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Impact of Infrastructure on Economic Growth: Evidence from G20 Countries

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ABSTRACT

This study investigates the impact of infrastructure investment on economic growth in G20 countries, with emphasis on both its direct and indirect effects through supply chain efficiency and national competitiveness. While existing literature has examined these relationships in various contexts, few studies have addressed them comprehensively within the G20, which collectively represents a substantial share of global GDP and trade. Using SEM-PLS and data from 2019–2023, the findings reveal that infrastructure investment has a statistically significant positive effect on economic growth. However, the indirect effects via supply chain efficiency and competitiveness are statistically insignificant, suggesting complexity in the transmission mechanisms. These results provide valuable insights for infrastructure policy and highlight the need for targeted strategies to enhance infrastructure utility and supply chain integration. This study contributes to the literature by providing empirical evidence from major economies and informing future infrastructure planning in global economic forums.

JEL Classification: H54, O47, O52, B41

Keywords: Infrastructure Investment; Supply Chain Efficiency; National Competitiveness; Economic Growth; G20 Countries

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INTRODUCTION

Macroeconomic infrastructure plays a pivotal role in the economic growth of a nation (Kodongo and Ojah, 2016). Several studies highlight that infrastructure facilitates the smooth flow of supply chains and enhances overall production capacity (Shah and Naghi Ganji, 2017). Supply chain efficiency refers to the effectiveness of the processes involved in the procurement, production, distribution, and delivery of goods and services from suppliers to end consumers (Alexandro and Basrowi, 2024). It is characterized by minimal disruptions, delays, and bottlenecks in the flow of materials, information, and products. National competitiveness, in turn, refers to a country's ability to participate effectively in global markets by producing goods, providing services efficiently, attracting investment, and sustaining economic growth. This involves a combination of factors, including a skilled workforce, innovation capacity, the business environment, and infrastructure (Capello, 2017).

This study aims to explore the dual impact of macroeconomic infrastructure on economic growth in G20 countries, focusing on both its direct effects and its indirect effects through improved supply chain efficiency and national competitiveness. The G20 consists of 19 countries and the European Union, collectively representing over 60% of the global population, 75% of global trade, and 80% of world GDP (Papava, 2022). As a multilateral platform for economic cooperation, the G20 plays a crucial role in shaping global economic policies and offers a unique setting for analysing the impact of infrastructure investments on economic growth in a global context. Despite extensive research on the effects of macroeconomic infrastructure on growth, supply chain efficiency, and competitiveness, there remains a notable gap in studies specifically focused on G20 countries. While much scholarly attention has been directed towards regions such as BRICS (Brazil, Russia, India, China, and South Africa), the G20 presents a distinct context due to its diverse economic structures, infrastructure needs, and central role in global trade. This research aims to fill this gap by examining the influence of infrastructure investment on economic growth within the G20 framework, offering comparative insights that are vital for policymaking in these major economies.

The research gap identified by Alexandro and Basrowi (2024) explores the influence of intermediary variables on macroeconomic infrastructure, supply chain efficiency, national competitiveness, and economic growth in BRICS countries. Despite extensive research on the impact of macroeconomic infrastructure on economic growth, supply chain efficiency, and competitiveness, there remains limited research specifically focusing on BRICS. The novelty of this study lies in its comparative perspective on the impact of infrastructure on economic growth among G20 countries. It aims to deepen understanding of the role of macroeconomic infrastructure within the G20 context. In addition, the study supports the exploration of similarities and differences in how infrastructure influences production, supply chain efficiency, and overall economic growth. By providing empirical evidence, it contributes to the literature on the role of macroeconomic infrastructure in G20 countries, offering insights into how infrastructure shapes economic outcomes through supply chain efficiency and national competitiveness. The findings are expected to inform infrastructure policymaking and strengthen the global competitiveness of G20 nations.

LITERATURE REVIEW

Economic growth remains a central objective for both developing and developed countries, particularly within the G20, which represents a wide spectrum of economic contexts. Quality economic growth is essential for improving national welfare (Kartini et al., 2023; Son and Kakwani, 2008). According to the Solow-Swan model (1956), economic growth is largely driven by capital accumulation, including infrastructure, which enhances productivity and reduces transaction costs. Fogel et al. (2013) emphasize the long-term importance of infrastructure in enabling the delivery of goods and services. However, without innovation and structural transformation, such gains may diminish over time. Romer (1990) endogenous growth theory extends this understanding by highlighting infrastructure's role in fostering innovation, particularly through digital transformation. High-speed internet and modern communication systems enhance productivity and strengthen market connectivity. In G20 countries, physical and digital infrastructure work hand in hand to drive growth. Developed members rely on advanced infrastructure to maintain competitiveness and foster innovation, while emerging economies depend on it to overcome structural constraints and attract investment. Thus,

infrastructure is not only a driver of productivity but also a catalyst that shapes two key dimensions relevant to G20 economic growth: supply chain efficiency and national competitiveness. These relationships form the foundation for this study's conceptual framework.

