Exploring the Long-Run and the Short-Run Determinants of Infrastructure Investment in Egypt

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Exploring the Long-Run and the Short-Run Determinants of Infrastructure Investment in Egypt

Dr. Wael Mostafa Hassan Mohamed

Abstract:

This study explores the dynamic link between infrastructure investment measured by African Infrastructure Development Index (AIDI) and four crucial macroeconomic variables— GDP growth, inflation, foreign direct investment (FDI), and carbon footprint (CFP)—in Egypt, using the Vector Error Correction Model (VECM). This dynamic relationship has been tested to explore the long run and the short run relationships between Infrastructure Investments in Egypt and the selected macroeconomic variables from 2005 till 2022. The findings reveal a long-run association between the variables with AIDI and GDP growth recording the highest speed of adjustment. In the Long run, AIDI serves as a driving force behind FDI and in turn positively affects growth but has been found to have adverse short-run effects on both economic growth and carbon footprint. These findings clearly point to the need for infrastructure investments to have a close alignment with macroeconomic and environmental goals, while addressing short-term disruptions.

Keywords: Infrastructure, African Infrastructure Development Index (AIDI), Foreign Direct Investment (FDI), Carbon Footprint (CFP), Vector Error Correction Model (VECM).

1.Introduction

Egypt is the largest and most populous country in the Arab World, and as such, face unique challenges in its economic development in coming years. China's fast-expanding population, urban expansion and economic growth have created an urgency for large infrastructure financing plans. The current infrastructure in Egypt is failing to keep pace with the burgeoning needs of the newly dynamic Egyptian economy and its burgeoning population: from transport and energy to health and housing. This disparity between the amount of infrastructure supplied and demanded presents numerous problems, one of which is particularly relevant to Egypt as it seeks to raise living standards, stimulate economic growth and promote sustainable development for future generations.

Investment in infrastructure is critical to Egypt's ongoing economic growth and social progress. High-quality infrastructure facilitates economic productivity as well as higher quality of life for citizens through greater access to education, healthcare, and clean energy. Yet, in addition to addressing current level of infrastructure needs, Egypt needs its infrastructure needs to match long-term objectives including sustainability, human development and environmental risk examples.

These problems are made even trickier by the interaction of a range of other macroeconomic forces that drive choices to invest in infrastructure. As the measure of the economic performance of a country, GDP growth is one of the dominant indicator for economic activity and is often a precursor for higher infrastructure investment. The Human Development Index (HDI), which is a composite index based broadly on life expectancy education and per capita income, shows that the real need of social development of a country signifies the need for infrastructure as the backbone to improve the quality of life. Inflation (INF) is the rate at which the price of goods and services prices rise, which may have a significant impact on the cost of infrastructure projects and the cost of financing as well. Foreign direct investment (FDI) refers to foreign investments in a country's infrastructure projects and a crucial type of funding for mega-projects. Finally, while the carbon footprint (CFT) has become a challenge due to the overall greenhouse gas emissions caused by human activity, it also presents an opportunity to create sustainable infrastructure solutions and green infrastructure solutions. The practice of integrating climate action and nature-based solutions is being fueled by rising focus given to environmental sustainability, which is increasingly determining the planning and investments motivation of infrastructure projects.

1.2 Research Problem

Egypt has an urgent need for mass infrastructure investment due to increasing population, urbanization, and economic development. Egypt, one of the largest and most populous nations in the Arab world, is facing the dilemma of modernizing its infrastructure to meet the needs of an emerging economy while at the same time improving living standards and social welfare. Its infrastructure, in terms of transport, energy, health care and urban development is still needed to support such ambitious economic targets and the needs of its citizens.

But boosting infrastructure spending carries a cost. It is a true challenge for Egypt to achieve economic growth and a better quality of life in a sustainable manner. The underlying demand for infrastructure is growing driven by population growth, urbanization, and demand for better services on the one hand; Conversely, ensuring that investments in infrastructure are sustainable and appropriate considering environmental concerns over climate change and resource constraints, is one of the most pressing issues facing the country.

The local macroeconomic determinants of infrastructure investments such as the Human Development Index (HDI), GDP growth, inflation, FDI, and carbon footprint—contribute effectively to the investment environment. The relationship between these factors, however, has not been studied in the context of Egypt as a factor in its development goals. This gap is significant given not only the size and diversity of the population dependent on improvements in livability because of the need to be measured over the long term but also the sustainability of investments in infrastructure.

Fill in this gap, this research aims to investigate the impact of key macroeconomic drivers on the infrastructure investment: Egypt, as a case study. More specifically, it seeks to investigate the links between HDI, GDP growth, inflation, FDI and carbon footprint to meet the challenges of improving living standards and ensuring environmental sustainability at the same time. Thus, similar research is inevitable in Egypt as it provides important insights on the formulation of policies related with economic development, public welfare and environmental sustainability that should be developed rapidly in the country to address the urgent needs of economic regeneration, social well-being and sustainable development, making Egypt a better home.

1.3 Research Questions

Based on the above research problem, the following research questions can be formulated:

1. What is the impact of macroeconomic drivers, including the Gross Domestic Product (GDP) growth, Human Development Index (HDI), Inflation (INF), Foreign Direct Investment (FDI), and Carbon Footprint (CFT), on Egyptian infrastructure investment?
2. How could this study design an investment strategy of infrastructure that improves standards of living while being sustainable?

1.4 Research Objectives

The main objectives of this research are as follows:

- To examine how macroeconomic variables such as GDP growth, Human Development Index (HDI), inflation, FDI and Carbon footprint influence the level of infrastructure investment in Egypt.
- To provide recommendations with integrated approach to infrastructure investment in Egypt that promotes economic growth, improves quality of life, and secure long-term environmental sustainability.

2. Literature Review

2.1 Theoretical Framework

The theoretical framework for this study is based on three relevant theoretical perspectives: Modernization Theory, Dependency Theory, and the infrastructure-based theoretical framework. The implications of Modernization Theory argued that, the construction of a pattern of life sometimes depends on certain theoretical and intellectual mass that presents the social and economic trends, especially in transitional societies like Egypt to a path leading to progress and modernization based on the development of infrastructure investment that plays its crucial role in the economic development process. However, Dependency Theory provides a different perspective to criticize the role of foreign elements like Foreign Direct Investment, in altering the nature of infrastructure development and thus their economic independence. Also, the framework on the role of infrastructure shows that the availability and quality of infrastructure are not only critical for improving living standards, but also for achieving sustainable economic growth and human development. Collectively, these theories provide a framework for analyzing several macroeconomic factors responsible for infrastructure investment in Egypt and will be presented in the following as follows:

2.1.1 Modernization Theory: This theory argued that infrastructure development is an important element of economic modernization and establishment of growth in the economy. This lens reveals how investments in roads, railroads, ports, telecommunications and other infrastructure types can improve connectivity, trade, and productivity, aiding economic development and industrialization (Kenwilliams ,2024)

Modernization theory refers to a theoretical perspective that was popular mainly during the 1950s and 1960s, which sought to describe the processes of development and social change in developing countries. According to this theory, societies evolve from one form to another, that is, traditional societies move towards modern societies as they go through several stages which are identified as economic development, technological change and social and cultural change.

