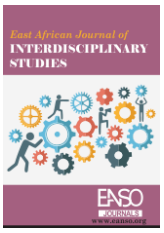
Article DOI: https://doi.org/10.37284/eajis.8.1.2949



East African Journal of Interdisciplinary Studies
eajis.eanso.org
Volume 8, Issue 1, 2025
Print ISSN: 2707-529X | Online ISSN: 2707-5303
Title DOI: https://doi.org/10.37284/2707-5303

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Effect of Road Infrastructure on Selected Economic Development Indicators in Kenya

Dennis Kiiru Njihia[1*] *& Charles Nzai, PhD*[1]

[1] Kenyatta University, P.O. Box 43844-00100, Nairobi, Kenya.
* Author's Email: dkiirum@gmail.com

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Date Published:

05 May 2025

Keywords:

Civil-Military Relations, Uganda Military, Uganda Police, Operation Wealth Creation, National Agricultural Advisory Services, Military Support, Military Socialisation.

ABSTRACT

Kenya, as a developing nation, has been making significant investments in infrastructure projects, including roads, railways, ports, and energy, in recent years. Such infrastructure development is expected to have far-reaching implications for various sectors of the economy. Efficient and reliable infrastructure networks are crucial for facilitating trade, attracting investments, improving connectivity, reducing transaction costs, and promoting economic activities. However, while there is a general understanding of the importance of infrastructure, it is essential to conduct a focused study to examine the specific effects and outcomes of infrastructure development in Kenya. The study was anchored by Solow neoclassical growth theory. A longitudinal research design was adopted. The study utilized time series secondary data from 1991 to 2021 on an annual basis. The data was obtained from the World Bank and the Kenya National Bureau of Statistics. Empirically, the study developed a transport-growth model that is an extension of Solow (1956) neoclassical growth function and estimate the model with time series data of Kenya. The study adopted Autoregressive Distributed Lag (ARDL) model and Granger causality approach as the technique for testing the study relationships. Diagnostic tests such as normality, Multicollinearity, heteroskedasticity and autocorrelation was conducted to ensure that the assumptions of regression analysis are not violated. Ethical considerations was adhered to by obtaining permit from NACOSTI, Kenyatta university graduate school and the permission from the ethical committee. The short run effect were analysed using ECM informed by the positive cointegration status of the variables all the models. Road infrastructure, labour participation and institution quality index significantly affected economic growth. However, technological growth has insignificant effect on economic growth. It can be concluded that, based on empirical results technological progress has not been fully utilised to generate economic growth. It is also important to point out that the creation of a conducive environment, particularly innovation and technological space enhances economic growth. This can be attained by having a tax haven for the inaugural innovators to sustain their motivation. Strong institutions are defined by adherence to the rule of law and conformity to

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

legislation. There is a need for people in the public sector to embrace the rule of law and existing regulations to reduce theft and corruption.

APA CITATION

Njihia, D. K. & Nzai, C. (2025). Effect of Road Infrastructure on Selected Economic Development Indicators in Kenya. *East African Journal of Interdisciplinary Studies*, *8*(1), 251-268. https://doi.org/10.37284/eajis.8.1.2949.

CHICAGO CITATION

Njihia, Dennis Kiiru and Charles Nzai. 2025. "Effect of Road Infrastructure on Selected Economic Development Indicators in Kenya". *East African Journal of Interdisciplinary Studies* 8 (1), 251-268. https://doi.org/10.37284/eajis.8.1.2949.

HARVARD CITATION

Njihia, D. K. & Nzai, C. (2025) "Effect of Road Infrastructure on Selected Economic Development Indicators in Kenya", *East African Journal of Interdisciplinary Studies*, 8(1), pp. 251-268. doi: 10.37284/eajis.8.1.2949.

IEEE CITATION

D. K., Njihia & C., Nzai "Effect of Road Infrastructure on Selected Economic Development Indicators in Kenya", *EAJIS*, vol. 8, no. 1, pp. 251-268, May. 2025.

MLA CITATION

Njihia, Dennis Kiiru & Charles Nzai. "Effect of Road Infrastructure on Selected Economic Development Indicators in Kenya". *East African Journal of Interdisciplinary Studies*, Vol. 8, no. 1, May. 2025, pp. 251-268, doi:10.37284/eajis.8.1.2949.

INTRODUCTION

The impacts of road infrastructure on the economy and communities have been studied by numerous scholars and the opinions have been varied, (Deng, 2013). Many researchers contend that rural roads ought to be enhanced in places where levels of poverty are severe with aim of integrating rural farmers and people into the market economy (Aderogba & Adegboye, 2019; Bhattacharya & Deka, 2021). On the other hand, other scholars argue that roads should be primarily improved in places where there are already existing viable economic activities, thus accelerating the dynamic process for commercial farming activities and subsequent manufacturing. However, despite all the contrasting opinions, there is a widely agreed-upon opinion that roads have considerable positive impacts on poverty reduction and the economy at large.