Supply chain efficiency reflects the extent to which infrastructure enables timely procurement, production, and distribution (Alexandro and Basrowi, 2024). Adequate transportation networks, energy access, and ICT infrastructure are essential to reduce logistical costs and delays. Shah and Naghi Ganji (2017) argue that poor infrastructure creates bottlenecks that increase costs and lower productivity, whereas efficient systems reduce trade friction and enhance performance. Several studies have examined the impact of infrastructure on economic development. For instance, Toader et al. (2018) show that ICT infrastructure enhances economic performance in the EU, although its impact varies depending on the level of digital maturity. This suggests that G20 countries may experience uneven outcomes due to diverse technological capabilities. The need to synchronize physical and digital infrastructure is therefore critical in the global supply chain environment. However, infrastructure development may also influence supply chain efficiency. For example, Moore and Glean (2016) highlight how poorly planned or uncoordinated projects can disrupt existing logistics networks. This issue is especially relevant in rapidly developing G20 economies, where infrastructure upgrades may lag behind supply chain modernization. Accordingly, this study considers supply chain efficiency as a mediating variable through which infrastructure investment may—or may not—enhance economic growth.

National competitiveness refers to a country's ability to produce goods and services efficiently, attract investment, and sustain economic growth within a competitive global market. Efficient infrastructure development supports national competitiveness by lowering production and distribution costs, improving product quality, and accelerating innovation. Capello (2017) shows a positive relationship between infrastructure and competitiveness, as infrastructure improves operational efficiency and attracts investment. In G20 countries, those with robust infrastructure gain a competitive advantage in global markets, while those with underdeveloped systems struggle to compete. For instance, empirical research by Kodongo and Ojah (2016) found infrastructure to be crucial for enhancing competitiveness in Sub-Saharan Africa. Similarly, Alexandro and Basrowi (2024) highlight that macroeconomic infrastructure in BRICS countries improves competitiveness through smoother supply chains. However, G20 countries differ significantly from BRICS in terms of institutional development and infrastructure maturity. In mature economies, rapid infrastructure expansion may yield diminishing returns or encounter policy inefficiencies. Political and administrative factors can also limit the effectiveness of infrastructure investment in enhancing competitiveness. Therefore, in the G20 context, this relationship may be complex—potentially negative or insignificant if investments are not aligned with national priorities or are poorly executed. The use of fact-based metrics can provide reliable evaluation standards, measure policy effects, and facilitate global comparisons in logistics performance (Jaramillo et al., 2018).

Efficient supply chains are expected to play a pivotal role in supporting economic growth by reducing delivery times, minimizing operational and transaction costs, and facilitating broader market access for goods and services. As a dynamic and interconnected system, the supply chain constitutes the backbone of global trade and production networks, enabling the timely movement of raw materials, intermediate goods, and final products across borders (Akhter et al., 2018). Its efficiency directly influences a country's competitiveness and productivity, particularly in economies that are highly integrated into global value chains. Queiroz and Farias Pereira (2019) highlight that global supply chains are continually evolving in response to technological advancements, shifting trade policies, and changing consumer demands. These changes necessitate constant adaptation and innovation to maintain competitive advantage. For G20 countries, many of which already possess advanced logistical infrastructure, the challenge lies not only in ensuring physical connectivity but also in modernizing regulatory frameworks and harmonizing fragmented policies. Outdated customs procedures, misaligned standards, and weak coordination among national and regional logistics authorities continue to generate significant supply chain inefficiencies.

Allahham et al. (2024) emphasize the growing importance of integrating big data analytics and artificial intelligence (AI) into supply chain management to predict disruptions, optimize routes, and mitigate risks. These technologies strengthen real-time decision-making and resilience, which are increasingly critical amid global uncertainties such as pandemics, geopolitical tensions, and climate-related disruptions. Consequently, supply chain efficiency should not be regarded solely as a logistical concern; it is equally a

matter of forward-looking policy design and technological preparedness. Within this context, the present study hypothesizes that the effect of infrastructure on economic growth may be contingent on its capacity to enhance supply chain performance. In economies with high levels of trade integration, this relationship becomes even more pronounced. Infrastructure investments that fail to address bottlenecks in coordination, information flow, and regulatory efficiency risk yielding suboptimal growth outcomes. Conversely, infrastructure that enables seamless, adaptive, and technology-enabled supply chains is likely to amplify positive economic impacts, particularly in globally connected sectors.