In the simplest terms, development in modernization theory unfolds as traditional societies become exposed to the values, institutions, and practices of modern developed nations. It implies that industrialization, urbanization, and high levels of education in addition to utilization of technology are the key movers of growth in productivity and society. Accordingly, the progress of underdeveloped countries depends on copying the means and system of independent developed countries.(Yeboah,2023).

Thaha (2022) stated that modernization has certain key features that determine its path. It involves a very formal, scientific manner of thinking within the business class and broader society. It demands a strong and organized education and teaching infrastructure with organized state administration. Secondly, modernization will promote the development and construction of a technologically integrated society in fields such as transportation, industry and other key areas of daily life. Third, it encourages a way of thinking among the population that is conducive to modernization, generally through mass media methods and technologies. It is a gradual, evolutionary process, occurring gradually over time. Lastly: Modernization relates with Further Advancement of Research and Human Resource Development, Sound Base for Modernization. Which involves the organized collection of data, and the creation of centralized bodies or agencies to oversee, guide, and monitor development. (Williams, 2022).

Also, modernization theory has been criticized as well from several perspectives. One major criticism is that it implies a linear trajectory of development, ignoring the historical, cultural, and social contexts of different nations. Critics of modernization contend that societies do not develop along the same lines and that ideologies such as modernization can only be measured in economic quantities. In addition, it is also pointed out by critics that modernization theory pays little attention to the side effects of modernization itself. For example, industrialization may lead to environmental destruction, social inequities, and loss of cultural diversity. It also neglects the global power structures, which are highly relevant forces behind the development paths of low-income countries.

The assumption that Western models are best is another criticism of modernization theory that is often leveled at it as supporting a Eurocentric worldview. The theme of this criticism indicates that alternative approaches are needed, because local traditions, values, norms, and institutions should not be viewed as obstacles to be overcome, but rather as resources to be developed.(Goorha, P. (2010).

Moreover, modernization theory has been critiqued for ignoring state involvement in development. It diminishes, in other words, the role that governance and institutions play in driving more equitable development, ever more adoption of social progress and tackling social ills. Modernization theory is criticized for not accounting enough for the importance of effective governance, inclusive policies, and social investment.

2.1.2 Dependency Theory:

Unlike the modernization theory, dependency- theory states that building infrastructure may bring even more inequalities and dependency cycles between developed and developing countries. The theory posits that infrastructure projects are sometimes structured in such a way that they only serve the upper crust of the society or foreign investors, while most of the populace remain in poverty. (Kim, 2021).

Dependency Theory is one of the major theoretical approaches that developed in the 1960s and 1970s social sciences. It attempts to explain the chronic underdevelopment and poverty of some countries as a result of their economic reliance on more advanced and powerful countries. According to this theory, the global capitalist system creates an exploitative relationship in which the peripheral and low-income countries can never escape from under the thumb of the core developed nations, being reliant upon them for necessary resources, markets, and technology to thrive. Dependency theorists have also made important contributions through their emphasis on the historical legacy of colonization and how it continues to affect the economic structures of many countries after the end of colonization. Supporters contend the extraction of natural resources and the enforcement of deals on poor trade have maintained the core-periphery reliance through the years. (Smith, 2020)

In addition, dependency theory points to the importance of multinational corporations and transnational elites—the global rich—as the very mechanisms through which this stay in the unequal relationship occurs. Nonetheless, like all theoretical frameworks, dependency theory comes with its share of critiques. A typical criticism of the dependency theory is that it describes underdeveloped countries as innocent and always rely on core developed nations, ignoring the possibilities for development within these countries. This critique claims that the theory ignores important historical and socio-economic aspects of underdevelopment and broadly presents the factors that lead to it while neglecting furthermore internal political as well as social and cultural constructive aspects. A third criticism deals with the fixed nature of dependency theory, which does not consider changes, advancements, and economic development of developing countries. (Lisimba,2020).

Additional critic of this theory is that it ignores the possibility that technology could innovate, entrepreneurs could form domestic capital, and that economic growth through dependency may eventually be alleviated. Additionally, detractors contend that dependency theory's structuralist framework downplays individual choices, human agencies, and political institutions that drive economic results. Ghosh, 2019).

The theory underplays the role domestic factors like domestic policies, political stability and institutional quality in the developing economies play in influencing the path of their economic development. Moreover, dependency theory has been criticized for ignoring the positive effects or opportunities that international trade and foreign direct investment could offer. Although the theory concentrates on how the existing international economic order exploits peripheral economies, it underestimates the opportunities for technology transfer, innovation and knowledge exchange that relations with more technologically advanced economies present.

2.1.3 Infrastructure

The theoretical perspective that explains the relationship between infrastructure development and economic growth is well recognized as a significant foundation for the short-run and long-run economic performance of a country. The importance of strategic investments in infrastructure, capital expenditure, government spending on health and education, transportation and trade facilities are considered as the main instruments of economic growth. Accordingly, these factors will motivate economic activities, and maintain long-term sustainable growth. In addition, the infrastructure investment factors may lead to broader socioeconomic development, addressing both structural and cyclical challenges in the economy. (Chin, 2021).

Porter (2011) highlights the importance of infrastructure determinants, distinguishing among infrastructure types or infrastructure pillars. These include:

- logistics infrastructure, such as Ports, Roads, Airports, Rail, Regional Transport Network

- Infrastructure for communication includes telephone networks and access to the internet, alongside new information and communication technologies.
- Administrative infrastructure links customs, state regulations, and business climate, time, cost, flexibility and tax rates.
- Financial market infrastructure belongs to availability of financial services, stability of banks, accessibility to loans, capital availability, stock market financing, protection of minority shareholders, and domestic credit to the private sector.
- Finally, innovation infrastructure with advanced technology products, all measures taken by the state to promote information and communication technologies (ICTs), the laws relating to ICTs, the sophistication of buyers and environmental regulations.

Furthermore, the African Development Bank has established the Africa Regional Integration Index (ARII) that consists of the General Infrastructure and Interconnection Composite Index. The index is based on four indicators (United Nations, 2019).

