Effect of Infrastructure and Foreign Direct Investment on Economic Growth in Sub-Saharan Africa

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Abstract
This article investigates the effect of infrastructure and foreign direct investment (FDI) on economic growth in Sub-Saharan Africa (SSA) using panel data on 46 countries covering the period 2003–2017. The data were analyzed using fixed effects, random effects, and system generalized method of moments (GMM) estimation techniques. Based on the system GMM estimates, the results indicate that a 1 percent improvement in electricity and transport infrastructure induces growth by 0.09 percent and 0.06 percent, respectively. Additionally, FDI proved to be growth enhancing only when interacted with infrastructure. The interactive effect of FDI and infrastructure improves economic growth by 0.016 percent. The results suggest that public provision of economic infrastructure reduces the cost of production for multinational enterprises, thus providing an incentive to increase investment in the domestic economy to sustain economic growth. The results also suggest that the impact of FDI on economic growth is maximized when some level of economic infrastructure is available. Our findings thus provide ample justification on the need for a significant government investment in infrastructure to provide a less costly business environment for both local and multinational enterprises to improve economic growth.

Keywords
Economic growth, infrastructure, foreign direct investment, Sub-Saharan Africa, system GMM

Introduction
The Africa Infrastructure Country Diagnostic test attributes more than 50 percent of Sub-Saharan Africa’s (SSA) most recent economic growth to infrastructure development. In spite of this achievement, infrastructure development in SSA lags behind all other developing regions. The percentage of paved...
roads averages 50 percent, with about only a third of the population within 2 km of seasoned roads compared to two-thirds in Europe, Asia and the Americas. Telephone penetration in the region also lags behind Europe, Asia, and the Americas. Potable water and electricity supply to the population average 60 percent and 30 percent, respectively. The region generates only 124 kWh per capita power per year. These infrastructural deficits have since been cited as the third most serious inhibitor to business development after finance and corruption. It is no surprise that at the G8 summit of 2005, the international community renewed its commitment to support investment in Africa’s infrastructure sector to accelerate economic growth (African Development Bank, 2013 May).

Infrastructure exists to serve either a social or an economic need. Social infrastructure includes schools and hospitals while economic infrastructure consists of energy, water, transport, and digital communications. Economic infrastructures have always played an important role in promoting economic growth. For instance, infrastructure development can facilitate trade and foreign direct investment (FDI), thus fostering intra-regional trade and investment flows needed for the creation of regional markets, acceleration of growth, and reduction in poverty (United Nations Conference on Trade and Development [UNCTAD], 2013). Together with expanded demand, infrastructure development can also encourage supply diversification and regional economic convergence (UNCTAD, 2013). However, Canning and Pedroni (2004) opined that investment in infrastructure beyond the optimal level required for maximum growth diverts investment away from other types of capital, resulting in reduced income growth.

Post independence policy interventions in SSA have significantly shifted from an interventionist regime to a more liberal system characterized by little restriction on trade and FDI, privatization, and strengthening of key state institutions. These were to provide room for massive capital flows into the region. However, the expected surge of inflows still lags behind the other regions of the world. FDI inflows to SSA have been uneven, with Angola, Nigeria, and South Africa being the major recipients. South Africa’s relatively huge FDI inflows have been attributed to the conscious effort of privatization, returns made by firms that relocated to neighboring countries during the apartheid period, and the existence of a large domestic market. A large share of the increase in FDI flows during the last decade of the twentieth century went to four oil-producing countries; Nigeria, Equatorial Guinea, Angola, and the Republic of Congo (Ajayi, 2008). Despite the slowdown in the global economy in 2012, FDI inflows to SSA held up. Aggregate inflows increased by approximately 5.5 percent although it fell by 6.6 percent for developing countries as an aggregate (Global Economic Prospects, 2013, January). High commodity prices, abundance of natural resources, and high rates of return on capital serve as investment incentives in the region. The extractive industry sector continues to receive large share of inflows while the declining share of the primary sector reflects in increasing investment in the services sector, particularly infrastructure-related projects in telecommunication, energy, transport, and construction (Global Economic Prospects, 2013, January).

