced dynamics underlying these critical variables. In essence, this study's overarching goal of descriptive analysis is to furnish a well-structured and data-driven overview of the critical variables under examination within the context of the BRICS nations. This foundational analysis serves as the cornerstone for subsequent, more comprehensive inferential analyses, enabling a deeper understanding of how macroeconomic infrastructure influences supply chains, competitiveness,

and economic growth across these diverse countries. The provided dataset in Table 1 offers insights into the economic performance and competitiveness of five countries—Brazil, the Russian Federation, India, China, and South Africa—across several key indicators over the years. These indicators include Infrastructure Investment (% of GDP), Supply Chain Smoothness (Score), National Competitiveness (Score), and Economic Growth (%).

- Infrastructure Investment: Among these countries, India recorded the highest level of infrastructure investment as a percentage of GDP in 2021 (7.00%), followed by Brazil (5.00%), China (4.00%), the Russian Federation (4.00%), and South Africa (3.00%). These figures demonstrate variations in the commitment to infrastructure development across the countries, with India leading.
- Supply Chain Smoothness (Score): China consistently maintained the highest supply chain smoothness scores, starting at 7.30 in 2010 and gradually declining to 6.10 in 2022. India also maintained relatively stable supply chain smoothness scores, hovering around 4.00. Brazil and the Russian Federation exhibited slight fluctuations but generally maintained scores around 4.00, while South Africa reported lower supply chain smoothness scores, declining from 3.80 in 2010 to 2.60 in 2022.
- National Competitiveness (Score): China consistently led in national competitiveness scores, starting at 4.74 in 2010 and increasing to 59.43 in 2022. India closely followed China in competitiveness scores, with gradual increases from 4.30 in 2010 to 41.56 in 2022. Brazil and the Russian Federation maintained relatively stable competitiveness scores, mostly around 4.00. However, South Africa exhibited a notable decline in competitiveness scores, decreasing from 4.34 in 2010 to 32.26 in 2022.
- Economic growth (%): India consistently reported positive economic growth, with the highest at 8.70% in 2022 and the lowest at 0.10% in 2015. China also maintained steady economic growth, from 2.30% in 2020 to 10.30% in 2010. Brazil and the Russian Federation experienced fluctuations in economic growth, with some years of negative growth. Brazil's growth ranged from -4.10% in 2020 to 7.50% in 2010, while Russia's Growth ranged from -7.80% in 2022 to 4.00% in 2010. South Africa showed modest economic growth, ranging from -6.50% in 2020 to 4.00% in 2011 and 2021.

In summary, the data highlights variations in infrastructure investment, supply chain smoothness, competitiveness, and economic growth across these countries. China and India often lead in different aspects, with India showing significant infrastructure investment and economic growth, while China excels in supply chain smoothness and competitiveness. Brazil and the Russian Federation maintain stability in several indicators, and South Africa faces challenges in competitiveness and economic growth. These insights provide a comprehensive view of the economic dynamics within these nations.

4.2 Hypothesis testing

Hypothesis testing plays a pivotal role in the research. This statistical technique enables the study to assess and validate hypotheses regarding the relationships between macroeconomic infrastructure, supply chain smoothness, national competitiveness, and economic growth in BRICS countries. By subjecting these hypotheses to empirical scrutiny, the research aims to provide evidence-based insights that can inform policy decisions and contribute to a comprehensive understanding of how macroeconomic infrastructure impacts a country's economic performance and competitiveness within the BRICS group. Table 2 presents the results of hypothesis testing in the study, establishing relationships between specific constructs: INFRA (Macroeconomic Infrastructure), SCS (Supply Chain Smoothness), NACOM (National Competitiveness), and CEG (Country's Economic Growth). The findings indicate that H1, H2, and H3 are accepted, signifying significant connections between INFRA and SCS, NACOM, and CEG, respectively. These relationships exhibit high T-statistics (5.720, 2.845, and 6.176) and extremely low P-values (0.000, 0.005, and 0.000, respectively), affirming their statistical significance. Conversely, H4, H5, H6, and H7 are rejected, implying that there is no substantial relationship between SCS or NACOM with CEG (T-statistics of 0.314 and 0.596, respectively), and including INFRA as a mediator in the links between INFRA and CEG or between INFRA and NACOM does not yield statistically significant effects (T-statistics of 0.292 and 0.541, respectively). In summary, the results underscore the pivotal role of INFRA in influencing SCS, NACOM, and CEG while suggesting that SCS, NACOM, or INFRA as mediators do not significantly contribute to the associations between INFRA and CEG or INFRA and NACOM.