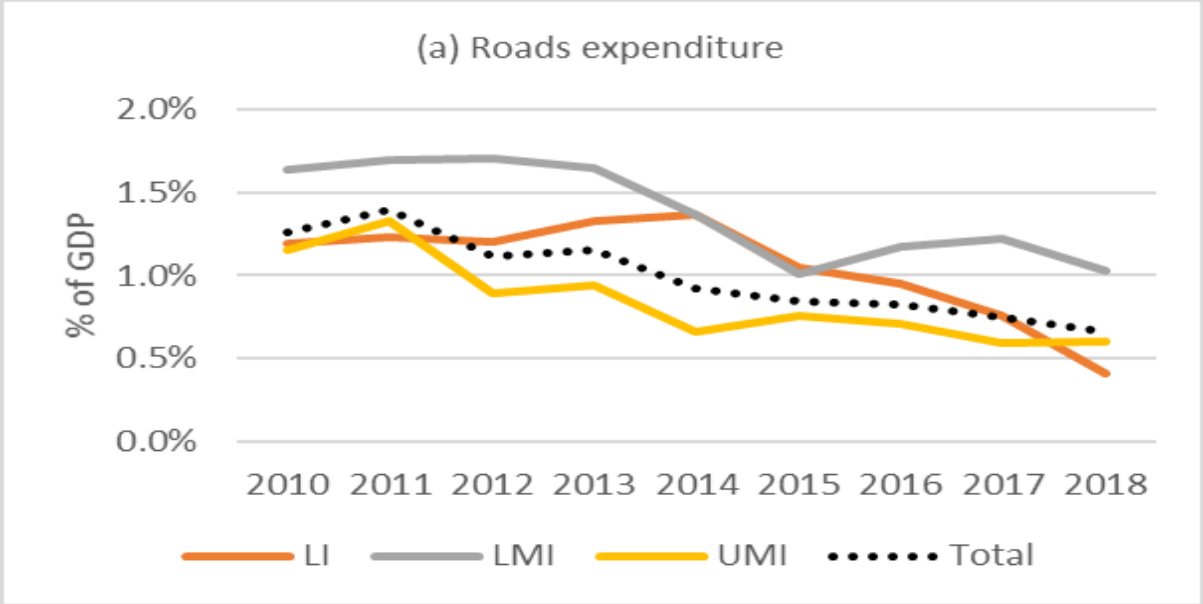
Transport infrastructure development has been identified as one critical ingredient to sustain development and accelerate economic transformation of a country (Pradhan & Bagchi, 2013). Among the various transport infrastructures, road infrastructure is essential in accelerating connectivity across the country, creating gross capital formation, reducing costs of economic production by cutting down transport expenses, facilitating movement of goods and services, human capital among others (Carrai, 2021). Well-established road networks create the necessary linkages between geographically dispersed facilities; facilitate social interactions and contact among economic agents, facilitating access to better health, education and other essential social services that speed economic growth and sustainable development (Khanani, et al., 2021). This also applies to rural areas where agriculture and livestock is the main economic activity. Therefore, improving rural access through good roads can lead to improved agricultural production by lowering costs for farm inputs and transport costs for marketed produce. Good road networks increase fertiliser utilisation, more yields, improve production, create more employment opportunities, improve living standards and reduce poverty levels (Githaiga & Bing, 2019).

On scholarly terms, the impact of road infrastructure on economic development remains a debatable topic lacking consensus. As such, the viability of road infrastructure has to be linked to government spending on a case-to-case basis. According to Foster et al. (2022), it is critical to consider the aggregate expenditure from roads alongside recurrent budgetary expenditure to enable cross-country comparisons of the sufficiency of funding

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

road repairs and maintenance. Governments globally continue to spend a lot of financial resources, human resources and material resources on road infrastructure. Among the OECD countries, the expenditure on road infrastructure as a percentage to Gross Domestic Product (GDP) was 0.7% in 2019 (International Transport Forum, 2021). China recorded the highest spending on road infrastructure as a percentage of GDP during the same period, 5.5 percent of GDP (International Transport Forum, 2021). The other highest spending on roads were Georgia (3.1 percent), Belarus (2.5 percent), Hungary (2.2 percent), Azerbaijan (2.0 percent) and Serbia (1.7 percent). In Sub-Saharan Africa, the expenditure on roads only averaged less than 2 percent of GDP, with significant variance across the various countries. In the industrialised economies, at least 1 percent of GDP is allocated to roads, and an average of 2 to 3 percent of GDP in the fast-emerging economies. Figure 1 shows road expenditure as % of GDP in low-income countries (LI), low-middle-income countries (LMI) and upper middle income (UMI).

Figure 1: Road expenditure % of GDP in low-income countries (LI), low middle-income countries (LMI) and upper middle income



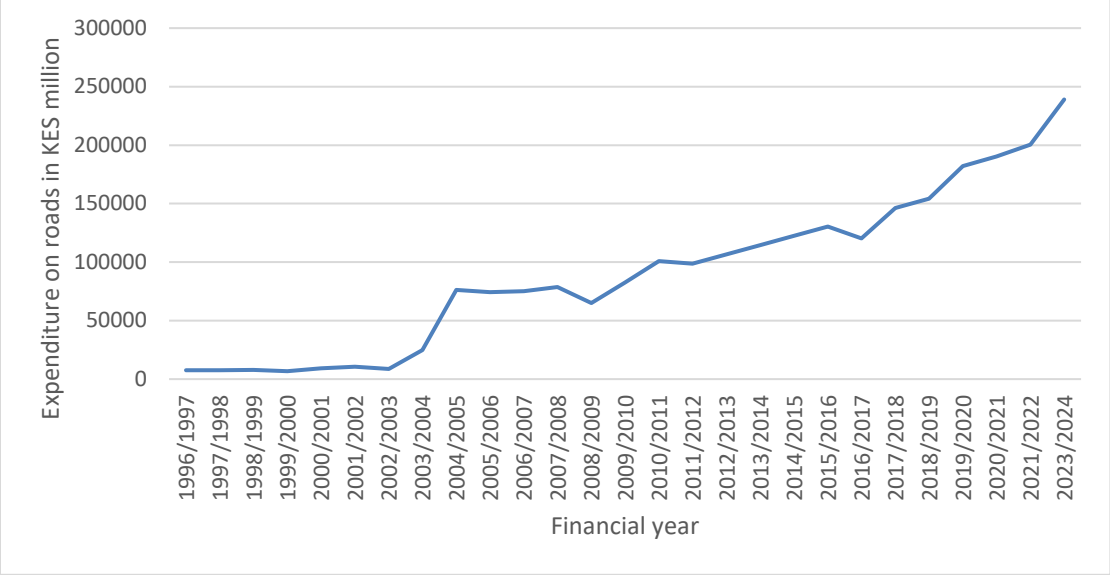
Source: *Authors' elaboration based on BOOST database*

Figure 1 shows that road expenditure was highest in low-middle-income countries and lowest in upper-middle-income countries, but has generally been declining between the periods 2010 to 2018. Aggregate expenditure on roads, accounted for about 0.8 percent of GDP. Average spending on roads is relatively high in low middle-income countries and low-income countries. In the upper-middle-income countries the spending on roads is the lowest.

Roads are a source of socioeconomic transformation. It is argued that government expenditure on road infrastructure will have a notable impact on GDP in Kenya. Considering this, Kenya over time has been allocating huge amounts to the government budgets on roads. The expenditure on roads over the years has been rising with an upward trajectory through with cuts in some years. Figure 2 shows annual expenditure by the Kenyan government on roads from the financial year 1996/1997 to the financial year 2023/2024.