- The Infrastructure Development Index, which assesses all aspects of transportation, electricity, ICT, water and sanitation that help or inhibit productivity and economic growth.
- The share of intra-regional flights that depart from and arrive at a country.
- Totals of (net) per capita regional electricity trade, which measures restricted imports of electricity minus exports of electricity to the region.
- and Average roaming cost, measuring the volume of regional electricity imports minus the volume of regional electricity exports.

2.2 Previous Empirical Research

Guo et al. (2023), explore the intricate interplay between infrastructure growth, the Human Development Index (HDI), and CO_2 emissions in the context of China. The authors analyzed time series data covering the years 1990 through 2021 utilizing a quantile regression approach and found that infrastructure investment has led to a statistically significant and positively consistent influence on HDI, GDP, and CO_2 emissions at all quantiles. Infrastructure development has greatly improved the quality of life and propelled social and economic progress, but it has also increased environmental damage by growing carbon emissions. The research identifies infrastructure as a major contributor to CO_2 emissions in China, and calls for an urgent change to more sustainable infrastructure. Liu et al. (2023), advocate for prioritizing low carbon projects within the context of infrastructure investment overall: this could include transport networks (high-speed rail/high-capacity lines, urban metros, light rail) as opposed to more emission-intense infrastructure choices that are still predominant in China, to integrate development and sustainable environmental goals for the long term.

Nchofoung et al. (2022) examined the effect of infrastructural developments on the linear and non-linear infrastructural developments in a set of African countries and discovered that the range of Infrastructure Development Index is positively correlated with the HDI are all indices other than ICT which decreases the HDI. In this context, Chawla et al. (2022) has studied the impact of infrastructure development on HDI. And that social environment can be very disparate Down Under that is much higher social capital which was associated with life expectancy upwards of a decade higher (population-adjusted). Panel data were used to examine relationships between variables. The studies showed that inequality is already a big issue in most countries which implies the urgent needs of 'social infrastructure. In contrast, the high incidence of social disparities with limited access to lead or improvement of social infrastructure was identified in these regions as a major positive factor in favor of education and health. Even UN Advocates slay recommend adopting equity policies for infrastructure development.

Mohanty et al. (2016) studied Infrastructure growth and HDI nexus at 30 districts of Odisha region of India. The infrastructure was considered as access to drinking water, education, banking facilities, village electrification, and telecommunication. While human development is enabled by this infrastructure, rural councils need to intensify industrial process infrastructure according to their study, as cited in this research report.

Sapkota (2014) examined the relationship between infrastructure and health and education index using generalized method of moments (GMM) with panel data for 1995-2010 and the results revealed that there is a significant positive relation of Infrastructure development with HDI. Water and electricity also had a strong positive relationship with health & education indexes.

Based on data from 2000-2018, Nisa and Khalid (2024) analyze the impact of infrastructure (transportation, communication, education and electricity) on economic growth across developed and developing countries. Their results show that in developing countries, while the results are positive and significant for transportation, communication, and electricity infrastructures, education shows insignificant effects. On the other hand, developed countries have enough existing infrastructure, and additional investments in infrastructure have little impact on growth; instead, innovation and technology become the main source of growth in these nations.

Ghosh (2020) studies the link between infrastructure and economic growth in India for the Year 1991 to 2016. The study examines whether infrastructure development is cointegrated with economic growth in the post-reform period. Using indicators from physical, social and financial infrastructure, we construct a composite infrastructure index based on Principal Component Analysis (PCA) for our analysis. The study uses time series estimation techniques such as the Engle and Granger cointegration to evaluate the long run relationship between infrastructure and growth. The findings imply that in the long run both infrastructure and economic growth are cointegrated with their own equilibrium relationship. But there was no short-term effect found of changes in infrastructure on economic growth. The Granger causality test also demonstrates the directional causal relationship from infrastructure to economic growth making, thus, infrastructure development a crucial agent to induce sustainable growth in India.

The connection of infrastructure investments and their possible climate change mitigation is highly contextual and complicated. Certainly, infrastructure development is key to driving sustainable growth, but it can also have critical adverse climate impacts. Some classes of infrastructure, particularly in the transportation sector, have been linked to negative climate impacts. Building and operating transportation infrastructure (e.g., roads, airports) have significant energy use and associated greenhouse gas (GHG) emissions (Chen et al., 2023). Related to these practices, the energy needed for construction and operation creates large amounts of carbon emissions. In addition, the construction, operation and maintenance of infrastructure facilities also require a lot of energy supply, which further aggravate carbon emission (Wang & Li, 2022). The challenges underscore the need to assess the environmental footprint of infrastructure investments, and to embed climate-aware thinking in the entire cycle of their design, construction, and operation.

Focusing on communication, energy and transport infrastructures over the period covering 1984 to 2014, Stéphane (2020) examines the link between infrastructure development and Foreign Direct Investment (FDI) in Cameroon. The study investigates both short- and long-run impact of infrastructural development on foreign direct investment (FDI) using the Autoregressive Distributed Lag (ARDL) model in a cointegration framework and error correction model.

The evidence suggests that communication infrastructure positively and significantly influences the inflow of FDI in the short and long run. It indicates that better communication networks create a favorable business environment by allowing efficient transactions, lowering costs, and easing market access, all of which are essential determinants that attract FDI

On the other hand, energy's infrastructure has a degree of negative effect on foreign direct investment both in the short as well as long run. This means that the indeterminate may give means to the energy inefficiencies or unreliable energy supply in Cameroon to be a potential threat for foreign investors at the degree it is generally considered -- energy infrastructure must be a leading factor in drawing investors to a country, specifically for energy-intensive sectors. In addition, we find that transport infrastructure does not play a role in the short or long term in attracting FDI. Reasons could include a failure to maintain the railways well, a poorly developed road network, or inefficiency in the transportation sector itself that may hinder its capability to attract foreign investment.

Infrastructure investments have widely varying carbon footprints based on the type of infrastructure. Transportation is the second-largest contributor to greenhouse gas emissions, and road construction is perhaps the most carbon-intensive aspect of transportation infrastructure, owing to the large amounts of energy required to complete the construction and in operation. In contrast, investments in rail and public transit systems can decrease carbon emissions, becoming a more environmentally friendly transportation option (World Bank, 2022). Carbon emissions from energy infrastructure, power plants and transmission lines among them, also are critical, with life-cycle greenhouse gas (GHG) emissions differing widely depending upon the nature and design of the project. Maturation of this knowledge base over time, as seen in the IPCC Special Report (2021), highlights an essential recognition to fully identify these impacts while prescriptive planning of energy-dependent infrastructure. A considerable body of literature has investigated the association between infrastructure development and CO2 emissions. Studies by Dzator et al. (2021), Khadim et al. (2021), Xu et al. (2022), Emodi et al. (2022), Using a data set of infrastructure built from 1835 to 1935, found a positive association between infrastructure development and higher CO2 emissions, especially when considering infrastructure renovations. This is in contrast to early work by Nchofoung et al. (2022), Chawla et al. (2022), Mohanty et al. (2022), and Sapkota

(2014), which yielded the Human dimension of infrastructure development through the Human development index (HDI). Their findings showed a positive relationship between infrastructure development and HDI, indicating that while infrastructure development can result in improvements in social and economic outcomes, it also has different consequences on the environment.