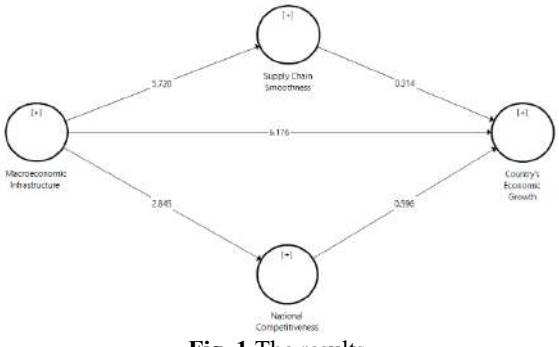

Fig. 1 The results

Table 2
Hypothesis result

Hypothesis	Construct*)	Original Sample	STDEV	T Statistics	P Values	Result
H1	INFRA → SCS	0.610	0.107	5.720	0.000	Accepted
H2	INFRA → NACOM	-0.234	0.082	2.845	0.005	Accepted
H3	INFRA → CEG	0.725	0.117	6.176	0.000	Accepted
H4	SCS → CEG	-0.038	0.122	0.314	0.754	Rejected
H5	NACOM → CEG	0.074	0.123	0.596	0.552	Rejected
H6	INFRA → SCS → CEG	-0.023	0.08	0.292	0.771	Rejected
H7	INFRA → NACOM → CEG	-0.017	0.032	0.541	0.589	Rejected

*) INFRA=Macroeconomic Infrastructure; SCS=Supply Chain Smoothness; NACOM=National Competitiveness; CEG=Country's Economic Growth

5. Discussion

The acceptance of H1, which posits that "Macroeconomic infrastructure influences on supply chain smoothness", is a significant milestone in the research, as it signifies a robust and statistically supported relationship between a nation's macroeconomic infrastructure and the smooth operation of its supply chains. The statistical analysis conducted in the study has yielded compelling evidence in favor of this hypothesis, with a notably high T-statistic of 5.720 and an exceedingly low P-value of 0.000. These statistical indicators underscore the strength and significance of the association, providing clear empirical support for the idea that the quality and adequacy of a country's macroeconomic infrastructure substantially impacts the efficiency and smoothness of its supply chain activities. This finding has substantial implications for policymakers, business leaders, and stakeholders. It underscores the critical role of macroeconomic infrastructure, including transportation, communication, and energy networks, in facilitating the seamless movement of goods and services within a country's supply chain. Efficient supply chains, as indicated by their smoothness, are known to reduce operational costs, minimize delays, enhance reliability, and ultimately bolster a nation's overall competitiveness in the global market. Furthermore, the acceptance of H1 emphasizes the importance of prioritizing investments in macroeconomic infrastructure development to enhance supply chain performance. Countries that recognize and address deficiencies in their infrastructure are likely to reap the benefits of smoother supply chain operations, which can, in turn, lead to improved national competitiveness and sustainable economic growth. In conclusion, the acceptance of H1 serves as empirical validation for the critical role of macroeconomic infrastructure in influencing supply chain smoothness, shedding light on the intricate interplay between infrastructure, supply chain efficiency, and a nation's economic competitiveness. It underscores the need for strategic infrastructure investments to foster robust supply chains and economic growth.