A country's competitiveness plays a critical role in shaping its economic trajectory by influencing its capacity to attract foreign direct investment, generate employment opportunities, and foster innovation-driven growth (Hämäläinen, 2003). In the context of the G20—an economic forum comprising both advanced and emerging economies—competitiveness serves as a strategic lever for sustaining global economic leadership and resilience. For instance, Abdillah (2018) underscores Indonesia's commitment to enhancing productivity and competitiveness as a key national priority, aligning with its constitutional mandates and long-term development strategies. This reflects a broader recognition among G20 members that strengthening competitiveness is essential for overcoming structural bottlenecks, reducing economic vulnerability, and integrating more effectively into global value chains. However, the relationship between competitiveness and economic performance is not always linear. In economies that have already achieved relatively high levels of competitiveness, the marginal gains in GDP may be limited unless complemented by continuous innovation, adaptive policy reforms, and institutional efficiency.

Melara Gálvez and Morales Fernández (2022) provide empirical evidence from Central America, where competitiveness scores improved significantly prior to the COVID-19 pandemic, yet such improvements did not consistently translate into substantial economic gains. This finding underscores a critical insight: while competitiveness is a necessary condition for growth, it is not sufficient—particularly in structurally diverse and institutionally heterogeneous economies such as those in the G20. Building on this insight, the present study hypothesizes that competitiveness may function as a partial mediator in the relationship between infrastructure development and economic growth. Specifically, while infrastructure—both physical and digital—directly contributes to economic performance, its full impact may be transmitted through improvements in national competitiveness, which in turn enhances productivity, investment attractiveness, and innovation potential. This mediating role is particularly relevant for policy discussions aimed at maximizing the returns on infrastructure investments in both advanced and emerging G20 economies.

Infrastructure directly influences supply chain efficiency, which subsequently affects economic growth. Shah and Naghi Ganji (2017) demonstrate that inadequate infrastructure leads to supply chain disruptions, escalating costs and reducing productivity. Conversely, improved infrastructure facilitates the smooth flow of goods, reduces trade barriers, and enhances market access, thereby supporting economic expansion. Reliable transportation networks—such as ports, airports, and highways—shorten delivery times and minimize delays, making supply chains more responsive to market needs. Similarly, efficient energy and telecommunications systems provide the foundation for industrial production and digital trade, which are increasingly vital in a globalized economy. In many developing countries, infrastructure bottlenecks remain key obstacles that prevent local businesses from competing internationally, as high logistics costs undermine export competitiveness and limit domestic industrial scaling. In contrast, countries that invest heavily in infrastructure frequently experience multiplier effects, where each dollar spent not only generates employment but also stimulates innovation, attracts investment, and fosters regional integration. Furthermore, modern infrastructure strengthens supply chain resilience, enabling firms to adapt rapidly to disruptions such as natural disasters or pandemics. Thus, infrastructure should be understood not merely as physical assets but as strategic enablers of economic transformation. Integrated planning that links transportation, logistics, and digital systems is essential to ensure supply chains remain competitive, inclusive, and sustainable.

National competitiveness refers to a country's ability to produce goods and services efficiently, attract investment, and sustain long-term growth in the global economy. Improved infrastructure reduces production costs, accelerates the distribution of goods and services, and facilitates innovation and productivity gains. Within the G20 context, nations with advanced infrastructure achieve competitive advantages that support innovation and expand production capacity, ultimately driving economic growth. Greater competitiveness attracts foreign investment, introduces advanced technologies, and expands market access, thereby

accelerating economic development. This study will explore the role of infrastructure in shaping national competitiveness in G20 countries and how this relationship, in turn, drives economic expansion.

Synthesis and Hypotheses Development

The integrated review of existing literature demonstrates that infrastructure investment influences economic growth not only through direct channels—by expanding productive capacity and improving market access—but also indirectly through two key mediating variables: supply chain efficiency and national competitiveness. These relationships are particularly salient in the diverse economic environments of G20 countries, where infrastructure effectiveness is shaped by institutional, technological, and regulatory conditions. To empirically examine these relationships, this study formulates the following seven hypotheses:

H1: Infrastructure has a direct effect on the economic growth of G20 countries.
H2: Infrastructure has a direct effect on the national competitiveness of G20 countries.
H3: Infrastructure has a direct effect on the supply chain efficiency of G20 countries.
H4: Supply chain efficiency has a direct effect on the economic growth of G20 countries.
H5: National competitiveness has a direct effect on the economic growth of G20 countries.
H6: Infrastructure has an indirect effect on economic growth through the supply chain efficiency of G20 countries.
H7: Infrastructure has an indirect effect on economic growth through national competitiveness in G20 countries.