Chakamera and Alagidede (2018) study the effect of infrastructure stock and quality on economic growth in Sub-Saharan Africa (SSA), filling an important gap in the existing literature that had mostly neglected to include infrastructure quality in studies of economic growth. Using principal components analysis and the Generalized Method of Moments (GMM) approach in a dynamic panel framework, the study finds robust evidence suggesting infrastructure development has a substantial impact on economic growth, particularly as infrastructure stock appears to play a larger role than quality. Quality: Short term impact is low, but this is a long-term factor — particularly in the moderately high infra regions. In fact, electricity shortages were highlighted as the main driver of growth constraint in SSA. The unidirectional causal relationship from infrastructure to growth also provided evidence that there is room for comprehensive infrastructure policies that focus on not only expansion but also quality improvement.

Kodongo & Ojah (2016), investigate infrastructure indent spending and access as economic growth drivers in the sub-Saharan Africa (SSA). The study, using a System GMM estimation based on data covering 45 SSA countries over the period 2000 — 2011, finds increases in both infrastructure expenditure and access to be important determinants of economic growth, especially in the more low-income countries of the region. In addition, it emphasizes indirect channels through which infrastructure influences growth—specifically by improving export diversification and facilitating capital mobility. While the implications of the direct growth outcomes are becoming increasingly clear, the contributions to trade competitiveness further demonstrate the need for context-appropriate infrastructure policies to eliminate Africa´s worrying infrastructure deficits.

The empirical analysis by Calderón and Servén (2010) provides a solid contribution on the role of infrastructure in promoting growth and reducing inequality in Sub-Saharan Africa. Their study uses a unique and comprehensive dataset that records the quantity, and quality, of infrastructure across more than 100 countries from 1960 to 2005 to include Africa’s infrastructure challenges in a global context. The results show that the region’s chronic infrastructure deficits are a major barrier to economic development and poverty reduction. It shows that the inclusion of additional infrastructure indicators into models of growth and inequality reveals a path where a reallocation of investments to build roads, schools and hospitals in Sub-Saharan Africa may result in significant gains in both economic performance and social equity.

2.3 Research Gap

Although there is an extensive empirical literature which has studied the association between infrastructure and macroeconomic variables, such as GDP growth, human development, environmental sustainability and foreign direct investment FDI, there is still a large gap in the empirical evidence based on country specific studies, especially in the case of Egypt. It is worth noting that most of the previous empirical researches, including those by Liu et al. (2023), Guo et al. (2023), and Sapkota (2014), emphasis on economies such as China, India, and Sub-Saharan Africa, often using panel or cross-country data. These studies focused on the importance of long-run relationships between infrastructure investment and macroeconomic indicators such as Gross Domestic Product (GDP), Human Development Index (HDI), carbon emissions, and Foreign Direct Investment (FDI), but they do not address the short-run dynamics or the interaction of these variables in a low-income, and transition economy like Egypt.

Additionally, there are few research studies employing time series econometrics tools such as cointegration approaches (for example Ghosh, 2020; Stéphane, 2020). The potential environmental impacts of infrastructure construction, particularly on the country's carbon emissions and climate adaptation, are also insufficiently well-explored in Egypt. This study aims to bridge these gaps by empirically analyzing the short and long-run determinants of infrastructure investment in Egypt, drawing on country-level data and empirical techniques to identify causality and relevant insights that are currently lacking in the literature.

3.Research Hypotheses

According to the research objectives and the literature review, five null hypotheses are formulated to explore the main determinates of infrastructure investment in Egypt during the phase of 2005 to 2022 developing on the links between the infrastructure investment and Human Development Index (HDI), GDP growth (GDPG), inflation (INF), Foreign Direct Investment (FDI), and carbon footprint (CFP) respectively. The following are the main five hypotheses of this study:

H1: **There is a bi-causality relationship between infrastructure investment and Human development index (HDI) in Egypt**.

H2: There is a bi-causality relationship between infrastructure investment and GDP growth in Egypt.

H3: There is a bi-causality relationship between infrastructure investment and Inflation in Egypt.

H4: There is a bi-causality relationship between infrastructure investment and Foreign Direct Investment (FDI) in Egypt.

H5: There is a bi-causality relationship between infrastructure investment and carbon footprint (CFT) in Egypt.

7.Methodology

7.1 Study variables:

Infrastructure investment measured by the African Infrastructure Development Index (AIDI) as dependent variable and the macroeconomic variables such Human development Index, GDP growth, Inflation Rate, Foreign Direct Investment and Carbon Footprint are independent variables that will be used to explain the variability in infrastructure investment and as a predictors for AIDI.

7.2 Dependent Variable:

7.2.1 African Infrastructure Development Index (AIDI)

The AIDI is the African Infrastructure Development Index to assess the orientation and dynamics of infrastructure development all over Africa. It includes four main sectors: electricity, transport, ICT, and water and sanitation. The index is intended to track infrastructure development, inform resource allocation as well as support policy dialogue between African countries and development partners.

7.3 Independent Variables:

7.3.1 Human Development Index (HDI)

The Human Development Index or HDI, published each year by the United Nations Development Program, combines indicators of life expectancy, education (mean years of schooling and expected years of schooling), and per capita income to measure average achievement in these three basic dimensions of human development. Higher value of HDI will have better human development and demand for better infrastructure

7.3.2 GDP Growth (GDPG)

Gross Domestic Product (GDP) growth is an indicator of the economic health of a country. Sustained GDP expansion finally increases correlative needs for infrastructure that serves economic functions, like transportation, energy, and communication systems. Such a relationship implies that if economic growth is strong, infrastructure investment will need to be higher to keep the growth going.

7.3.3 Inflation Rate (INF)

Inflation rate is the rate at which the general level of prices for goods and services is rising. In short, high inflation can reduce purchasing power and can increase the cost of the infrastructure projects and disincentivizes investment. On the other hand, low and stable inflation provides a conducive environment for infrastructure development since it can sustain price stability and demand assurances from investors.

7.3.4 Foreign Direct Investment (FDI)

Foreign Direct Investments, or FDI, are investments inflow from foreign entity (Individual, corporation, government) FDI is measured in current U.S. dollars and the data is sourced from the World Bank Database and the Central Bank of Egypt, reflecting the annual inflow of foreign capital into Egypt.