FDI may be either inorganically made by purchasing a business entity in the recipient country or organically made by extending operations of an already existing business entity to another country. Both theories and empirics support the importance of this form of investment in enhancing economic growth and development. It has been highly favored on the grounds that it leads to technological transfers, access to research and development, managerial know-how, and creation of market access to the global value chain to increase employment of resources and production. The influx of capital and its associated increase in corporate tax revenue provide the host country with additional resources for financing development projects. Furthermore, FDI introduces greater competition in the domestic economy, therefore providing an incentive for local manufacturers to increase their efficiency to enhance productivity gains. Thus, aside from improving the investment environment, most SSA countries have put various measures in place with the hope of attracting large FDI inflows.
Literature contends that a multinational enterprise’s decision to invest in a foreign country is mainly motivated by the economic and institutional context of the host economy. These motives are further enhanced by the infrastructure environment in terms of transport, information and communication technology (ICT), power, as well as the quality of human resource. While in developing countries infrastructure has been identified as a chief motivator of FDI, it is only an indicator in developed economies (Bae, 2008; Rehman, Ilyas, Alam, & Akram, 2011). Adequate infrastructure provides a favorable business climate for profit-maximizing foreign investors by reducing the real cost of production (Abu Bakar, Che Mat, & Harun, 2012; Khadaroo & Seetanah, 2007). Sekkat and Veganzones-Varoudakis (2007) emphatically stated that infrastructure tends to attract more FDI inflow than trade openness and investment climate. Since the cost of constructing a non-rivalry and non-excludable public infrastructure like road networks is enormous, a foreign investor will not be motivated to move to an infrastructure-deficient economy just to take advantage of lower labor costs and market demand (Khadaroo & Seetanah, 2007). This corroborates the arguments advanced by Erenburg (1993), that if public infrastructure were not extended to multinational enterprises then they would be less cost-efficient in their production process.

The rationale for this study is to analyze the effect of various forms of infrastructure development and FDI inflows on economic growth in SSA. The findings of this study will guide policymakers in addressing the problem of misdirected and inefficient allocation of resources for infrastructure development to attract enough FDI for sustained growth in SSA economies. The article contributes to the existing literature through the novel interaction between FDI and general composite index of infrastructure. It was found that, FDI is growth enhancing only when it effectively interacts (combined) with economic infrastructure.

The rest of the article is organized as follows: the second section presents a review of pertinent literature on the infrastructure–growth nexus as well as the FDI–growth nexus. The subsequent sections discuss the data, methodology and the empirical findings of the study. The final section summarizes the prime contribution and policy relevance to the study.

**Literature Review**

**Infrastructure and Economic Growth**

In recent years, a plethora of studies have examined the link between infrastructure development and economic growth. Most of the studies have found a positive relationship between economic growth and infrastructure development. These findings are generally independent of the measure of economic infrastructure employed in the analysis.

Our review begins with empirical works that used ICT as a general proxy for economic infrastructure. For instance, Roller and Waverman (2001) investigated the impact of telecommunications infrastructure on economic growth using data from 21 Organisation for Economic Co-operation and Development (OECD) countries covering a period of 20 years. They estimated a structural model that endogenizes telecommunication investment by specifying a micro model of supply and demand for telecommunication investments. The micro model was then jointly estimated with the macro-growth equation. The study found evidence of a positive causal link between telecommunications infrastructure and economic growth, granted that a critical mass of telecommunication infrastructure is present. Similarly, Sridhar and Sridhar (2007) investigated the relationship between telephone penetration and economic growth using data for developing countries. Using three-stage least squares, they estimated a system of equations that
endogenize economic growth and telecommunication penetration. They found that traditional economic factors explain demand for landlines and mobile phones, even in developing countries. Additionally, after controlling for the effects of capital and labor, they found that mobile phones and landlines are positive determinants of national output.