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Figure 2: Expenditure on roads in KES million



Source. *Kenya Roads Authority*

Based on the Figure 2, the expenditure on roads has been rising over the years, though with some falls in some financial years. From 1996 to 2003, the allocation of funds to roads in Kenya was less than KES 10 billion. However, from the financial year 2003/2004, there was a sharp increase in the allocation of funds to KES 24.9 billion. This was after the coming of the National Rainbow Coalition (NARC) led by Late President Mwai Kibaki, who was seen as more oriented to infrastructure compared to his predecessor, Late President Daniel Toroitich Arap Moi (Ministry of Planning and National Development, 2003/2007; Burgess et al., 2015). The value of road building has been identified in the empirical research. From 2003/2004, there has been an increased allocation of funds to roads in Kenya. The allocation of funds to roads has been reflected in the increase in the total road network in Kenya. Figure 3 shows total road networks in Kenya in kilometres from 1996/1997 to 2023/2024.

Statement of the Problem

Road infrastructure plays a vital role in economic development by facilitating the movement of goods, services, and people. In Kenya, the fact that a significant portion of the population relies on rural agriculture as their primary source of income, improved road infrastructure may directly impact the livelihoods of the rural populations. Accessible and efficient road infrastructure is essential for farmers to transport their produce to markets and consumers, enabling economic growth and income generation (Lesutis, 2022). However, despite the a priori expectations of theory on the relationships between improved road infrastructure and economic growth and poverty levels, data for Kenya reveal contrary behaviour which warrants investigation. Both expenditure by the government to improve road infrastructure in Kenya and the quantity of paved roads steadily rose from 1997 to 2023 but economic growth (GDP) more or so remained stagnant during the same period, posting an average of about 5 per cent growth rate or less. Astonishingly, per capita income of the country's people rose steadily between the same periods, which is consistent with a priori theoretical expectation with the rise in improved road infrastructure. But where did this per capita income come from when GDP was more or less stagnant, and the population has been rising? Equally, poverty levels generally fell during the same period, once

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

again raising questions about such a trend when GDP was not doing well. These contradictory trends in the country without doubt demand thorough investigations.

The existing literature has exploited the influence of road infrastructure on economic growth, and some areas relating to this subject have not been explored fully and this resulted in a research gap. The research observed gaps in the methodology that the previous studies employed in estimating the effects of road infrastructure on economic growth study done by Mose (2022) did to establish why the trends on expenditure on road infrastructure (rising) and economic growth (stagnant) were direct opposites but revealed a positive relationship between them.

Theoretical Framework

This section comprises theoretical literature employed and the synthesis of other studies undertaken on road infrastructure and economic development. It also outlines the theoretical underpinnings and review of existing literature.

Theoretical Literature

The study was posited by Solow neoclassical growth theory. Solow's neoclassical growth theory, also known as the Solow-Swan model, was advanced independently by Robert Solow and Trevor Swan in the mid-1950s. Solow, an American economist, developed the model in 1956, while Swan, an Australian economist, extended and formalised it in 1956-1957. The theory postulates that labour force growth, capital accumulation, and technological progress drive long-term economic growth (Deardorff, 1970). It suggests that in the long run, increases in physical capital and improvements in technology contribute to economic growth, while diminishing returns to capital and labour prevent sustained economic expansion (Dykas, Tokarski & Wisła, 2022). The idea emphasises the significance of investing in human and physical capital and promoting innovation for long-term increases in production and living standards (Lee, 2022). It also emphasises the relevance of technology developments and productivity gains in driving economic growth.

Solow's neoclassical growth theory is predicated on a number of important tenets. The first is that it assumes a steady pace of technical advancement that has an impact on the economy's total productivity (Udoh, Ukere, & Ekpenyong, 2023). Second, according to Segura, Franco, and Perán (2023), it is predicated on the concept of diminishing returns to labour and capital, which states that as labour and capital inputs rise, the additional production attained from each new unit decreases with time. The theory also counts on perfect market competition as well as constant rates of savings and investment. The hypothesis has its detractors, though. Its detractors contend that it ignores the contribution of institutional elements, entrepreneurship, and innovation to economic growth. Additionally, it ignores the possible negative effects of inequality on economic progress by failing to take into consideration the unequal distribution of wealth and income. The theory also makes the assumption that the labour force is homogenous and does not fully address the dynamics of technological advancement and its effect on long-term growth (Gori, Manfredi, Marsiglio & Sodini, 2022).

The neoclassical growth theory of Solow is crucial for comprehending the connection between Kenyan economic progress and road building. The idea emphasises how investments in physical infrastructure, such as road systems, are crucial to capital accumulation, which promotes economic growth. Road infrastructure is essential for enabling mobility, lowering transaction costs, and enhancing market access in Kenya. Kenya can improve connectivity, encourage commerce and investment, and boost economic activity by investing in road infrastructure. The theory further emphasises the role of technical development by arguing that improvements in road infrastructure may result in increases in productivity and efficiency. The neoclassical growth theory of Solow can assist

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Kenyan policymakers in appreciating the importance of road infrastructure as a driver of economic development and direct them in making smart investments that would promote long-term growth and higher living standards.

Empirical Literature

In India, Nenavath (2023) did a study on the impact of transportation infrastructure on economic growth employing ARDL models. Data covering the period 1990 to 2020 was employed. Nenavath (2023) found that in the long run, transportation infrastructures had a positive impact on economic growth in India, except air transport infrastructure. In addition, Granger causality test demonstrated a unidirectional effect from transport infrastructure to economic growth.

By adopting Solow (1956) neoclassical growth function, Mose (2022) investigated the nexus between road transport infrastructure and economic growth with a focus to the Kenyan scenario. Time series data covering the years 1990-2020 were employed. The Granger causality technique and ARDL were adapted to model the relationship between the study variables. It was established that both in the short run and long run, growth in road length measured by total expenditure on roads had a positive and statistically significant impact on economic growth. Additionally, causality relationship between road infrastructure development and economic growth was established by error correction model (ECM).