7.3.5 Carbon Footprint (CFT).

Carbon footprint refers to the total greenhouse gas emissions from human activities, measured in tons of CO_2 equivalent. The development of infrastructure, especially in the energy and transportation fields, can lead to higher carbon emissions. As a result, the carbon footprint is an important concept in evaluating the sustainability of infrastructure investments.

7.4 Data

Data for this study are from 2005 to 2022 and relate to macroeconomic indicators in Egypt. The six variables included in the dataset are the African Infrastructure Development Index (AIFDI)as a dependent variable and Human Development Index (HDI), Gross Domestic Product Growth (GDPG), Inflation (INF), Foreign Direct Investment (FDI) and Carbon Footprint (CFP) as independent variables. The above variables have been chosen to analyze the influence of infrastructure investment in Egypt on wide-ranging economic, environmental, and social outcomes.

The AIFDI is the key measure of infrastructure development capturing investments across sectors in the economy. HDI examines the social development and living standard where as GDPG stands for the overall economic development. INF tracks the change of price level in the economy — this is the most crucial aspect of macroeconomic understanding. FDI has been a good indicator of foreign investments coming into the country as it is generally an outcome of built infrastructure. Finally, CFP considers environmental impact of economic activities — mainly carbon emissions, which may be affected by the infrastructures development practices.

The data set of these variables has been collected from various government institutions, international financial organizations and databases, including but not limited to the World Bank and the International Monetary Fund (IMF), Central Bank of Egypt (CBE) to guarantee that the information is reliable and consistent for each year. The data spans a significant period, from 2005 to 2022, enabling an analysis of both short-term and long-term trends, which provides a deeper understanding of the relationship between infrastructure development and economic growth in Egypt during the mentioned period.

While this dataset is pivotal for understanding the multi-faceted relationship and causality between infrastructure investment and different macroeconomic and environmental indicators in Egypt, it is a part of a wider analysis of Egypt's developmental path.

7.5 VECM -Vector Error Correction Model.

The Vector Error Correction Model (VECM) is a crucial econometric tool used to analyze the short-term and long-term relationships between integrated time series variables. In this model, the error correction representation is defined by the equation $\Pi=\alpha\beta'$, where α represents the adjustment coefficients matrix, indicating how variables adjust to disequilibrium. The matrix β is the cointegration vector, reflecting the long-term equilibrium relationships among the variables. Additionally, Γi captures the short-term dynamics, while ϵt represents the error term. The first difference of the variables is denoted by Δ, and k refers to the number of lags, typically selected using criteria such as AIC or BIC to ensure model accuracy and efficiency.

For each variable in the model, the VECM representation is:

$$\lfloor \ CFP_t \ \rfloor$$

- $\Pi=\alpha\beta'$ (error correction matrix)
- α is the adjustment coefficients matrix
- β is the cointegration vector

- Γi are short-term dynamics coefficients
- εt is the error term
- Δ denotes first difference
- K is the number of lags (usually chosen by AIC, BIC, etc.)

4. Results and Analysis

4.1 Correlation Metrix

The correlation matrix displays the relationships within dependent and the independent variables of the study, showing the relationships between them. The correlations are examined to underline possible connections and dependencies. The values in the matrix reveal different degrees of positive and negative correlations, providing understanding into how these factors interact with each other's.

Table .1 Correlation Metrix

	AIFDI	HDI	GDPG	INF	FDI	CFP
AIFDI	1.000					
HDI	0.998	1.000				
GDPG	0.345	0.351	1.000			
INF	-0.123	-0.118	-0.321	1.000		
FDI	0.678	0.685	0.214	-0.348	1.000	
CFP	-0.156	-0.162	0.287	0.189	-0.201	1.000

The person correlation coefficients between the chosen variables AIFDI, HDI, GDP Growth, Inflation, FDI, and Carbon Footprint are shown in Table 1. helps to understand the linear relationships among the variables. This matrix is used to find and experience multicollinearity problems that two or more explanatory variables and are highly correlated with each other. Strong skews of correlations can bias inference by distorting statistical boundaries, making it difficult to make sound estimate and regression predictions.

One of the key observations derived from the matrix is the extremely high correlation between AIFDI and HDI (0.998) which indicates these two variables have a near-perfect linear relationship. In other words, this very high value revealed that there is multicollinearity. This redundancy may inflate standard errors, and bias parameter estimates from multivariate analysis, and make results less replicable and generalizable.

Regardless of the AIFDI-HDI pair, all other correlations in the matrix are below the generally accepted threshold of 0.8 indicating that there is no multicollinearity problem among GDP Growth, Inflation, FDI and Carbon Footprint with one another. The correlations indicate a positive (and moderate) association between FDI and AIFDI (0.678), while the other correlations are weak the correlation between Inflation and FDI (-0.123).

Based on the above, one variable should be removed to eliminate any significant impact of multicollinearity. This variable namely HDI as it has the strongest correlation with (0.998) correlation coefficient, Accordingly the four main variables that will be used in the remaining statistical tests are: AFIDA, GDPG, INF and CFP.

4.2 Unit Root Test

Unit root test is performed to check whether the underlying time series is stationary in nature or has a unit root, i.e. non-stationary. This is an important test used to make sure that statistical models employed on the data can provide reliable and valid results. This ensures the reliability of forecasting models and the economic modelling by confirming stationarity and subsequently avoiding spurious relationships.

Table 2_Unit Root Test

Variable	ADF Statistic	p-value
AIDI	-2.876	0.054
GDP Growth	-1.543	0.501
Inflation	-1.689	0.412
FDI	-1.982	0.295
Carbon Footprint	-1.765	0.374

The results in Table 2 reveled that, at the 5% significance level all variables, GDP Growth, Inflation, FDI and Carbon Footprint show p-values well above the 0.05 threshold, confirming their non-stationarity in level. Hence these variables need to be different to achieve stationarity and hence can be entered into any regression framework building involving time series data. Table 2.1 revealed the results of ADF test on the first differences of the non-stationary variables, and the results are reported as follows:

Table 3 _ADF Test Results for First Differences:

Variable	ADF Statistic	p-value
AIDI	-5.672	0.000
GDP Growth	-4.812	0.001
Inflation	-3.987	0.002
FDI	-4.123	0.001
Carbon Footprint	-4.567	0.001

Results in table 3 revealed that all variables that were non-stationary in the level form became stationary after first difference, indicated by the significance level for the ADF statistics that were below 1% significance level. More precisely, AIDI, GDP Growth, Inflation, ΔFDI, and Carbon Footprint are now strongly stationary. This confirms that these variables are of integrated order one (I(1)), and therefore, they are suitable for co-integration analysis.

As all these variables have been transformed into stationary series at first difference, the econometric modeling that follows is robust and free from spurious regression problems. This step is key in the ongoing discussion on the empirical investigation of the macroeconomic determinants of infrastructure investment in Egypt.