Another group of authors focused on the impact of transport infrastructure on growth. Sturm, Jacobs, and Groote (1999) estimated the output effect of infrastructure investment in the Netherlands between the period 1853 to 1913 and found strong evidence of a positive impact of transport infrastructure investment on Dutch gross domestic product (GDP) in the second half of the nineteenth century. Similarly, using panel data for a sample of 24 Chinese provinces from the period 1985 to 1998, Démurger (2001) provided empirical evidence on the links between infrastructure investment and economic growth in China. It was revealed that besides differences in reforms and openness, geographical location and infrastructure endowment accounted significantly for observed differences in growth performance across provinces. In addition, it was found that transport facilities largely explain the growth gap. Chandra and Thompson (2000) examined the relationship between large infrastructure spending and the level of economic activity. By collecting historical data on interstate highway construction and economic activity in the USA at the county level, they found that highways have a differential impact across industries; certain industries grow as a result of reduced transportation costs, whereas others shrink as economic activity relocates. Conversely, Stone, Strutt, and Hertel (2010) quantified the links between infrastructure investment and poverty reduction using a multiregional general equilibrium model, supplemented with household survey data for the Greater Mekong Subregion (GMS). Their findings suggested strong gains to the GMS countries as a result of infrastructure development and trade facilitation with national poverty reducing throughout the region.

Other studies on this phenomenon analyzed the impact of two or more composite indexes of infrastructure on economic growth. Notably, Canning and Pedroni (2004) investigated the long-run consequences of infrastructure provision on per capita income in a panel of countries over the period 1950–1992. They developed simple panel-based tests that enabled them to isolate the sign and direction of the long-run effect of infrastructure on income such that it was robust in the presence of heterogeneous short-run causal relationships. Their findings indicated that telephones, electricity-generating capacity, and paved roads were provided at close to the growth-maximizing level on average but were undersupplied in some countries and oversupplied in others. Égert, Kozluk, and Sutherland (2009), however, examined the links between infrastructure and growth and the role of public policies in OECD countries using different econometric approaches. Their time series results revealed a positive impact of infrastructure investment on growth. They also showed that the effect varies across countries and sectors and over a period of time. Furthermore, they found evidence of possible overinvestment, which may be related to inefficient use of infrastructure. However, the Bayesian model’s averaging of cross-sectional growth regressions confirms that infrastructure investment in the telecommunications and power sectors has a robust positive effect on long-term growth (but not in railways and road networks). Moreover, Snieska and Simkunaite (2009) examined the theoretical and empirical relationship between infrastructure and economic development in the Baltic states. They found a positive relationship between GDP per capita and paved roads. Specifically, a 1 percent increment in the length of paved road increases GDP per capita by 0.29 percent ceteris paribus. Additionally, they found a positive relationship between GDP per capita and telephone lines. Precisely, a 1 percent increment in the number of telephone lines increases GDP per capita by 0.33 percent ceteris paribus. Sahoo, Dash, and Nataraj (2010) investigated the role of infrastructure in promoting economic growth in China for the period 1975 to 2007. Based on principal component analysis and the autoregressive distributed lag (ARDL) approach, they
found that infrastructure development contributed significantly to the growth of the Chinese economy than both private and public investment. They also discovered a unidirectional causality from infrastructure development to output growth.

Yet, there are studies that did not explicitly define the measure of economic infrastructure employed in the analysis. Kumo (2012), for example, conducted pairwise Granger causality tests between economic growth, investment in economic infrastructure, and employment in South Africa for the period 1960–2009 using a bivariate vector autoregression (VAR) model with and without a structural break. He found that there is a bidirectional causality between investment in economic infrastructure and GDP growth in the long run. Also, Herranz-Loncán (2007) analyzed the impact of infrastructure investment on economic growth in Spain between 1850 and 1935. Using new infrastructure data and VAR techniques, he showed that the growth impact of local-scope infrastructure investment was positive.

Peterson and Jessup (2007) could not find enough evidence to support the hypothesized positive link between infrastructure and growth. They examined the interrelationships between infrastructure and economic activity using two Washington state highway infrastructure datasets in combination with county-level employment, wage, and establishment numbers for several industrial sectors for a subset of counties from 1990 to 2004. Based on the VARs, error correction models, and directed acyclic graphs, they found that the relationships between infrastructure investment and economic activity are often weak and are not uniform in effect.