Although numerous studies have examined the relationship between infrastructure and economic growth, much of the existing research has concentrated on developing economies or specific groups such as the BRICS. Research explicitly investigating the impact of infrastructure on economic growth within the G20 context remains limited. The G20 encompasses countries with highly diverse economic structures, varying levels of infrastructure development, and differing policy environments, which necessitates a comprehensive analytical approach. This study seeks to address this gap by providing a comparative analysis of how macroeconomic infrastructure influences economic growth, supply chain efficiency, and national competitiveness across G20 economies. The findings are expected to generate new insights into the role of infrastructure in enhancing economic efficiency and strengthening the global competitiveness of G20 countries in international markets.

METHODOLOGY AND DATA

This research employs Structural Equation Modelling with Partial Least Squares (SEM-PLS) to examine the influence of macroeconomic infrastructure on supply chain efficiency, national competitiveness, and economic growth among G20 countries. SEM-PLS is a component-based, variance-based modelling technique used to empirically confirm and test theories (Xiong et al., 2015). Structural Equation Modelling (SEM) is generally understood as a combination of two separate statistical methods, namely factor analysis and simultaneous equation modelling. In this study, a simultaneous equation model is applied to the latent variables under investigation. The method used to solve the structural equations is PLS, or the Partial Least Squares approach. Structural equations are represented by relationships between latent variables, illustrated by one-arrow lines to indicate causality (regression) and two-arrow lines to depict correlation or covariance (Wahyono, 2011).

According to Husain (2015), Structural Equation Modelling (SEM) is designed to address the limitations of the regression method. SEM is divided into two categories: Covariance-Based SEM (CB-SEM) and Variance-Based SEM, more commonly known as Partial Least Squares (PLS). Furthermore, PLS applies the bootstrapping method, which eliminates issues related to the assumption of normality. This allows PLS to be effectively applied even with small sample sizes (Chandra Pratama Putra and Ade Asmi, 2017). In practice, PLS analysis is often supported by SmartPLS software. For example, Beatrix (2014) investigated the impact of change orders on cost, time, and quality in construction projects in Surabaya, ultimately influencing the completion process of such projects. This study uses secondary data from reliable sources such as the World

Bank and the Global Competitiveness Index for the years 2019-2023. The panel data comprises cross-sectional observations of G20 countries over the period 2019–2023. This enables the study to capture both country-specific variations (across different G20 members) and temporal changes (over time).

Panel data analysis helps control for individual heterogeneity (differences between countries) as well as time dynamics (changes across years), making it well-suited to examining the complex relationships between infrastructure and economic outcomes within the G20. The study covers all 19 G20 member countries and justifies their inclusion based on their economic significance and diversity in infrastructure development. The variables considered are infrastructure investment, supply chain efficiency, national competitiveness, and economic growth (see Table 1). Structural Equation Modeling with Partial Least Squares (SEM-PLS) is employed to assess the impact of macroeconomic infrastructure on supply chain efficiency, national competitiveness, and economic growth across the G20.

This relationship is formalised in the following equation:

The Relationship between Infrastructure Investment (INF) and Supply Chain efficiency (SCE):

$$SCE = \beta_1 INF + \varepsilon_1 \quad (1)$$

The Relationship between Infrastructure Investment (INF) and National Competitiveness (NC):

$$NC = \beta_2 INF + \varepsilon_2 \quad (2)$$

The Relationship between Infrastructure Investment (INF) and Economic Growth (EG):

$$EG = \beta_3 INF + \varepsilon_3 \quad (3)$$

The Relationship between Supply Chain efficiency (SCE) and Economic Growth (EG):

$$EG = \beta_4 SCE + \varepsilon_4 \quad (4)$$

The Relationship between National Competitiveness (NC) and Economic Growth (EG):

$$EG = \beta_5 NC + \varepsilon_5 \quad (5)$$

In the research model, two indirect relationships are identified and expressed in the following equations:

Indirect relationship of Infrastructure Investment (INF) to Economic Growth (EG) through Supply Chain Efficiency (SCE):

$$Indirect\ Relationship\ 1 = \beta_1 . \beta_4 \quad (6)$$

Indirect relationship of Infrastructure Investment (INF) to Economic Growth (EG) through National Competitiveness (NC):

$$Indirect\ Relationship\ 2 = \beta_2 . \beta_5 \quad (7)$$

The total effect of Infrastructure Investment (INF) on Economic Growth (EG) is the sum of its direct effect and its indirect effects through Supply Chain Efficiency (SCE) and National Competitiveness (NC).