In Indonesia, Nawir et al. (2023) did a study on the impact of road infrastructure development on economic growth in. Self-administrative surveys-based on Cross-impact Direct Influence and interviews were adapted. For the data analysis purpose, Cross-impact matrix multiplication applied to the classification (MICMAC) method and the Scenario Wizard package was utilised. Based on the MICMAC assessment, nine key factors were essential in the development of road infrastructures in Indonesia. They comprise investment in technology and innovative practices, a master plan for road infrastructure development, transportation system, development of action plans, master plan for road infrastructure development, maintaining a comprehensive transport database, financial-economic facilities, community participation, transportation management, addressing transportation/ land-use conflicts, safety and security. A positive impact on economic growth was established.

Irshad and Ghafoor (2023) aimed to examine the nexus between road infrastructure and economic growth in a sample of 91 countries. The authors employed panel data analysis, using fixed effects models and instrumental variables estimation. The study discovered a positive and statistically significant link between improved road systems and economic expansion. They came to the conclusion that expanding the road network may significantly affect economic growth. Some opponents claim that because the study only focused on the one-way link between infrastructure and growth, it failed to appropriately account for potential reverse causation. Additionally, the study's use of aggregate data may obscure the diversity of ways that road infrastructure impacts various industries and geographical areas within nations.

Using a sizable panel dataset of 71 nations, Badada, Delina, Baiqing, and Krishnaraj (2023) evaluated the impact of road infrastructure on economic growth. The generalised method of moments (GMM) estimate was one of the strategies the authors used while working with dynamic panel data. The research revealed a favourable and substantial link between improved road systems and economic expansion. They concluded that expenditures in road infrastructure had long-lasting benefits on economic growth. Some opponents claim that the study's emphasis on statistics at the national level may have missed the variation in how road infrastructure affects people at the local or regional levels. Additionally, the study did not specifically take into account the state of the road

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

system, which may have an impact on how it affects economic growth.

The goal of Ghahari, Tsui Alabi et al. (2019) was to examine how roadway infrastructure affects state-level economic development in the US. The authors looked at the association between highway capital stock and economic development across states using fixed-effects panel data models. According to the study, a direct and statistically significant link between state-level economic development and highway infrastructure was established. They concluded that investing more in highways helps the economy. Critics contend that the study's singular emphasis on the United States restricts the applicability of its conclusions to other areas or nations. The study did not take into account the interplay between road infrastructure and other types of infrastructure or potential spillover effects of highway expansion on adjacent states.

Ben (2019) sought to investigate how road infrastructure affects urban economic development in the US. The authors investigated the link between road infrastructure and urban economic growth using spatial econometric methods such as fixed-effects estimates and instrumental variables. According to the study, there is a direct and positive correlation between road infrastructure and urban economic growth. They concluded that investments in road infrastructure help metropolitan regions' economies grow. Critics claim that the study's concentration on metropolitan areas within a single nation may restrict the findings' applicability to rural areas or other places worldwide. The possible differential effects of road infrastructure on various sorts of economic activity inside metropolitan areas were also not expressly taken into account by the study.

Overview of the Literature and Research Gaps

There is a wealth of research gaps on the impact of road infrastructure on economic growth, with theoretical frameworks and empirical studies examining this relationship in various nations and areas. The study reviewed Solow's neoclassical growth theory. There are still some gaps and places that may use further investigation, but overall, the available data shows a good correlation between road infrastructure and economic growth. Past studies have elicited debate regarding the viability of road infrastructure in driving economic growth. The proponents of road infrastructure argue that roads are critical linkages in the opening up the economically resourceful but neglected areas. However, critics argue that road infrastructure consumes huge financial resources, which may not be recouped, especially in low-resource regions.

Studies like those by Taghizadeh-Hesary, et al. (2021) and Mattson (2021) have demonstrated a favourable effect of road infrastructure on GDP growth. These studies emphasize how better road connectivity may increase market access, ease commerce, and draw in investment. To account for any variation in these impacts across different nations and areas and to understand the precise processes by which road infrastructure boosts economic growth, additional study is nonetheless required.

There are still a few holes in the field's knowledge despite the enormous quantity of studies that have been done. In order to determine the real direct influence of road infrastructure on economic growth and resolve any endogeneity difficulties, a more thorough causal study is first required. The particular pathways and methods through which road infrastructure affects economic growth, including spillover effects, agglomeration economies, and sector-specific impacts, require additional study. By examining how Kenya's economic development is impacted by its road infrastructure, the current study seeks to make a contribution to this field. Additionally, past research has demonstrated that transport infrastructure is fundamental for economic growth (Aderogba and Adegboye, 2019; Iskandar, 2023; Nenavath, 2023).

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Research Methodology

The study used non-experimental study design. Unlike experimental study design, this design does not enable the researcher to manipulate collected data. Data source is primary and was collected by use of structured questionnaires. The effect of road infrastructure on economic growth was modeled by Solow's neoclassical growth theory. Solow's neoclassical growth theory, while primarily focused on explaining long-term economic growth, can provide insights into the nexus between road infrastructure and economic development. The model however was later improved to include other elements like infrastructure, savings and population growth (Barro, 1990; Gisore, 2021). While labour, capital, and technology are the primary factors influencing economic growth through capital formation, roads are included as an additional input in the neoclassical aggregate production function within the modified Solow model, which supports the infrastructure-led economic growth (Tang & Tan, 2017).

In Solow's framework, the impact of road infrastructure on economic development is captured through the accumulation of capital. Better road infrastructure can enhance the productivity of businesses, reduce transportation costs, and increase the efficiency of resource allocation. These improvements can contribute to increased investment, improved resource utilization, and overall economic output. The Solow model argues that economic growth is affected by labour, capital, and technology.

The Solow-Swan growth model takes into account labour or population growth, capital accumulation, and increases in productivity, sometimes known as technical advancement, to try to explain long-term economic growth. The Solow-Swan model, a nonlinear model with a single ordinary differential equation that predicts the change in the per capita stock of capital, is built from the Cobb-Douglas type production function;

$$Q = AK^aL^b \quad \ldots\ldots 1$$

Where; Q is output**,** **A** is **multifactor productivity**, **a** and **b<1**, signifying declining returns to a single factor, and **a + b = 1**, signifying constant returns to scale.

Any rise in production Q, according to Solow-Swan, could result from one of three things:

1. An improvement in L. However, this could suggest a decrease in Q-L or output per worker due to diminishing returns to scale.

2. An elevation of K; the production and Q-L would both rise with an increase in the capital stock.

3. An increase in Q-L or output per worker could also be accompanied by a change in A or multifactor productivity in the production system or progress.