**Foreign Direct Investment and Economic Growth**

There is an extensive theoretical discussion on the dynamic relationship between FDI and economic growth. Two strands of literature, that is, “modernization” and “dependency” views have prolonged the debate on the effects of FDI on economic growth. Proponents of the modernization view argue that technological and knowledge transfers associated with foreign aid and investment impact positively on growth by reducing idea and object gaps between developed and developing countries (Kumar & Pradhan, 2005). Dependency theorists, however, hypothesized that heavy reliance on foreign capital may impact negatively on growth in the host economy by crowding out indigenous firms because their ability to compete is limited by their size, finance, and extent of market power (ActionAid, 2003; Bornschier & Chase-Dunn, 1985). These views motivated scholars and policymakers to extend the discussion to different areas of human endeavors aimed at improving living standards in developing countries. We discuss some of the key empirical findings of the FDI–growth nexus in the rest of this section.

Quite a number of empirical works conclude that there is a positive relationship between economic growth and FDI. Such studies postulate that FDI is complementary to domestic investment, where it brings new employment opportunities, introduces innovative technologies and efficient methods of production, thereby spurring growth in the host economy. Li and Liu (2005) empirically investigated the effects of FDI on growth based on a panel of 84 countries from 1970–1999. They found a significant endogenous relationship between FDI and economic growth from mid-1980s onward. The results revealed that FDI may indirectly promote growth through its interaction with human capital. Similarly, Mengistu and Adams (2007) studied this relationship using a sample of cross-sectional data on 88 developing countries for the period 1985–2003. Based on both the ordinary least squares (OLS) and fixed effect estimation techniques, they found a positive significant relationship. However, the impact was greater in Asia than in the other developing economies. The growth path was through efficiency-inducing effects rather than augmentation of domestic investment. Emin (2011) examined the economic
growth–inflation–FDI nexus in Turkey from 1970 to 2008. The results from the Johansen co-integration technique suggested a positive and significant relationship between FDI and economic growth. Similarly, Saleem, Zahid, Shoaib, Mohamood, and Nayab (2013) found FDI and growth to be positively related in Pakistan from 1990 to 2011.

Makki and Somwaru (2004) studied the impact of FDI and economic growth in 66 developing countries from 1971–2000. The estimates of the seemingly unrelated regression (SUR) suggest that FDI has substantial influence on growth. Based on the OLS, SUR, three-stage least squares, Sylvester (2005) came out with similar conclusions for 29 developing countries between 1970 and 1989. Moreover, Okafor (2017) found evidence to support a positive effect of FDI on growth in Nigeria for the period 1987–2012. Ogbokor (2016) studied the impact of FDI on growth in Namibia from 1990–2014. FDI was found to have a stronger influence on economic growth compared to real exchange rate and trade openness. Andinuur (2013) examined the relationship among inflation, FDI, and economic growth in Ghana using data from 1980 to 2011. Based on the vector error correction model (VECM), the study found a positive impact of FDI on GDP growth in Ghana. Solomon (2011) investigated the effects of FDI and other macroeconomic indicators on economic growth in 111 FDI host economies from 1981–2005. Based on the system GMM estimates, she found FDI to have a positive significant impact on growth rate.

Some studies also focused on causality analysis with their conclusions underpinning the findings discussed earlier. Gholami, Tom Lee, and Heshmati (2006) studied the causality between investment in ICT and FDI inflows in 23 major countries with heterogeneous economic development for the period 1976–1999. The results showed that FDI Granger-causes production in developing countries. Similar causal relationship was established by Tang, Selvanathan, and Selvanathan (2008) in China for the period 1988–2003 using the VAR system with an error correction model. Chowdhury and Mavrotas (2006) analyzed the causal relationship between FDI and economic growth in Chile, Thailand, and Malaysia for the periods 1969 and 2000. Based on the Toda–Yamamoto test, they found unidirectional Granger causality running from GDP to FDI in Chile. However, there was bi-causality between FDI and GDP for Thailand and Malaysia. The bootstrap test was used to confirm the robustness of the above findings. Chakraborty and Nunnenkamp (2006) also assessed the growth impact of FDI movement into specific industries in India for the period 1987 to 1995. They found a bidirectional causality between FDI and output from the manufacturing sector but none in the primary sector. Nonetheless, FDI had a transitory effect on output from the services sector. Umoh, Jacob, and Chuku (2012) analyzed the FDI–economic growth nexus in Nigeria using data from 1986 to 2001. The study employed both the standard and the error correction models. The results suggested a bidirectional causality between FDI and GDP growth.