$$Total\ Effect = \beta_3 + (\beta_1 . \beta_4) + (\beta_2 . \beta_5) \quad (8)$$

The complete equation in the model is depicted as follows:

Economic Growth (EG):

$$EG = \beta_3 INF + \beta_4 SCE + \beta_5 NC + e_1 \quad (9)$$

Supply Chain Efficiency (SCE):

$$SCE = \beta_1 INF + e_2 \quad (10)$$

National Competitiveness (NC):

$$NC = \beta\_2\, INF + e\_3 \quad (11)$$

In this equation, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ represents the path coefficient of each relationship involving infrastructure investment, while e_1, e_2, e_3 denotes the error term for each equation. This model allows for the evaluation of both the direct and indirect effects of Infrastructure Investment on Economic Growth, mediated through Supply Chain Efficiency and National Competitiveness.

The study employs secondary data obtained from several published data sources. The variables used in this research are summarised in the following table:

Table 1 Description of Research Variables

Variable	Variable Description	Research Study by
Infrastructure Investment	Percentage of Infrastructure Investment	Alexandro and Basrowi (2024); Melara-Gálvez and Morales-Fernández (2022)
Supply Chain Efficiency	LPI (Logistic Performance Index)	Mishrif et al. (2024); Shah and Naghi Ganji (2017)
National Competitiveness	Score on the Global Competitiveness Index	Albekova (2024)
Economic Growth	Percentage of GDP	Khan et al. (2020)

The research design is explained in the following figure:

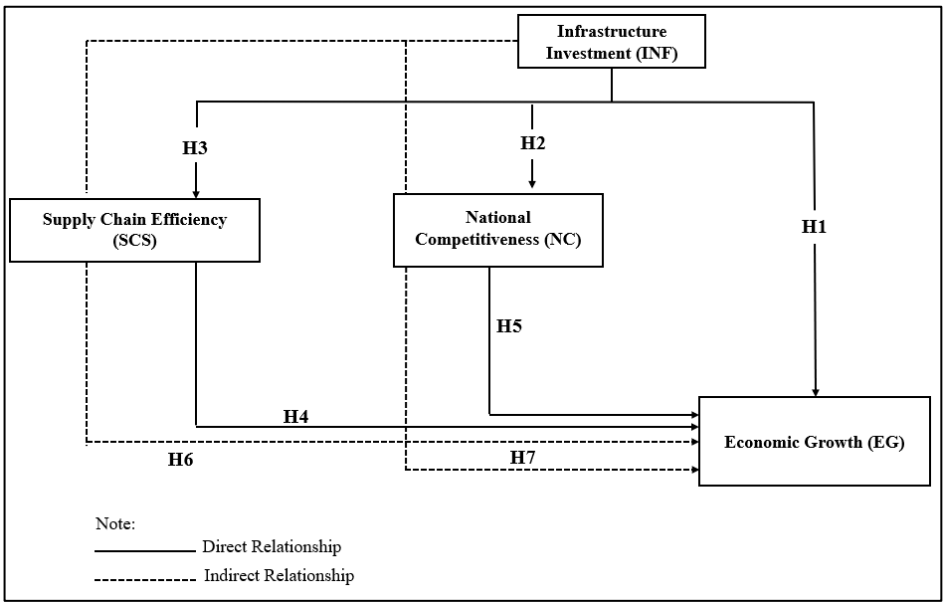

Figure 1 Design of the analysis

FINDINGS

This research examines both the direct relationship between infrastructure investment and economic growth, and the indirect relationship between the two, mediated by supply chain efficiency and national competitiveness. Infrastructure investment is expected to play a crucial role not only in enhancing economic efficiency and capacity but also in strengthening national competitiveness by improving supply chain performance. Increased competitiveness, driven by a smoother supply chain, is anticipated to create a more conducive environment for economic growth. Therefore, this study focuses on the dual impact of infrastructure investment, both direct and indirect, on economic growth.

The analysis begins with data reliability tests, including multicollinearity, normality, and autocorrelation. The multicollinearity test ensures that no high linear correlations exist among the independent variables, which could otherwise distort the results. Table 2 presents the test results, showing that the Variance Inflation Factor (VIF) values for each variable are below the threshold of 10.