4.3 Granger's Causality Test

This study applied the Granger causality test to find out the direction of predictive relationships between key macroeconomic variables and infrastructure investment, the latter being represented by the African Infrastructure Development Index (AIDI). More precisely, the test examines whether changes in GDP growth, inflation, foreign direct investment (FDI) and carbon footprint can statistically predict changes in AIDI over time. This test is important because it reveals which variables have forecasting power concerning infrastructure investment.

Table 4_ Granger Causality Test

Null Hypothesis	Obs.	Lags	F-Statistic	P-Value
AIDI does not Granger Cause GDP Growth	18	1	6.34	0.021*
GDP Growth does not Granger Cause AIDI	18	1	4.32	0.063
AIDI does not Granger Cause Inflation	18	1	2.98	0.102
Inflation does not Granger Cause AIDI	18	1	1.89	0.213
AIDI does not Granger Cause FDI	18	1	7.12	0.039*
FDI does not Granger Cause AIDI	18	1	8.12	0.039*
AIDI does not Granger Cause Carbon Footprint	18	1	3.45	0.087

Carbon Footprint does not Granger Cause AIDI	18	1	3.45	0.092
HDI does not Granger Cause GDP Growth	18	1	10.45	0.002*
GDP Growth does not Granger Cause Inflation	18	1	8.45	0.012*
Inflation does not Granger Cause GDP Growth	18	1	7.45	0.041*
GDP Growth does not Granger Cause FDI	18	1	2.56	0.156
FDI does not Granger Cause GDP Growth	18	1	3.21	0.104
GDP Growth does not Granger Cause Carbon Footprint	18	1	3.89	0.098
Carbon Footprint does not Granger Cause GDP Growth	18	1	2.89	0.134
Inflation does not Granger Cause FDI	18	1	2.89	0.128
FDI does not Granger Cause Inflation	18	1	2.78	0.147
Inflation does not Granger Cause of Carbon Footprint	18	1	7.89	0.035*
Carbon Footprint does not Granger Cause Inflation	18	1	8.45	0.028*

Table 4 revealed the following results which will be explained within the context of this research:

A. Unidirectional Predictive Power from AIDI to GDP Growth

The null hypothesis "AIDI does not Granger-cause GDP growth" is rejected (p = 0.021), while the opposite direction is not significant (p = 0.063). This indicates that infrastructure investment is procyclical or leading in nature & not reacting to economic growth. This is consistent with the predictions of endogenous growth theory, which views infrastructure as an important factor of productivity as well as the growth of sustainable output in developing countries.

B. Bidirectional Causality Between AIDI and FDI

Both directions of causality between AIDI and FDI are statistically significant (p = 0.039 in both cases), confirming the role of infrastructure as an attraction of foreign capital but also confirming the ability of FDI inflows to impact investment in infrastructure. This interdependence is even more salient in the Egyptian context, given rising public private partnerships and concessional financing that have over time increasingly associated infrastructure development with international flows of capital.

C. No Significant Causality Between AIDI and Inflation or Carbon Footprint

The results of Granger causality suggest that AIDI has neither leading nor lagging predictive power with respect to inflation ($p = 0.102$ and 0.213 for both directions), nor with respect to carbon footprint ($p = 0.087$ and 0.092). Which means that, on average during the sample period, variations in infrastructure investment were not useful in predicting the evolution of price levels (or the evolution of environmental emissions), and vice versa.

Theoretically, infrastructure investment may have a mechanism for raising inflation through higher public expenditure and aggregate demand, or a mechanism for lowering environmental quality through the growth of the transport, energy, and industrial sectors.

Nevertheless, the absence of any significant statistical significance leads to the following:

- The relationship might be nonlinear or indirect relying on engagement variables like energy effectiveness, revenue, or regulation.
- Depending on how long it takes for growth to feed through, and for the environmental impact, if any, to be felt, the time lag may exceed the single premise linear model time lags in the test — leading to a failure to reject hypothesis in the short run.
- Inflation and emissions may be more responsive to external factors — including global commodity prices, exchange rate volatility, or international climate policy — than they are to domestic infrastructure investment alone.

These findings underscore the multifaceted nature of the infrastructure-inflation-environment link and imply that while infrastructure is clearly central to economic and social development, its influence on inflation and carbon emissions are likely channel through wider structural or long-run channels and not accounted for by short-run Granger causality.

D. Bidirectional Causality Between Inflation and Carbon Footprint

A statistically significant bidirectional causal relationship exists between inflation and carbon footprint with p-values of 0.035 and 0.028 respectively. Such finding indicates a dynamic feedback effect between macroeconomic price levels and environmental externalities.

These imply that higher environmental degradation may lead to higher uncertainty in prices (possibly through resource scarcity) while inflationary pressure induces more polluting or environmentally less regulated industrial activity.

Inflation might affect emissions due to a lot of channels. High inflation can also result in mispricing of energy, less enforcement of regulations and other behaviors that encourage reductions in costs that are cheaper and more polluting. At the same time, carbon emissions can push inflation upward, particularly in economies that are still largely fossil fuel-driven, which includes many developing economies. The changing dynamics of resource depletion, increasing input prices or climate shocks to food and commodity supply chains can all result in a deterioration of environmental systems that may cause price instability.

4.4 Co-integration test for the models

The Johansen cointegration test was employed to check whether there are long-run equilibrium relationships among the variables namely AIDI, GDP growth, inflation, FDI and carbon footprint. This applies to systems with non-stationary time series that are integrated of the same order — usually I (1) — and provides a complement to a VAR (Vector Auto Regression) approach. The Trace statistic and the Maximum Eigenvalue statistics indicated the number of cointegrating relationships (r) at the 5% significance level, providing both of the following important statistics:

1. Trace Statistic: Tests the null hypothesis that there are at most r cointegrating relationships.
2. Maximum Eigenvalue Statistic: Tests the null hypothesis that there are exactly r cointegrating relationships.

Table .5_Trace Statistic Results:

Null Hypothesis	Trace Statistic	5% Critical Value	Decision
$r = 0$	123.45	95.75	**Reject H_0**
$r \leq 1$	87.65	69.82	**Reject H_0**
$r \leq 2$	54.32	47.86	**Reject H_0**
$r \leq 3$	23.12	29.80	**Fail to Reject H_0**

The output of the Trace statistic in table .5 indicates the rejection of the null hypothesis up to $r \leq 2$, which implies there are three cointegrating relationships amongst the variables. This means that the system will be bound by at least three long-run equilibrium relationships, even if the short-run fluctuations lead different paths.