Solow modified the production function of Cobb-Douglas form into what is sometimes referred to as per capita form in order to focus on what occurs to Q-L or output per worker and consequently, except the employment ratio changes, output per capita also changes as follows:

$$Q/_L = AK^aL^{1-b} = A\,K^a/_{L^{1-b}} \quad \ldots\ldots 2$$

since multiplying by L^{1-b} is the same as dividing by L^{1-b}. Additionally, subsequently the model assumes that a + b = 1 and that; a = 1 - b.

$$Q/_L = A\,K^a/_{L^a} = A\left(K/_L\right)^a \quad \ldots\ldots 3$$

Defining q is given as $Q/_L$ and k is given as $K/_L$, that is, letting **small letters equal per-capita income variables,** the Solow model is ultimately stated in Equation 4, which explains the dynamics of the model when growth emanates because of changes in technology and capital accumulation.

$$q = Ak^a \quad \ldots\ldots 4$$

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Equation 4 is consistent with this study's empirical models for objectives one and two since q was GDP economic growth; and, k capital. Therefore, as per equation 3, growth in labour, capital and technology triggers the economic growth which then triggers per capita GDP. Thus, the growth rate of total factor productivity can be estimated if data on the capital stock formation, labour force and output growth rate are available.

The linear empirical model proved to be essential in this study in estimating the impact of road infrastructure on economic development. See the general linear equation in 5.

$$Y_g = \beta_0 + \beta_j X_k + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots 5$$

As per the equation, Y_g stands for the predictor variables, that is the selected economic indicators that include economic growth, poverty reduction and per capita income. The X_k is the predictor variable road infrastructure. The ε is the error term of the model representing measurement errors, random fluctuations or other exogenous variables that impact the model but are not included. However, road infrastructure is not the only factor that affects economic growth, poverty reduction and per capita income, but there are other factors selected in the theoretical and empirical literature. The other explanatory variables include labour force, technological growth, capital stock formation, population growth, institutional quality and human development index. By including these other explanatory factors, the empirical model to determine the effect of road infrastructure on economic growth and per capita GDP in Kenya

$$Y_g = \beta_0 + \beta_1 RI_t + \beta_2 L_t + \beta_3 A_t + \beta_4 CSF_t + \beta_5 PG_t + \beta_6 IQI_t + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where is Y_g represents economic growth, RI is road infrastructure, L is labour force, A_2 is technological growth, CSF capital stock formation, PG is population growth and IQI institutional quality index. t is time, ε *is* the erro term of the model.

Measurement of the study variables are presented in Table 1.

Table 1: Operationalization and Measurement of Variables

Variable	Meaning	Unit Measure
Dependent variables		
Economic growth	Defines the increase in the total value of goods and services produced within an economy over a specific period.	Economic growth rate per year
Independent variables		
Road infrastructure	connotes the physical network of roads, highways, bridges, and related facilities that enable transportation and connectivity within a geographical area	Total length of roads in km
Labour force participation	Refers to the productive labour force in the economy	This is the labour force participation rate, is a measure in percentage of the aggregate productive population aged 15 and above (Labour force participation rate (% of total population ages 15+))
Technologic growth	Refers to technological progress in output production.	It was measured as the % amount of money to GDP spent on R&D over the study period
Capital stock formation	Refers to the total value of the gross fixed capital formation, inventories,	It was measured as % gross capital formation to GDP

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Variable	Meaning	Unit Measure
	acquisitions subtracting disposals of valuables.	
Population growth	Refers to change in human populations	Annual % growth in the number of people
Institutional quality index	Is proxy of the efficiency of the government.	A composite of political stability, government effectiveness, control of corruption, rule of law, regulatory quality, and voice and accountability (0-100%)
Human development index	The human development index refers to level of development of human being based on three parameters.	The parameters include education, health, and income where a composite index that comprises the three indicators of HDI (0-100%)

Data analyzing entails the process of cleaning data, preparing and with the aid of a software, examining the data to come up with meaningful information (Cooper & Schindler, 2017). Data analysis was conducted using EViews 10. A significance level of $p < 0.05$ was used. Data analyses involved descriptive tests (means, standard deviation, minimums and maximums) and inferential (time series models). The study adopted Autoregressive Distributed Lag (ARDL) model to determine the effect of road infrastructure on selected economic development indicators.

Results

The section presented finding of the study and its discussions.

Descriptive Statistics

Descriptive statistics is important in providing data structure and its distribution that informed the modelling. It enables the research feel and explore the nature of data in answering research question or enabling researcher attaining study objectives.

Table 2: Descriptive Results

Variable	Mean	Median	maximum	Minimum	Std Dev	Skewness	kurtosis
Economic growth (Percentage)	3.6014	3.8379	8.0584	-0.7984	2.3771	-0.1694	2.1876
Road infrastructure (KM)	10556.02	10455.1	21983.0	1850.0	6304.7	0.1333	1.7377
Labour force participation	73.5251	73.2340	74.4100	72.3900	0.6165	0.1783	1.772
Technologic growth (percentage)	0.3012	0.2600	0.8900	0.1500	0.1579	1.6815	6.8558
Capital stock formation	19.119	19.3418	24.950	15.003	2.4781	0.1055	2.4663
Population growth	2.670	2.8093	3.2116	1.9427	0.3801	-0.6902	2.0739
Institutional quality index	20.2922	20.3715	29.0476	10.27027	4.7267	-0.0114	2.5327
Human development index	0.5219	0.525	0.6000	0.471	0.0415	0.1599	1.5547

Based on the finding in Table 2, economic growth of Kenya averaged at 3.6% annually and this characterized was by highest growth recorded at 8.05% and lowest growth at -0.79% and this yielded a deviation of 2.3771. The Economic growth has a negative skewness of -0.16% and this implied that

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

economic growth has been fluctuating over the study period.

The country has constructed an average of 10,556.02km in the last 20 years with the highest road constructed stretching to 21,983.0km and on the lower bound ranging at 1850.0km. This resulted to a deviation of 6,304.7 and skewness of 0.1333 (positive). The labour force participation nationally averaged at 73.525 percent, the highest participation recorded was 74.41 percent and the lowest participation was 72.39. The level of labour participation resulted to a deviation of 0.6165 and skewness of 0.1783. The labour participation has been stagnating at 70 percent and this has not improved over time hence has been constant.