In spite of the several studies that reported positive and significant effect of FDI on economic growth, few studies proved otherwise. For instance, based on the estimates of the fixed effects model, Adams (2009) found that FDI was insignificant in promoting economic growth in a panel of SSA countries for the period 1990–2003. Similarly, Lyroudi, Papanastasiou, and Vamvakidis (2004) examined the effect of FDI on growth in the US and Western European transition countries between the periods 1995 and 1998. The results of the Bayesian analysis indicate that FDI did not exhibit any significant relationship with growth in these economies. Herzer and Klasen (2008) also sought to challenge this widespread belief that FDI promotes growth in 28 developing countries using the cointegration technique. On a country-by-country basis, they did not find any evidence to support the long- and short-run effects of FDI on economic growth.

The previous studies reviewed present somewhat similar results. However, while some of these studies are outdated, others concentrate on the use of a single or narrow measure of infrastructure.
This has its limitation of not capturing the true effects of various forms of infrastructure on economic growth. Hence, this article fills the existing research gap through our methods of analyses in the following unique ways.

First, we examine the growth effects of four composite measures of economic infrastructure as discussed by the African Development Bank’s Africa Infrastructure Development Index (AIDI) (2018) in our empirical model. Second, a novel interaction between FDI and general infrastructure index is explored to provide deeper insight into the additional drivers of economic growth. Finally, the study uses the most recent available data (2003–2017) to analyze these unique relationships in SSA. In doing so, the study contributes to the literature by proposing new economic growth and FDI models to guide policymakers in addressing the problem of misdirected and inefficient allocation of scarce resources for infrastructure development to better attract FDI inflows to ensure sustained growth of SSA economies.

Methodology

Data

This study employs secondary data from a panel of 46 SSA countries covering the period 2003–2017. Data is limited to these countries, variables, and time period due to inadequate time series data on SSA countries. Regulatory quality indices were sourced from Worldwide Governance Indicators (WGI) (2018) database, while the infrastructure development indices were obtained from the African Development Bank’s AIDI (2018) database. Data on all other variables were sourced from the World Bank (2018).

Theoretical and Empirical Model

Several theoretical frameworks have been suggested in the literature to model the effects of infrastructure and FDI on economic growth. Following the conceptual framework of the neoclassical Solow production function, we proceed with a bivariate Cobb–Douglas function of the general form:

\[ Y_{it} = K_{it}^{\alpha} L_{it}^{1-\alpha} \varepsilon_{it} \]  

where

- the \( i \) and \( t \) subscripts denote the cross-sectional dimension across countries and time dimension, respectively.
- \( Y_{it}, K_{it}, \) and \( L_{it} \) denote the levels of output, physical capital, and labor.
- \( \alpha \) is elasticity of physical capital with respect to output and \( 0 < \alpha < 1 \).
- \( \varepsilon \) is the random error term.

The reduced form of the above equation appears as:

\[ \ln Y_{it} = \alpha \ln K_{it} + (1 - \alpha) \ln L_{it} + \varepsilon_{it} \]  

Based on theory and empirical research, the empirically estimable log-linear form of equation (2) with modest modification is given as:
\[ \ln GDP_{it} = \phi_0 + \phi_1 \ln K_{it} + \phi_2 \ln L_{it} + \phi_3 \ln FDI_{it} + \phi_4 \ln HR_{it} \\
+ \phi_5 \ln RQI_{it} + \phi_6 \ln TRADE_{it} + \phi_7 \ln FINDEV_{it} + \phi_8 \ln GE_{it} \\
+ \phi_9 \ln TRANS_{it} + \phi_{10} \ln ELEC_{it} + \phi_{11} \ln ICT_{it} + \phi_{12} \ln WSS_{it} + \epsilon_{it} \]  

(3)

where

- \( \phi_s \) represents the coefficients in the multiple regression model.
- \( \ln GDP_{it}, \ln K_{it}, \ln L_{it}, \ln FDI_{it}, \ln HR_{it}, \ln RQI_{it}, \ln TRADE_{it}, \ln FINDEV_{it}, \ln GE_{it} \) represent the log of economic growth, physical capital, labor force, Foreign Direct Investment (FDI inflow), quality of human resource, regulatory quality index, trade openness, financial development and government expenditure, respectively.
- \( \ln TRANS_{it}, \ln ELEC_{it}, \ln ICT_{it}, \ln WSS_{it} \) represent the composite infrastructure indices for transport, electricity, ICT, and water and sanitation, respectively.
- \( \epsilon_{it} \) is the random error term that captures all other unobservable variables which can influence economic growth.