The acceptance of H2, albeit with a negative direction, which asserts that "Macroeconomic infrastructure influences national competitiveness", is an intriguing finding, particularly in the context of BRICS countries. The BRICS nations, Brazil, Russia, India, China, and South Africa, represent a diverse group with varying economic development and infrastructure maturity levels. In the BRICS context, this result prompts a deeper examination of the specific dynamics at play within these nations. While improved macroeconomic infrastructure is generally considered essential for economic growth and competitiveness, the negative relationship in this study suggests that the impact of infrastructure development on national competitiveness may be complex. It highlights the importance of assessing infrastructure investments in a nuanced manner, accounting for factors unique to each BRICS country. For example, some BRICS countries may have encountered challenges related to inefficient allocation of infrastructure resources, regulatory bottlenecks, or inadequate infrastructure asset utilization. The findings may also reflect the complexities of infrastructure development in rapidly changing economic environments, such as those seen in BRICS nations. As such, the acceptance of H2 with a negative direction in the BRICS context underscores the need for tailored approaches to infrastructure planning and development within these countries. Policymakers and stakeholders should carefully consider each BRICS nation's specific challenges and opportunities to ensure that infrastructure investments contribute positively to their national competitiveness in the global arena. Moreover, it emphasizes the importance of further research to delve deeper into the intricate relationship between infrastructure and competitiveness within the BRICS context. It recognizes that a one-size-fits-all approach may not suit this diverse group of nations.

The acceptance of H3, which posits that "Macroeconomic infrastructure influences a country's economic growth", is a significant finding with far-reaching implications, particularly in the context of the BRICS nations—Brazil, Russia, India, China, and South Africa. These countries represent diverse economic landscapes and varying levels of infrastructure development within the group. The acceptance of H3 underscores the vital role played by macroeconomic infrastructure in shaping a nation's economic growth trajectory. In the BRICS context, this result resonates deeply as these countries are characterized by their rapid economic expansion and dynamic development. It highlights that investments in macroeconomic infrastructure, encompassing transportation networks, energy supply, and communication systems, can positively and statistically significantly impact a country's economic growth. The statistical analysis, revealing a high T-statistic of 6.176 and an exceptionally low P-value of 0.000, reinforces the robustness of this relationship. For policymakers and stakeholders in BRICS nations, this finding holds profound implications. It emphasizes prioritizing infrastructure development as a catalyst

for economic growth and prosperity. Effective and strategic investments in infrastructure can lead to enhanced trade, increased productivity, reduced transaction costs, and improved overall competitiveness, which are critical factors in driving economic expansion within the BRICS group. Furthermore, the acceptance of H3 also suggests that BRICS countries can leverage their existing infrastructure assets and invest in targeted improvements to foster sustained economic growth. However, it is essential to recognize that the impact of infrastructure development may vary among BRICS nations due to their unique economic structures and challenges. Therefore, tailored infrastructure policies and investment strategies that align with each country's specific needs and goals are imperative. In conclusion, the acceptance of H3 in the context of BRICS countries reaffirms the pivotal role of macroeconomic infrastructure in driving economic growth. It underscores the potential for these nations to harness the power of infrastructure development as a catalyst for sustainable and inclusive economic advancement while also emphasizing the importance of context-specific strategies to maximize the benefits of such investments within the diverse landscape of the BRICS group.

The rejection of H4, H5, H6, and H7 bears significant implications, particularly in the context of the BRICS nations—Brazil, Russia, India, China, and South Africa. These hypotheses, which explored the relationships between various constructs, provide insights into the intricate dynamics between macroeconomic infrastructure, supply chain smoothness, national competitiveness, and economic growth within the BRICS group.

H4, which posited that “Supply Chain Smoothness influences a country's economic growth”, was not supported by the statistical analysis. It suggests that, contrary to expectations, the smoothness of supply chain operations does not exhibit a statistically significant direct impact on a country's economic growth within the BRICS context. This finding prompts a closer examination of the factors influencing economic growth within these nations, which may be more complex and multifaceted. Similarly, H5, which suggested that "National competitiveness influences a country's economic growth," was also rejected. It implies that the direct influence of national competitiveness on economic growth, as measured in the study, is not statistically significant among the BRICS countries. This outcome underscores the need to explore additional factors and contextual nuances that may contribute to economic growth within this diverse group.

Furthermore, H6 and H7, which examined the mediating roles of supply chain smoothness and national competitiveness in the relationship between macroeconomic infrastructure and economic growth, were both rejected. These findings imply that, within the BRICS nations, these mediating factors do not significantly alter the relationship between macroeconomic infrastructure and economic growth. It underscores the need for a more nuanced understanding of how these variables interact in the specific context of BRICS countries.