The technological growth averaged at 0.3012% of GDP and the highest recorded was 0.89% and the lowest was 0.1500% of GDP. This amounted to a deviation of 0.1579 and skewness of 1.6815. The allocation of resources to aid research and development activities and evidently it remains low against the projection of 2 percent of GDP. The capital stock formation averaged at 19.119% of GDP. The country devoted 24.950% of GDP to capital formation on the upper end and 15.00% of GDP on the lower end. This resulted to a deviation of 2.4781 and positive skewness (0.1050). The increase in capital stock formation is essential in driving productivity and hence enhancing GDP growth. The population growth averaged at 2.67%, with the highest growth hitting 3.2116% and slowing down to 1.9427%. This generated a deviation of 0.3801 and negative skewness (-0.6902). This implies that the population growth rate has been steady.

The institutional quality index recorded an average of 20.3%, with the highest being 29.04% and the lowest being 10.27%. This resulted in a deviation of 4.7267 and a negative skewness (-0. 0114). The human development index averaged at 0.5219, while the highest human development index was 0.60 and the lowest HDI was 0.471. This generated a deviation of 0.0415 and positive skewness (0.1599). The HDI has stagnated within the period under investigation.

Time Series Properties

Time series data needs to be checked to avoid spurious relationships. Time series data is checked by undertaking a unit root test and establishing their stationarity status. A combination of stationary and non-stationary variables (Dependent and Explanatory) requires specific type of model to be employed to avoid a spurious relationship. The study used Augmented Dickey-Fuller test to check stationarity of the variables. The use of ADF is considered appropriate for homoscedastic and uncorrelated errors (Herranz, 2017). The study developed hypothesis that guided testing of the unit root, where the null hypothesis stated that there is a unit root in the data set to be tested, while alternative hypothesis implied that the data set was stationary. The decision rule to either reject or accept null hypothesis was determined by the p values generated that is if p values produced is less than 0.05 then reject null hypothesis and conclude the data set is stationary and the converse is also true. The result of the research is presented in Table 3 at the Unit level.

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Table 3: Unit Root Results at Level

Variable	ADF at Level	P-Values	Status
Economic growth	-4.1063	0.0034	Stationary
Road infrastructure	2.6613	1.000	Non Stationary
Labour force participation	-2.1166	0.2401	Non Stationary
Technologic growth	-4.2225	0.0025	Stationary
Capital stock formation	-2.5606	0.1121	Non Stationary
Population growth	-0.1538	0.9339	Non Stationary
Institutional quality index	-1.1272	0.6917	Non Stationary
Human development index	0.3531	0.9771	Non Stationary

The finding of the ADF computation as indicated in Table 3 show that all the variables except technological growth and economic growth are non-stationary. The variables of technological growth and economic growth are stationary at the level. There was a need to generate first differences of variables that were non-stationary and test their stationarity status and the findings are presented in Table 4.

Table 4: Unit Root results after differencing

Variable	ADF at Level	P-Values	Status
Poverty reduction	-4.4316	0.0015	Stationary
Per capita income	-3.4154	0.0186	Stationary
Road infrastructure	-3.9443	0.0052	Stationary
Labour force participation	-9.4276	0.0000	Stationary
Capital stock formation	-6.8547	0.00000	Stationary
Population growth	-5.1841	0.00003	Stationary
Institutional quality index	-6.1324	0.0000	Stationary
Human development index	-4.4316	0.0015	Stationary

The finding in table 4 indicated that all the variables that were non stationary at level are stationary at first at all levels. Therefore justify the use of ARDL model since variables were either stationary at level I(0) or stationary at first difference I(1).

ARDL Model Diagnostic Tests

The study carried out various diagnostic tests to check the fitness of the model and these include normality test, serial correlation and Heteroscedasticity.

Normality

Jarque Bera test that target residuals was undertaken to check whether data conform to the OLS assumption of new skewness and normal distribution of residuals and the finding is presented in Table 5.

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Table 5: Normality Test Results

Variable	Jarque-Bera Statistics	Probability
Capital formation	0.425397	0.8084000
GDP growth	1.000824	0.606281
Human Development Index	2.830822	0.242887
Institutional	0.282726	0.868224
Labour	2.1110559	0.348095
Per Capita Income	3.566883	0.168060
Population Growth	3.569223	0.167862
Poverty Rate	0.710840	0.700879
Roads	2.149747	0.341341
Technology	13.81368	0.0600

Based on the findings presented in Table 5, Jarque Bera statistic of all the variables supported by p values were greater than 0.05 and this depicted that all the variables' residuals followed a normal distribution.

Serial Correlation

Breusch-Godfrey Serial Correlation LM Test was adopted by the investigation to check for autocorrelation in the error terms. It involved the formulation of a null hypothesis that predicted that there is no correlation in the data set, while the alternative hypothesis stated otherwise and these results are presented in Table 6.

Table 6: Serial Correlation Results

Breusch-Godfrey serial correlation LM Test (2 Lags)			
F statistics	1.078405	Prob F(2,11)	0.3735
R square	4.426138	Prob Chi square	0.1094

The findings in Table 6 indicated that F-statistic was 1.078405 supported by a p-value of 0.3735. The generated p-value was larger than 0.05 and this indicated that lack of serial correlation in the dataset. Null hypothesis was not discarded and a conclusion was drawn that absence of serial correlation in the data set.

Heteroscedasticity

The study carried out a test of heteroscedasticity using Breusch-Pagan/Godfrey test. The study tested a null hypothesis which stated that error variance is homoscedastic and the finding is presented in Table 7.

Table 7: Heteroscedasticity Findings

Heteroscedasticity **Test Breusch-Pagan- Godfrey**			
F statistics	0.764773	Prob F(13,13)	0.6821
R squared	11.70058	Prob.Chi-Square (13)	0.5523
Scaled explained SS	2.206141	Prob.Chi-Square (13)	0.9996

The finding of the study established that F F-statistic was 0.764773 and this was supported by p value of 0.6821. A P value larger than 0.05 was obtained, hence the variance of the error term was constant. This affirmed the null hypothesis that there is no heteroscedasticity in the data set and further analysis can be undertaken.

Model Estimation

The study employed ARDL-ECM to determine the relationship among the study variables. Before

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

running ARDL-ECM it is essential to explore the long-term relationship of the study variables. Cointegration test is an econometric tool employed in testing the long-term relationship of variables.