Table 2 Multicollinearity Test Results

Variable	VIF	1/VIF
SCE	2.01	0.499
NC	1.87	0.535
INF	1.11	0.903

Source: Stata Processed (2024)

Table 2 shows the results of the multicollinearity test using the Variance Inflation Factor (VIF) and its inverse (1/VIF) for the three variables: SCE, NC, and INF. The VIF value for SCE is 2.01, indicating low multicollinearity with the other variables, as it is well below the common threshold of 10. Similarly, NC records a VIF value of 1.87, also well below the threshold, showing no serious multicollinearity concerns. INF has the lowest VIF value of 1.11, suggesting minimal correlation with the other predictors. Overall, these results confirm the absence of significant multicollinearity among the independent variables. Additional diagnostic tests were also conducted, namely normality and autocorrelation tests, as presented in Table 3.

Table 3 Normality and Autocorrelation Test

Testing	Probability
Normality (Shapiro-Wilk)	0.00012
Autocorrelation (Wooldrige Test)	0.1440

Source: Stata Processed (2024)

The results of the normality test show a probability value of 0.00012, indicating that the test result is highly significant. This means that, at a commonly used significance level of 0.05, we reject the null hypothesis that the residual data are normally distributed. Overall, the Shapiro-Wilk test results indicate that the residuals of the model do not follow a normal distribution, since the p-value is very small ($p < 0.05$). This may suggest potential issues in the model that require refinement, such as variable transformation or the application of a more suitable modelling approach. The results of the autocorrelation test using the Wooldridge test on panel data show an F value of 2.334 with a probability of 0.1440. Since the p-value is greater than 0.05, we fail to reject the null hypothesis that there is no first-order autocorrelation. Thus, there is insufficient evidence to suggest the presence of autocorrelation in the model, and the assumption of no autocorrelation can be accepted.

The study's findings are presented in Table 4, which shows that infrastructure investment has a significant direct influence on economic growth. This is statistically confirmed by a beta coefficient of 0.292 and a p-value of 0.002, indicating a positive and significant relationship between infrastructure investment and economic growth. Therefore, the study rejects the null hypothesis and supports the existence of a positive influence between the variables. These results are consistent with the findings of Alexandro and Basrowi (2024), who argue that investment in macroeconomic infrastructure, including transportation networks, energy supply, and communication systems, can have a positive and statistically significant impact on a country's economic growth. Effective and strategic infrastructure has the potential to increase trade, enhance productivity, reduce transaction costs, and improve overall competitiveness, all of which are key drivers of economic expansion. Therefore, it is important that infrastructure policies and investment strategies be tailored to the specific needs and goals of each country. In addition, Sirega et al. (2023) emphasise that

infrastructure plays a crucial role in accelerating economic growth by creating new employment opportunities, reducing poverty levels, and increasing per capita income. Roach and Al-Saidi (2021) further highlight that well-maintained and adaptable infrastructure enables countries to withstand economic shocks and adjust to changing circumstances, thereby supporting long-term economic growth. Based on the results outlined above, the following hypothesis testing was carried out:

Table 4 Hypothesis Test Results

Description	Coefficient	Standard deviation	T statistics	P values
Infrastructure -> Economic Growth	0.292	0.095	3.059	0.002
Infrastructure -> National Competitiveness	-0.164	0.076	2.173	0.030
Infrastructure -> Supply chain efficiency	-0.306	0.078	3.937	0.000
Supply chain efficiency -> Economic Growth	0.061	0.122	0.501	0.617
National Competitiveness -> Economic Growth	-0.031	0.142	0.216	0.829
Infrastructure -> Supply chain efficiency -> Economic Growth	-0.019	0.039	0.477	0.633
Infrastructure -> National Competitiveness -> Economic Growth	0.005	0.026	0.197	0.843

Source: SEM-PLS, Data Processed (2024)