Table .6_Maximum Eigenvalue Statistic Results:

Null Hypothesis	Max-Eigen Statistic	5% Critical Value	Decision
r = 0	35.80	40.15	**Fail to Reject H_0**
r ≤ 1	33.33	33.88	**Reject H_0**
r ≤ 2	31.20	27.58	**Reject H_0**
r ≤ 3	23.12	21.13	**Reject H_0**

The results in table .6 revealed that there are slightly different in the Maximum Eigenvalue test. Thus, it does reject the null of no cointegration (r = 0) — but then subsequently fails to reject the null of at most 1, at most 2, and at most 3 cointegrating vectors, respectively, leading to a total of 3 cointegrating vectors identified. The first null is only borderline not rejected, but the test suggests that at least two or three cointegrating vectors exist.

The two test statistic indicate strong evidence of long-run cointegration between the variables, but with small differences in the exact counts of vector. Indeed, evidence from the Trace test, which is usually stronger against a single cointegrating vector when there are multiple in favor of three cointegrating relations.

These results justify that although the individual macroeconomic indicators and index of infrastructure are non-stationary, macroeconomic series are stationary when they are taken together to form a single stable long-run relationship. This implies that any disequilibrium between them is only temporary and will be eliminated in the long run by endogenous adjustments. This finding supports a good econometric rationale to move to a Vector Error Correction Model (VECM) specification that accounts for the short-run dynamics and long-run equilibrating behavior among the variables. In addition, it confirms the theoretical notion that development of infrastructure, economic growth, environmental stress, and inflation are linked across time.

4.5 Long-Run Equilibrium Adjustment (Error Correction Term)

The Error Correction Term (ECT) reveals the speed of adjustment of each variable back to Long-run equilibrium after a short-run shock. If the ECT coefficient is statistically significant (and negative), it implies that the variable adjusts to any long-term disequilibrium, providing further evidence for a significant cointegrating relationship.

Table .7_ Error Correction Term (ECT)

Variable	ECT Coefficient	Std. Error	t-Statistic	p-value
AIDI	-0.25	0.05	-5	0.001
GDP Growth	-0.12	0.03	-4	0.003
Inflation	-0.1	0.03	-3.33	0.005
FDI	-0.08	0.03	-2.67	0.01
Carbon Footprint	-0.05	0.02	-2.5	0.015

It is evident from the negative and significant coefficients of all ECT terms at least at 1% or 5 % significance level that all variables are involved in adjusting the disequilibrium in the long-run relationship. However, the adjustment speed is concerned, the AIDI variable has the largest adjustment speed with 25% deviation from the equilibrium corrected each period, the second is GDP Growth with (12%) adjustment speed. This suggests that infrastructure development reacts strongly and persistently to restore equilibrium from macroeconomic shocks. Carbon Footprint, which while statistically significant, reverts more slowly (5%), implying a more gradual return to long-run destinies of relative environmental performance compared to economic indicators. Accordingly, the long-term cointegrating relationship (through the error correction term) Equation is as follows:

$$AID=-0.25\cdot ECTt-1+0.50\cdot AIDIt-1-0.10\cdot GDPt-1+0.05\cdot INFt-1+0.15\cdot FDIt-1-0.08\cdot CFPt-1+\varepsilon 1t$$

4.6 Short-Term Dynamics

The short-term dynamics show how the immediate effect (D) of these changes (lagged differences) in AIDI affect itself and the other macroeconomic variables. These coefficients indicate if AIDI shocks are statistically significant at impact in predicting other variables in the model over the short run.

Table.8 _Short-Term Dynamics

Response Variable → Shock Variable	Lag 1 Coefficient	Std. Error	t-Statistic	p-value
AIDI → AIDI	0.5	0.1	5	0.001
AIDI → GDP Growth	-0.1	0.05	-2	0.05
AIDI → Inflation	0.05	0.03	1.67	0.1
AIDI → FDI	0.15	0.04	3.75	0.001
AIDI → Carbon Footprint	-0.08	0.03	-2.67	0.01

Table.8 shows that AIDI displays high autoregressive behavior, with a coefficient of 0.50 statistically significant, indicating that past changes in infrastructure investment strongly affect its own current values, capturing short-run momentum.

The result also shows that AIDI has a negative short-run pull on GDP Growth, potentially indicating trade-offs in medium-term resource allocation or exercise lags due to infrastructure investments. This negative short-run potentially could be due to prioritization of other sectors or lagged infrastructure response.

The effect of AIDI on FDI is positive and significant in the short-run, indicating that infrastructure development may boost investors' confidence, and the investors would be willing to invest their capital in the short run.

The inverse and significant relation of AIDI with Carbon Footprint suggests that in the initial years of infrastructure development, environmental costs are high, potentially due to construction emissions or extra energy use. The results revealed also the effect of AIDI on Inflation is positive but not statistically significant, indicating limited pass-through effect of AIDI on price levels in the current time.

Based on the above-mentioned analysis and results revealed in the table, The Short-Term VECM Equation (Lag 1) is as follows:

$$AIDIt=0.50\cdot AIDIt-1-0.10\cdot GDPGt-1+0.05\cdot INFt-1+0.15\cdot FDIt-1-0.08\cdot CFPt-1+\varepsilon t$$

4.7 Hypotheses Testing

No.	Hypothesis	Results
	Hypothesis 1:	
1.	There is a bi-causality relationship between infrastructure investment and human development index (HDI) in Egypt.	**---------------**
	Hypothesis 2:	
2.	There is a bi-causality relationship between infrastructure investment and GDP growth in Egypt.	**Rejected**
	Hypothesis 3:	
3.	There is a bi-causality relationship between infrastructure investment and Inflation in Egypt.	**Rejected**
	Hypothesis 4:	
4.	There is a bi-causality relationship between infrastructure investment and Foreign Direct Investment (FDI) in Egypt.	**Accepted (Fail to Reject)**
	Hypothesis 5:	
5.	There is a bi-causality relationship between infrastructure investment and carbon footprint (CFT) in Egypt.	**Rejected**

5. Conclusion, Implications and Recommendations

5.1 Conclusion and implications

The Vector Error Correction model (VECM) has been informative about the dynamic relationship between infrastructure investment (as represented by the African Infrastructure Development Index — AIDI) and macro dynamic and GDP Growth, Inflation, Foreign Direct Investment (FDI), and Carbon Footprint in Egypt.

The VECM application was verified since the cointegration analysis showed that there exists a long-run equilibrium relationship among these variables. The ECT results indicate that AIDI, and GDP Growth show the highest speed of adjustment with negative and statistically significant coefficients. We are trained on data before 2023-10. In this, AIDI effects the most rapid adjustments, supporting that the construction of infrastructure is reactionary to systemic discrepancies within the larger macroeconomic setting.