Cointegration Test

Since the variables were of I(0) and I(1) bound test was employed. The findings is presented in Table 8.

Table 8: Bound Test Results for Cointegration

Bound Test	Calculated F	Lower critical F value	Upper critical F value	Level of significance
Model 1	18.6893	2.56	3.49	5%
Model 2	4.0230	2.56	3.49	5%
Model 3	9.2555	2.56	3.49	5%

Based on the findings in Table 8 calculated F values of the models are 18.6893, 4.0230 and 9.2555 and all were greater than the upper critical F values (3.49) for the test. This implies that there exists a long-term relationship among the study variables in each model, hence they are cointegrated. Therefore, long-term relationship exists between the dependent and explanatory variables under investigation.

Effect of road infrastructure on economic growth in Kenya

The cointegration analysis established the presence of a long-term relationship between the variables. There is need to undertake ECM to establish the speed of adjustment to equilibrium on the effect of road infrastructure on economic growth. The study used AIC to determine the minimum number of lags required to establish the short- and long-term effects of road infrastructure on economic growth. The study used initial lag length of 4, ARDL Model (3,3,3,0,3,3). The model also provided the significance of each lags of each variable under estimation. The finding is presented in Table 9.

Table 9: ARDL Model Results

Variable	Coefficient	Std. error	t-statistic	prob
D(GDP(-1)	1.715133	0.155081	11.05962	0.0001
D(GDP(-2)	0.719981	0.091641	7.856563	0.0005
D(GDP(-3)	0.214441	0.051160	4.21110	0.0001
D(Roads)	0.004277	0.000425	10.06019	0.0002
D(labour)	2.175427	0.684519	3.178036	0.0246
D(Tech)	2.320937	0.546172	4.249462	0.0081
D(Pop)	-13.03947	3.112822	-4.188955	0.0086
D(Inst)	0.222707	0.124480	1.789101	0.0914
CointEq(-1)*	**-0.319128**	**0.0213098**	**-14.97569**	**0.0000**
Long Run Coefficients				
Variable	**Coefficient**	**Std. error**	**t-statistic**	**prob**
Roads	0.000581	0.00103	5.631389	0.0024
labour	-4.361912	0.959082	-4.548009	0.0061
Tech	1.915208	1.123209	1.705122	0.1489
Pop	-0.46999	0.678741	-0.692457	0.5195
Inst	0.102631	0.0071979	14.25849	0.0001
C	**323.1527**	**71.24822**	**4.535590**	**0.0062**

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Based on the findings in Table 9 which presents the Error correction Term of -0.319128 and is supported by the p value (0.000). This is evident that there is presence of cointegration among the variables under investigation since all the coefficients were statistically significant with a corrective sign (negative) at a 95 percent confidence level. It also depicts the speed of adjustment in the long run equilibrium model as a result of shocks, which was found out to be 31.91 percent. This means the speed of adjustment towards equilibrium is 31.9 percent on a quarterly basis. The cointegrating equation was given as follows

Further, the cointegration form (ECM) finding in Table 9 indicated that all the variables were statistically significant in the short run at a 5 percent significance level, except institutional quality index which was statistically insignificant. Road infrastructure, labour participation, technological growth, institutional quality index and GDP lag 1, 2 and 3 have a positive influence on the current economic growth. However, population growth has a negative influence on economic growth.

In the long run, the finding of study deduced that road infrastructure development has a positive and significant influence on the economic growth of a country. This implied a construction of 1KM road will lead to 0.000581 percent in economic growth. Construction of proper roads creates a conducive environment where the cost of road transportation is reduced significantly and reduces congestion time and fosters economic growth. Appropriate roads form the linkage between markets and production units, such synergy creates proper effective accessibility among markets and producers thus reducing wastage and strengthening economic growth. The road construction also has a multiplier effect since it creates both direct and indirect jobs and also diversification that fosters economic growth. The findings of this study agree with studies by Nenavath (2023) and Nawir et al. (2023), which predicted that road development significantly improved economic growth.

Labour participation adversely affects the economic growth of a country in the long run. A unit percentage increase of labour participation resulted in a decline of economic growth by -4.361912%. Labour participation is an important driver of economic growth. Active and productive participation of labour is known to yield a higher output that is captured by economic growth. However, the effectiveness of labour participation depends on the economic policies and skills mismatch may negate the influence of labour participation and thus result in a decline in economic growth.

The growth of technology did not have an impactful effect on the economic growth of a country in the long run. A unit increase in technological growth results 1.9% increase in economic growth. Adoption of technology is known to enhance the efficiency of the production process and thus foster productivity. This is evident in developed economies that have employed technology in production processes to enhance efficiency in generating their output. However, in the long run, technology may be obsolete or the introduction of a new one may make the old technology ineffective, thus explaining the insignificant role or the negative influence of technology in economic growth among developing economies. Use of inappropriate technology, especially the emerging economies, may derail economic growth and this commonly happens when a country copies and pastes technology without checking on fundamental components and its suitability.

The Institutional Quality Index has a positive and significant effect on the economic growth of a country. An increase of a unit of institutional quality index yields 0.102631 percent of economic growth. Appropriate institutional quality has proved to be essential in engineering economic growth, for instance, it reduces transaction costs since its strategies eliminate barriers that negate investment and thus enhance economic growth. An effective legal systems and framework that define the

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

institutional quality index is crucial in encouraging and protecting innovations such as intellectual property rights which fosters the economic growth of a country. Overall, economies with strong and defined institutions are in a better position to attract investments, enhance innovations and promote human capital that fosters economic growth. On the other hand, weak institutions are characterized by corruption, inefficiencies and sluggish economic growth and thus reducing economic growth.

Conclusion and Implications

Based on the analysis of road infrastructure, labour participation, population growth and institution quality index significantly influenced economic growth, while technological growth did not have a significant impact. It can be concluded that despite technological progress made in other countries, Kenya is still lagging behind in technology and that is why it cannot be translated into economic growth.

Accelerating road infrastructure is an important component in enhancing economic growth, per capita income and poverty reduction. Therefore, recommendations have been made based on study findings so as to sustain desired economic growth, per capita and poverty reduction. The HDI progress is still inconsequential on economic growth and therefore there is need to have a comprehensive approach that involves improving health care and education through affordable financing. This can be attained by actualizing universal health care coverage and introducing an affordable but sustainable financial model for education to strengthen the HDI.