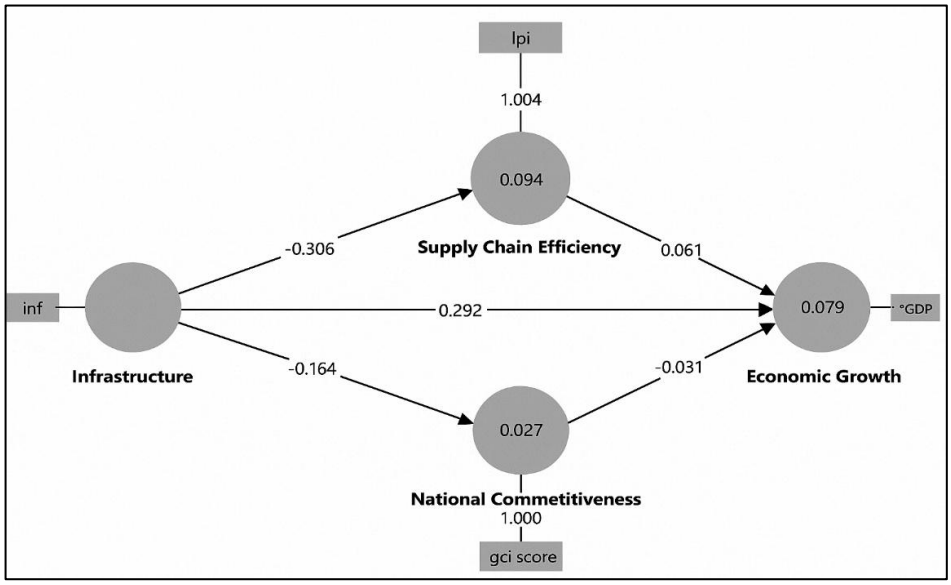

Figure 2 Total Effect of the Analysis

One of the most notable findings is the negative relationship between infrastructure investment and national competitiveness, with a significant negative beta coefficient of -0.164 (p = 0.030). This result contrasts with the theoretical expectation that improved infrastructure enhances competitiveness by lowering operational costs and improving market access. Several factors may explain this unexpected outcome. Inefficiencies in infrastructure development may lead to suboptimal resource allocation and underutilisation. In some G20 countries, rapid infrastructure expansion may have created regulatory bottlenecks or inadequate planning, limiting the competitive benefits. Bureaucratic hurdles and poor coordination between government agencies and private actors can delay project implementation, reducing overall effectiveness. Political instability or inconsistent policies may also produce infrastructure that fails to address key economic needs, thereby constraining competitiveness. Contrary to existing literature, for example Alexandro and Basrowi (2024), who highlight the positive relationship between infrastructure and competitiveness, this study underscores the complex dynamics in G20 countries. It shows that rapid infrastructure development does not always translate into improved competitiveness, particularly when hindered by inefficiencies in implementation and policy challenges.

Another surprising finding is the negative relationship between infrastructure investment and supply chain efficiency, with a beta coefficient of -0.306 (p-value = 0.000). This result challenges the expected positive effect of infrastructure on supply chain efficiency. One possible explanation is that newly developed infrastructure may not be sufficiently integrated into existing supply chains, leading to temporary disruptions. For example, the construction of new roads, ports, or airports may delay existing supply routes or disrupt established logistics networks during the construction phase. In addition, the quality of the infrastructure itself may not meet the standards required to facilitate supply chains, particularly in countries where rapid

urbanisation and technological change have outpaced infrastructure improvements. This issue may be more pronounced in emerging G20 economies, where infrastructure development may not be adequately aligned with the needs of modern supply chains, creating inefficiencies. This finding also differs from previous studies such as those by Moore and Glean (2016) and Agyei et al. (2021) which argue that infrastructure improvements generally result in smoother logistics and enhanced supply chain performance. In the context of G20 countries, however, supply chain efficiency may be hindered by factors such as a lack of coordination between infrastructure development and logistics operations, as well as technological gaps.

Hypothesis H4 posits that supply chain efficiency has a direct positive effect on economic growth in G20 countries. However, the results of this study fail to reject the null hypothesis, as the p-value for the relationship is 0.617, indicating no significant statistical association. This outcome contradicts prior studies, where smoother supply chains are often linked to higher economic growth, particularly in developing economies (Abdillah, 2018). Several factors could explain why this relationship was not significant in G20 countries. First, many G20 countries already have highly efficient supply chains due to advanced infrastructure, which may have reduced the marginal impact of further improvements on their economies. For example, countries such as Germany and the United States already have well-developed logistical networks, so additional improvements may have a diminished effect on economic growth compared with economies with underdeveloped infrastructure. Second, regulatory or institutional barriers in some G20 countries may hinder the smooth functioning of supply chains despite high-quality infrastructure. Bureaucratic inefficiencies, customs regulations, and trade restrictions can still cause delays, reducing the overall impact of supply chain efficiency on economic growth. In contrast to studies focusing on developing economies, such as those by Alexandro and Basrowi (2024), where supply chain efficiency plays a more significant role in driving economic performance, the G20 context presents a different dynamic. The relatively mature supply chains and strong institutional frameworks in many G20 countries may result in a situation where the benefits of further improvements are not immediately impactful.