In the context of BRICS, these results collectively emphasize the complexity of the factors influencing economic growth. While macroeconomic infrastructure is acknowledged as a crucial determinant of economic performance, its impact may be influenced by a multitude of factors beyond the scope of this study. These findings call for further research and a deeper exploration of the specific drivers of economic growth within each BRICS country, recognizing that a one-size-fits-all approach may not apply to this diverse group. In conclusion, rejecting H4, H5, H6, and H7 within the BRICS context underscores the intricate nature of economic growth dynamics within these nations. It highlights the need for tailored and context-specific approaches to understanding and fostering economic growth in the BRICS group, recognizing that a deeper exploration of the multifaceted factors at play is essential for informed policymaking and strategic decision-making.

6. Conclusion

This study delved into the intricate relationships between macroeconomic infrastructure, supply chain smoothness, national competitiveness, and economic growth within the BRICS nations (Brazil, Russia, India, China, and South Africa). The analysis revealed several crucial findings. First, the research accepted H1, indicating that macroeconomic infrastructure significantly influences supply chain smoothness. Robust statistical evidence supported this relationship, highlighting the importance of infrastructure in enhancing supply chain efficiency. As indicated by their smoothness, efficient supply chains reduce operational costs and enhance a nation's global competitiveness. Second, H2 was accepted, albeit with a negative direction, suggesting that macroeconomic infrastructure influences national competitiveness, but the relationship is complex within BRICS countries. This finding underscores the need for nuanced approaches to infrastructure development, recognizing the unique challenges faced by each nation. Third, H3 was accepted, emphasizing that macroeconomic infrastructure significantly influences a country's economic growth. The robust statistical evidence underscores the pivotal role of infrastructure in shaping economic growth within the diverse BRICS group. However, H4 and H5, which proposed direct links between supply chain smoothness, national competitiveness, and economic growth, were rejected. It implies that these relationships are not statistically significant in the BRICS context, emphasizing the complexity of economic growth dynamics within these nations. Furthermore, H6 and H7, which explored the mediating roles of supply chain smoothness and national competitiveness, were rejected. These findings suggest that these mediating factors do not significantly alter the relationship between macroeconomic infrastructure and economic growth in BRICS countries.

This study highlights the critical role of macroeconomic infrastructure in enhancing supply chain smoothness and driving economic growth within BRICS countries. It underscores the need for tailored infrastructure strategies considering each

nation's unique circumstances. While supply chain smoothness, national competitiveness, and direct links to economic growth were not supported, the study calls for further research to explore the multifaceted factors influencing economic growth within the diverse landscape of the BRICS group. This nuanced understanding is essential for informed policymaking and strategic decision-making in these rapidly developing nations.

Theoretical and practical implications

The study's theoretical contributions are significant. It reaffirms the importance of macroeconomic infrastructure in enhancing supply chain efficiency and fostering economic growth, aligning with existing literature. However, rejecting other hypotheses prompts a reconsideration of the direct relationships between supply chain smoothness, national competitiveness, and economic growth within the BRICS context. It highlights the need for a more nuanced theoretical framework that accounts for contextual factors specific to each BRICS country. From a practical standpoint, the research findings offer valuable insights for policymakers, business leaders, and stakeholders in BRICS countries. The positive influence of macroeconomic infrastructure on supply chain efficiency underscores the importance of strategic infrastructure investments. Additionally, the non-significant direct relationships revealed by the rejected hypotheses suggest that enhancing national competitiveness and achieving economic growth within the BRICS group may require more comprehensive strategies that extend beyond these isolated factors. Policymakers should consider tailored approaches to infrastructure development, economic policy, and competitiveness enhancement that align with the unique characteristics of each BRICS nation.

Limitations and recommendations

Despite the valuable insights provided, this study has certain limitations. First, it focuses on a limited set of variables, and economic growth is a multifaceted phenomenon influenced by numerous factors beyond the scope of this research. Future studies should consider broader variables to gain a more comprehensive understanding of economic growth within BRICS countries. Second, the study assumes linear relationships between constructs, which may need to be more accurate in the intricate dynamics of economic growth. Future research could explore nonlinear relationships and investigate potential threshold effects. Third, the research needs to delve deeper into country-specific nuances within the BRICS group. Conducting more granular analyses for each nation could yield valuable insights tailored to individual contexts.