The definitions, measurements, and justifications for the choice of variables are discussed in Appendix A.

**Estimation Technique**

We begin our panel analyses with the Levin–Lin–Chu (LLC) (2002) and Im–Pesaran–Shin (IPS) (2003) unit root tests for balanced panels to examine the statistical properties of the data and its suitability for this study. We assume a variable observed on \( N \) countries and \( T \) periods and a model with individual effects and no time trend. The LLC considers a model in which the coefficient of the lagged dependent variable is restricted to be homogenous across all units of the panel:

\[
\Delta y_{i,t} = \alpha_i + p y_{i,t-1} + \sum_{z=1}^{p_i} \beta_{i,z} \Delta y_{i,t-z} + \epsilon_{i,t} 
\]

(4)

for \( i = 1, \ldots, N \) and \( t = 1, \ldots, T \).

They suggested the following hypotheses:

- \( H_0: p = 0 \)
- \( H_1: p = p_i < 0 \) for all \( i = 1, \ldots, N \)

The IPS test is based on the cross-sectional independence assumption. This test allows for heterogeneity in the value of \( p_i \) under the alternative hypothesis. Monte Carlo simulations suggest that the IPS test performs better than the LLC in small samples. The IPS also considers equation (4) above and its relevant assumption but substitutes \( p_i \) for \( p \). Thus, the resulting model is given as:

\[
\Delta y_{i,t} = \alpha_i + p_i y_{i,t-1} + \sum_{z=1}^{p_i} \beta_{i,z} \Delta y_{i,t-z} + \epsilon_{i,t} 
\]

(5)
It tests the null hypothesis that all the panels are nonstationary:

$$H_0: p = 0$$

Against the alternative:

$$H_1 = \left\{ p_i < 0, \ | \text{for } i = 1, 2, \ldots, N_1 \right\} \cup \left\{ p_i = 0, \ | \text{for } i = N_1 + 1, \ldots, N \right\}$$

Finally, we estimate these relationships using the random and fixed effect models as well as the system GMM estimator by Arellano and Bond (1991) with corrected standard errors. These estimates have proven to be important in panels that are characterized by a relatively fewer number of years and a large number of cross sections per year (Roodman, 2006). The GMM estimation technique in particular helps tackle the potential econometric problems of endogeneity of regressors and measurement errors associated with dynamic panel models (Bond, Hoeffler, & Temple, 2001).

Two main estimation methods can be used to solve the problem of endogeneity: the instrumental variable and Arellano–Bond GMM estimators. We restricted our analyses to the system GMM as the instrumental variable approach may lead to inefficient estimates of parameters. Again, system GMM incorporates more instruments and improves the efficiency of the estimates compared to difference GMM (Roodman, 2009). Unlike the basic OLS, random effects (RE), and fixed effects (FE) estimation, system GMM does not require normality and can accommodate heteroscedasticity of any unknown form.

### Results and Discussion

We conducted diagnostics tests on the pooled OLS, RE, and FE models to eliminate any model misspecification problem that may render statistical inferences invalid. The results of the Breusch–Pagan Lagrange multiplier indicate that there are significant differences across countries (i.e., panel effect exists), hence we reject the pooled OLS model for the random effects model (refer to Table 1). The Hausman test favored the random effects over fixed effects estimations. The Wooldridge test also fails to reject the null hypothesis of no first-order autocorrelation. To correct for the presence of heteroscedasticity, robust standard errors were employed and reported in parentheses for all models.