Hypothesis H5 suggests that national competitiveness has a direct positive effect on economic growth in G20 countries. However, the p-value for this relationship is 0.829, which also indicates a lack of statistical significance. This finding is surprising because national competitiveness is generally considered a major driver of economic growth, as it attracts investment, stimulates innovation, and enhances productivity (Capello, 2017). One possible explanation for this lack of significance is that national competitiveness in G20 countries is already high, so changes in competitiveness may not lead to immediate or substantial improvements in growth. Countries such as Germany, the United States, and Japan already rank highly in global competitiveness indices, and further improvements may not produce large gains in growth compared with countries with weaker institutions and lower competitiveness. In addition, market saturation in developed G20 countries may mean that increases in national competitiveness through infrastructure development or policy reforms may not have as strong an economic impact as in emerging economies, where infrastructure and competitiveness improvements can drive more dramatic growth. Furthermore, macroeconomic factors such as global market conditions or trade dynamics may have a greater influence on economic growth than competitiveness alone. In contrast to findings in developing countries, where competitiveness is closely tied to economic growth (Abdillah, 2018). G20 countries may experience diminishing returns from improvements in national competitiveness, especially in economies that are already highly competitive. As a result, the relationship between competitiveness and growth may not be as pronounced in these advanced economies.

Hypothesis H6 suggests that infrastructure investment indirectly affects economic growth through supply chain efficiency. However, the mediation model indicates that the relationship between infrastructure investment, supply chain efficiency, and economic growth was not statistically significant (p-value = 0.633). The estimated indirect effect coefficient for this pathway was −0.0187, indicating a weak and negative mediation effect. Similarly, Hypothesis H7, which proposed that infrastructure has an indirect effect on economic growth through national competitiveness, also did not yield significant results (p-value = 0.843), with a small positive coefficient of 0.0051 for the indirect effect. These findings suggest that supply chain efficiency and national competitiveness may not fully mediate the relationship between infrastructure investment and economic growth in the G20 context. The failure to reject the null hypothesis for these indirect relationships highlights the complexity of infrastructure's role in economic growth. Unlike studies focusing on developing countries, such as those by Alexandro and Basrowi (2024), where infrastructure's indirect effects are often significant, the indirect effects in G20 countries may be weaker due to institutional barriers, market

saturation, or the already high levels of competitiveness and supply chain efficiency. Regulatory and policy challenges may further limit the effectiveness of infrastructure investments in enhancing supply chain efficiency and national competitiveness, thereby constraining their role as mediators.

When compared with existing literature, the findings of this study suggest that the indirect effects of infrastructure on economic growth through mediators such as supply chain efficiency and national competitiveness may be weaker in developed economies or those with already efficient infrastructure systems. The results also highlight the need for more targeted infrastructure policies in G20 countries, focusing on integrating infrastructure improvements with supply chain optimization and competitiveness strategies.

CONCLUSION

This study aimed to explore the impact of infrastructure investment on economic growth in G20 countries, focusing on both direct and indirect effects through supply chain efficiency and national competitiveness. The findings reveal a significant direct relationship between infrastructure investment and economic growth, consistent with the theoretical framework that infrastructure drives productivity and enhances economic output. However, the study also produced unexpected results regarding the relationships between supply chain efficiency and economic growth (H4), as well as national competitiveness and economic growth (H5), both of which were not statistically significant. These non-significant results can be attributed to several factors, including the highly developed infrastructure and saturated markets in many G20 countries, where further improvements may have limited immediate effects on growth. In addition, institutional barriers or policy inefficiencies could be hindering the expected positive impact of infrastructure on supply chain efficiency and national competitiveness. These findings suggest that while infrastructure remains critical for economic growth, its effects in highly developed economies may not always translate directly into increased growth.

Moreover, the lack of significant indirect effects (H6 and H7) through supply chain efficiency and national competitiveness indicates that these factors may not fully mediate the relationship between infrastructure investment and economic growth in the G20 context. This may be due to institutional and regulatory challenges, as well as the mature and efficient supply chains and competitive advantages already present in many G20 countries. These factors suggest that the indirect effects of infrastructure on growth may be more pronounced in developing countries with less mature infrastructure and lower levels of competitiveness. The findings of this study are constrained by its cross-sectional design, which limits the ability to capture the long-term effects of infrastructure investment. Future research could use panel data to explore temporal dynamics and account for longitudinal changes in infrastructure and its impact on economic outcomes. Additionally, future studies should investigate the role of sector-specific infrastructure, such as digital or green infrastructure, to determine whether these forms of investment have a stronger impact on growth in G20 countries. Finally, examining policy differences and institutional contexts across the G20 could provide deeper insights into how supply chain efficiency and national competitiveness mediate the relationship between infrastructure and growth.

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