In conclusion, this study offers important theoretical and practical contributions regarding the impact of macroeconomic infrastructure on supply chain efficiency and economic growth within the BRICS nations. However, it also underscores the complexity of economic growth dynamics and highlights the need for further research and nuanced approaches to address the unique challenges and opportunities within each BRICS country.

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Appendix

Table 1A.
Descriptive analysis

Countries	Years	Infrastructure investment (%)	Supply Chain Smoothness (Score)	National Competitiveness (Score)	Economy Growth (%)
Brazil	2010	4.00	4.00	4.23	7.50
	2011	4.00	4.10	4.28	4.70
	2012	4.00	4.20	4.27	0.90
	2013	4.00	4.30	4.40	-3.80
	2014	4.00	4.40	4.33	-1.40
	2015	4.00	4.50	4.34	0.10
	2016	4.00	4.60	4.08	0.80
	2017	4.00	4.70	4.06	1.00
	2018	4.00	4.80	4.14	1.80
	2019	4.00	4.90	37.60	4.10
	2020	4.00	5.00	37.60	-4.10
	2021	4.00	5.10	38.21	3.20
	2022	4.00	5.20	38.59	0.50
Russian Federation	2010	4.00	3.90	4.15	4.00
	2011	4.00	3.90	4.24	4.00
	2012	4.00	3.90	4.19	2.00
	2013	4.00	3.90	4.20	1.30
	2014	4.00	3.90	4.25	-0.40
	2015	4.00	3.90	4.37	-2.80
	2016	4.00	3.90	4.44	0.30
	2017	4.00	3.90	4.51	1.50
	2018	4.00	3.90	4.64	2.30
	2019	4.00	3.90	35.84	2.00
	2020	4.00	3.90	35.84	-3.00
	2021	4.00	3.90	36.23	4.70
	2022	4.00	3.90	36.60	-7.80
India	2010	6.00	4.20	4.30	8.00
	2011	6.00	4.10	4.33	6.50
	2012	6.00	4.00	4.31	5.00
	2013	6.00	3.90	4.32	7.40
	2014	6.00	3.80	4.28	7.00
	2015	6.00	3.70	4.21	7.60
	2016	6.00	3.60	4.31	7.10
	2017	6.00	3.50	4.52	6.70
	2018	6.00	3.40	4.59	7.30
	2019	5.00	3.30	40.89	4.20
	2020	3.00	3.20	40.89	-2.30
	2021	7.00	3.10	41.22	8.70
	2022	6.00	3.00	41.56	8.70
China	2010	10.00	7.30	4.74	10.30
	2011	9.00	7.20	4.84	9.20
	2012	9.00	7.10	4.82	7.80
	2013	9.00	7.00	4.83	7.70
	2014	8.00	6.90	4.84	7.30
	2015	7.00	6.80	4.89	6.90
	2016	7.00	6.70	4.89	6.70
	2017	7.00	6.60	4.95	6.80
	2018	5.00	6.50	5.00	6.60
	2019	4.00	6.40	58.38	6.10
	2020	3.00	6.30	58.38	2.30
	2021	4.00	6.20	58.58	8.10
	2022	4.00	6.10	59.43	4.80
South Africa	2010	3.00	3.80	4.34	2.50
	2011	3.00	3.70	4.32	3.20
	2012	3.00	3.60	3.31	2.50
	2013	3.00	3.50	4.37	1.50
	2014	3.00	3.40	4.37	1.30
	2015	3.00	3.30	4.35	-0.70
	2016	3.00	3.20	4.39	-0.30
	2017	3.00	3.10	4.47	1.30
	2018	3.00	3.00	4.32	0.80
	2019	3.00	2.90	31.61	1.50
	2020	3.00	2.80	31.61	-6.50
	2021	3.00	2.70	31.88	4.00
	2022	3.00	2.60	32.26	2.50

Source: World Economic Forum, 2023