The Levin–Lin–Chu and Im–Pesaran–Shin unit root tests reported in Table 2 suggest that some of the variables are nonstationary at their log levels. To avoid any misleading regression results associated with nonstationary variables, we further considered their first differences. The latter results suggest that all the

<table>
<thead>
<tr>
<th>Table 1. Diagnostic Tests</th>
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<tbody>
<tr>
<td>Name of Test</td>
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<tr>
<td>Pooled OLS/random effects</td>
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<tr>
<td>Random/fixed effects</td>
</tr>
<tr>
<td>First-order autocorrelation</td>
</tr>
</tbody>
</table>

*Source:* Authors’ calculations using Stata 13.0.

*Note:* $^{***} p < 0.01$. 
variables are stationary at first difference. Kitamura and Phillips (1997) and Okafor, Piesse, and Webster (2015) explained that when the number of observations is greater than the time period, the nonstationarity of variables does not pose a serious econometric problem because autocorrelation is much less severe as in the case of our estimated models in Tables 1 and 3. Thus, the unit root tests also justify the propriety of our choice of models.

As shown in columns 2 and 3 of Table 3, the Wald chi-square test and F-statistic are both significant, indicating joint significance of the coefficients in both the random and fixed effect models. The coefficients of physical capital, government expenditure, labor force, quality of human resource, trade openness, financial development, regulatory quality, infrastructure indices and interactive term (LNFDI × INFRAS) have the expected signage, while FDI showed otherwise. Also, physical capital, labor force, human resource, financial development, regulatory quality, infrastructure indices and interactive term (LNFDI × INFRAS) proved to be statistically significant at the conventional levels. However, government expenditure, FDI and trade openness are insignificant at all three levels of significance, implying that improvements in these variables have no growth effects, at least over the period studied.

To account for potential endogeneity of regressors and loss of dynamic information in the random and fixed effect models, we estimated a system GMM model with results shown in column 4 of Table 3. Our estimated model passes the diagnostic tests related to Sargan–Hansen tests of overidentifying restriction which also does not reject exogeneity and the Arellano–Bond test for autocorrelation of the first-differenced residuals. Precisely, we failed to reject the null hypothesis of valid overidentifying restrictions and no first- and second-order autocorrelation, respectively.

The estimated coefficients in the latter somewhat validate those in the preceding models. We found evidence to support that infrastructure development plays an important role in the growth of SSA economies. In fact, electricity and transport infrastructure are robust determinants of economic growth regardless of the estimation technique employed. More precisely, a 1 percent improvement in electricity and
<table>
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<th>Variable</th>
<th>RE</th>
<th>FE</th>
<th>GMM</th>
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<tr>
<td>lnGDP_{t-1}</td>
<td>—</td>
<td>—</td>
<td>0.907</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.033)*****</td>
</tr>
<tr>
<td>lnK</td>
<td>0.037</td>
<td>0.038</td>
<td>0.038</td>
</tr>
<tr>
<td></td>
<td>(0.013)*****</td>
<td>(0.013)*****</td>
<td>(0.011)*****</td>
</tr>
<tr>
<td>lnGE</td>
<td>0.003</td>
<td>0.003</td>
<td>0.033</td>
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<tr>
<td></td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.015)*****</td>
</tr>
<tr>
<td>lnL</td>
<td>0.043</td>
<td>0.043</td>
<td>0.042</td>
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<tr>
<td></td>
<td>(0.017)*****</td>
<td>(0.016)*****</td>
<td>(0.012)*****</td>
</tr>
<tr>
<td>lnFDI</td>
<td>-0.086</td>
<td>-0.077</td>
<td>-0.006</td>
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<tr>
<td></td>
<td>(0.071)</td>
<td>(0.074)</td>
<td>(0.036)</td>
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<td>lnTRADE</td>
<td>0.035</td>
<td>0.037</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td>(0.032)</td>
<td>(0.032)</td>
<td>(0.014)*****</td>
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<td>lnFINDEV</td>
<td>0.052</td>
<td>0.052</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>(0.021)**</td>
<td>(0.021)**</td>
<td>(0.008)***</td>
</tr>
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<td>lnHR</td>
<td>0.089</td>
<td>0.089</td>
<td>0.085</td>
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<tr>
<td></td>
<td>(0.026)*****</td>
<td>(0.026)*****</td>
<td>(0.028)*****</td>
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<td>RQI</td>
<td>0.317</td>
<td>0.326</td>
<td>0.097</td>
</tr>
<tr>
<td></td>
<td>(0.119)*****</td>
<td>(0.119)**</td>
<td>(0.027)*****</td>
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<td>lnELEC</td>
<td>0.038</td>
<td>0.039</td>
<td>0.092</td>
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<tr>
<td></td>
<td>(0.013)*****</td>
<td>(0.013)*****</td>
<td>(0.244)*****</td>
</tr>
<tr>
<td>lnTRANS</td>
<td>0.055</td>
<td>0.055</td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td>(0.023)**</td>
<td>(0.023)**</td>
<td>(0.022)*****</td>
</tr>
<tr>
<td>lnICT</td>
<td>0.027</td>
<td>0.026</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.003)*****</td>
<td>(0.003)*****</td>
<td>(0.002)</td>
</tr>
<tr>
<td>lnWSS</td>
<td>0.172</td>
<td>0.171</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>(0.042)*****</td>
<td>(0.042)*****</td>
<td>(0.002)</td>
</tr>
<tr>
<td>lnFDI × INFRAS</td>
<td>0.018</td>
<td>0.017</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>(0.006)*****</td>
<td>(0.006)*****</td>
<td>(0.004)*****</td>
</tr>
</tbody>
</table>