Several statistically significant relationships were determined in the short-run dynamics with the VECM. AIDI has a catalyst function towards FDI; its short-run influence is positively significant for social and economic development. These results suggest that investments in infrastructure are not just a consequence of our economic policy but rather represent an engine of human welfare and the attraction of productive capital. But the negative short-run relationship between AIDI and GDP Growth suggests there are short-term burdens or delays attacking e.g. necessary infrastructure investment which may reduce output growth temporarily before the flow of benefits comes over in the long run. Moreover, the negative association between AIDI and Carbon Footprint indicates possible environmental trade-offs, which require careful attention to sustainable infrastructure planning and green investment strategies.

In summary, the VECM results highlight the importance of infrastructure to Egypt's development agenda and demonstrate its long-run integrative role and its short-run causal impact on key economic and environmental indicators.

The most relevant implications of these findings are:

1) policy interventions to expand and modernize infrastructure should be contextually aligned with macroeconomic and environmental targets.

2) expansion should prioritize global public goods, while also reducing global demand for climate-damaging industrial processes. Complementary policies,

including investment in human capital, regulatory reforms to bring in FDI, and environmental safeguards—can enhance the positive impact of infrastructure investment on growth and reduce the risks of short-term disruptions and long-run sustainability.

This empirical analysis adds to previous literature by examining the interplay between infrastructure investment and development benchmarks for a developing country. In addition, it confirms the theoretical concept that infrastructure is both a catalyst and the result of socio-economic change. Further studies could add to the context of this analysis using a sectoral infrastructure index or by using panel data across countries to generalize the findings to a broader context across the African continent.

Finally, From the VECM results, AIDI significantly corrects for increase to deviations from the long-run equilibrium relationship with GDP Growth, Inflation, FDI and Carbon Footprint. Overall, the negative and statistically significant error correction terms across all variables indicate a long-run relationship, as well as show that the variables appropriately react to disequilibrium. The short-run dynamics also show the significant predictive power of past changes in AIDI, FDI and Carbon Footprint for the current change in AIDI, suggesting important feedback effects in infrastructure investment behavior.

5.2 Recommendations

1. **Align Infrastructure Investment with Macroeconomic and Environmental Goals**:

   Policymakers must remain focused on how their strategies for infrastructure investments align with wider macroeconomic and environmental objectives. Long-term sustainability goals should also be addressed through infrastructure development but economic needs cannot be ignored as well. Targeting green investment strategies and placing emphasis on green infrastructure will mitigate the potential environmental trade-offs to growth.

2. **Prioritize Infrastructure Expansion for Global Public Goods**:

   Projects that deliver global public goods such as clean energy infrastructure, sustainable transportation systems, and climate-resilient infrastructure should be prioritized in expansion efforts. This strategy would foster domestic economic development and help reduce global environmental impacts by decreasing dependence on climate-destroying industrial methods.

3. **Address Short-Term Disruptions with Complementary Policies**:

to alleviate negative immediate effects of delays in infrastructure investment on economic growth, complementary policies ought to be introduced. Among them are investing in human capital, policy reforms to attract foreign direct investment (FDI), and the introduction of environmental safeguards. Such policies can mitigate the risks of short-term disruptions and encourage the long-term benefits of infrastructure development.

4. **Encourage Private Sector Participation in Infrastructure Investment**

Public–private partnerships (PPPs) should be encouraged to improve the efficiency and effectiveness of infrastructure investment. This may ease the pressure on government finances while allowing new ideas and efficiencies to develop and be implemented in creating and managing large infrastructure projects.

6.Further Research Directions

1. **Sector-Specific Infrastructure Impacts**:
   A sector-specific infrastructure like transportation, energy, and healthcare should be investigated regarding its effects on the growth of the economy versus environmental sustainability. This can lead to more nuanced understanding of how various kinds of infrastructure drive development.
2. **Cross-Country Analysis**:
   Study of panel data across different countries, especially in Africa, could be benchmarked to know if the finding of this study applies in other settings or not. Comparisons like these could be useful to policymakers in those economies.
3. **Digital and Technological Infrastructure**:
   As the telecommunications and information technology infrastructure increasingly drive economic development, research on these sectors regardless of the country of origin is critical. Examining how these factors helped shape macroeconomic stability provides a new lens on future infrastructure strategies.
4. **Environmental Impacts of Infrastructure**:
   More research should examine the implications of infrastructure investment on long-term environment issues such as carbon footprints.” It is through research where these strategies to minimize negative impacts on the land while maximizing the economic gains can be identified.

5. **Exploring Financing Models for Sustainable Infrastructure**:
   Exploring alternative financing approaches, like green bonds or impact investment, for sustainable infrastructure could further help to facilitate infrastructure development while meeting economic and environmental sustainability requirements. Similarly, studies can explore the practicality and efficiency of financing mechanisms of this sort in developing economies.

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ملخص:

تستكشف هذه الدراسة العلاقة الديناميكية بين استثمار البنية التحتية، المُقاس بمؤشر تنمية البنية التحتية الأفريقي (AIDI)، وأربعة متغيرات اقتصادية كلية أساسية - نمو الناتج المحلي الإجمالي، التضخم، الاستثمار الأجنبي المباشر، والبصمة الكربونية - في مصر، باستخدام نموذج تصحيح الخطأ المتعدد المتغيرات ((VECM) وقد اختُبرت هذه العلاقة الديناميكية لاستكشاف العلاقات طويلة وقصيرة الأجل بين استثمارات البنية التحتية في مصر ومتغيرات الاقتصاد الكلي المختارة خلال الفترة من ٢٠٠٥ إلى ٢٠٢٢. وتكشف النتائج عن وجود ارتباط طويل الأجل بين هذه المتغيرات، حيث سجل مؤشر تنمية البنية التحتية الأفريقي (AIDI) ونمو الناتج المحلي الإجمالي أعلى معدل تكيف. وعلى المدى الطويل، يُمثل مؤشر تنمية البنية التحتية الأفريقي (AIDI) قوة دافعة للاستثمار الأجنبي المباشر، ويؤثر بدوره إيجابًا على النمو، ولكن وُجد أن له آثارًا سلبية قصيرة الأجل على كل من النمو الاقتصادي والبصمة الكربونية. وتشير هذه النتائج بوضوح إلى ضرورة أن تكون استثمارات البنية التحتية متكامله بشكل وثيق مع الأهداف الاقتصادية الكلية والبيئية، مع الإخذ في الاعتبار معالجة الاضطرابات قصيرة الأجل.

الكلمات المفتاحية: البنية التحتية، مؤشر تنمية البنية التحتية الأفريقية(AIDI) ، الاستثمار الأجنبي المباشر(FDI) ، البصمة الكربونية(CFP) ، نموذج تصحيح الخطأ متعدد المتغيرات (VECM)