REFERENCES

Aderogba, B. A., & Adegboye, A. A. (2019). Assessing the impact of road infrastructure on poverty reduction in developing economies: the case of Nigeria. *Modern Economy*, *10*(12), 2430-2449.

Badada, B., Delina, G., Baiqing, S., & Krishnaraj, R. (2023). Economic Impact of Transport Infrastructure in Ethiopia: The Role of Foreign Direct Investment. *SAGE Open*, *13*(1), 21582440231162055.

Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy*, *98*(5, Part 2), S103–S125. https://doi.org/10.1086/261726

Ben, S. O. (2019). Significance of Road Infrastructure on Economic Sustainability. *American International Journal of Multidisciplinary Scientific Research*, *5*(4), 1-9.

Bhattacharya, R., & Deka, N. (2021). Roads matter at the periphery: India's post-liberalization road projects in the Northeast. *Journal of Social and Economic Development*, *23*(2), 321-337.

Carrai, M. A. (2021). Adaptive governance along Chinese-financed BRI railroad megaprojects in East Africa. *World Development*, *141*(7); 105388.

Carrai, M. A. (2021). Infrastructure and the political economy of nation-building in the global South. *Globalizations*, *18*(6), 1018–1035. https://doi.org/10.1080/14747731.2020.1862893

Deardorff, A. V. (1970). Growth paths in the Solow neoclassical growth model. *The Quarterly Journal of Economics*, *84*(1), 134-139.

Deng, T. (2013). Impacts of transport infrastructure on productivity and economic growth: Recent advances and research challenges. *Transport Reviews*, *33*(6), 686–699. https://doi.org/10.1080/01441647.2013.851745

Deng, T. (2013). Impacts of transport infrastructure on productivity and economic growth: Recent advances and research challenges. *Transport Reviews*, *33*(6), 686-699.

Dykas, P., Tokarski, T., & Wisła, R. (2022). *The Solow model of economic growth: application*

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

to contemporary macroeconomic issues. Routledge.

Foster, V., Rana, A., & Gorgulu, N. (2022). Understanding Public Spending Trends for Infrastructure in Developing Countries.

Ghahari, S., Tsui Alabi, B. N., Alinizzi, M., Alqadhi, S., Chen, S., & Labi, S. (2019). Examining relationship between infrastructure investment and performance using state-level data. *Journal of Infrastructure Systems*, *25*(4), 04019026.

Gisore, N. W. (2021). Public infrastructure investment and economic growth in Kenya: An application of the Solow growth model. *African Journal of Economic Policy*, *28*(1), 87–105.

Githaiga, N. M., & Bing, W. (2019). Belt and road initiative in Africa: the impact of standard gauge railway in Kenya. *China Report*, *55*(3), 219-240.

Gori, L., Manfredi, P., Marsiglio, S., & Sodini, M. (2022). COVID-19 epidemic and mitigation policies: Positive and normative analyses in a neoclassical growth model. *Journal of Public Economic Theory*, *24*(5), 968-992.

International Transport Forum (2021). Statistics Brief. https://www.itf- oecd.org/sites/default/files/docs/inland-transport-infrastructure-investment-gdp-stable.pdf

Irshad, R., & Ghafoor, N. (2023). Infrastructure and economic growth: evidence from lower middle-income countries. *Journal of the Knowledge Economy*, *14*(1), 161-179.

Iskandar, D. (2023). Transportation infrastructure and regional economic development: A review of recent evidence. *Transport Policy, 136*, 54–63. https://doi.org/10.1016/j.tranpol.2023.01.005

Khanani, R. S., Adugbila, E. J., Martinez, J. A., & Pfeffer, K. (2021). The impact of road infrastructure development projects on local communities in peri-urban areas: the case of Kisumu, Kenya and Accra, Ghana. *International journal of community well-being*, *4*(1), 33-53.

Khanani, R., Ahmad, N., & Hussain, Z. (2021). The impact of transportation infrastructure on economic growth: Empirical evidence from Pakistan. *Journal of Economic Studies, 48*(6), 1212–1227. https://doi.org/10.1108/JES-02-2021-0076

Lee, J. (2022). Evidence and strategy on economic distance in spatially augmented Solow-Swan growth model. *arXiv preprint arXiv:2209.05562*.

Lesutis, G. (2022). Infrastructure as techno-politics of differentiation: Socio-political effects of mega-infrastructures in Kenya. *Transactions of the Institute of British Geographers*, *47*(2), 302-314.

Mose, N. (2021). Determinants of regional economic growth in Kenya. *African Journal of Business Management*, *15*(1), 1-12.

Mose, N. (2022). Road transport infrastructure and economic growth in Kenya. *International Journal of African and Asian Studies, 80, 75-84*

Nawir, D., Bakri, M. D., & Syarif, I. A. (2023). Central government role in road infrastructure development and economic growth in the form of future study: the case of Indonesia. *City, Territory and Architecture*, *10*(1), 12.

Nenavath, S. (2023). Does transportation infrastructure impact economic growth in India?. *Journal of Facilities Management*, *21*(1), 1-15.

Nenavath, S. (2023). Infrastructure development and economic growth nexus: Evidence from developing countries. *Journal of Infrastructure Development*, *15*(1), 25–42. https://doi.org/10.1177/09749306231151065

Article DOI: https://doi.org/10.37284/eajis.8.1.2949

Pradhan, R. P., Arvin, M. B., & Nair, M. (2021). Urbanization, transportation infrastructure, ICT, and economic growth: A temporal causal analysis. *Cities*, *115*(7); 103-119.

Segura, J., Franco, D., & Perán, J. (2023). Long-run economic growth in the delay spatial Solow model. *Spatial Economic Analysis*, *18*(2), 158-172.

Tang, C. F., & Tan, B. W. (2017). The determinants of public transport investment: A panel data analysis. *Transport Policy, 55*, 79–89. https://doi.org/10.1016/j.tranpol.2017.02.002

Udoh, I., Ukere, I., & Ekpenyong, A. (2023). Environment and Growth Sustainability: An Empirical Analysis of Extended Solow Growth Model. *Journal of Environmental Science and Economics*, *2*(2), 7-17.