Arellano–Bond AR (1)  
\[ z = -1.89 \]  
\[ P(z) = 0.058 \]

Arellano–Bond AR (2)  
\[ z = -0.61 \]  
\[ P(z) = 0.542 \]

Sargan test  
\[ \chi^2 = 430.05 \]  
\[ P(\chi^2) = 0.207 \]

Hansen test  
\[ \chi^2 = 35.43 \]  
\[ P(\chi^2) = 1.000 \]

No. of observation 736 736 736

**Source:** Authors’ calculations using Stata 13.0.

**Note:** ***p < 0.01, **p < 0.05. Standard errors are in parentheses.
transport infrastructure induces growth by 0.092 percent and 0.067 percent, respectively. Whereas electricity infrastructure provides a major source of energy for powering the various machines, transport infrastructure facilitates the conveyance of raw material to production sites and enables access to market centers with high purchasing power. These results are consistent with the empirical findings of Sridhar, and Sridhar (2007), Snieska and Simkunaite (2009), and Égert et al. (2009).

The novel interaction between FDI and a general composite index of infrastructure is also explored. Interestingly, FDI proved to be growth enhancing in all three models only when effectively combined with the required level of economic infrastructure. This finding suggests that adequate economic infrastructure in SSA economies reduces the cost of production to profit maximizing foreign investors, thus providing incentives to increase investment to improve economic growth. It could also be interpreted as being consistent with the empirical findings of Saidi and Hammam (2018), Armah (2016), Abu Bakar et al. (2012), Babatunde (2011), Bellak, Leibrecht, and Damijan (2009), Demirhan and Masca (2008), and Khadaroo and Seetanah (2007) that FDI moves to infrastructure-abundant economies. In economies where there is massive infrastructure development, the positive growth impact of FDI is guaranteed. Our evidence justifies the need for massive investment in economic infrastructure to provide a less costly business environment for multinational enterprises.

With regard to the control variables, physical capital and labor proved to be robust determinants of growth. We find evidence to justify their inclusion in both traditional growth theories and empirical studies (Hoover & Perez, 2004; Lucas, 1988; Mankiw, Romer, & Weil, 1992; Romer, 1990; Solow, 1956; Weil, 2005). Higher level of human resource development also provides an engine for growth. High levels of literacy, numeracy, skilled, and productive labor force promote growth through the ease of learning and adapting to modern and faster methods of production. A hospitable regulatory environment (i.e., regulatory quality) promotes growth by eliminating institutional bottlenecks and operationalizing sound economic policies and regulations to permit and boost private investment (Djankov, McLiesh, & Ramalho, 2006; Haidar, 2012; Jalilian, Kirkpatrick, & Parker, 2007; Nicoletti & Scarpetta, 2003) Thus, we argue that direct credit controls, bureaucracy, bribery, and corruption associated with obtaining business license, nonenforcement of property rights, foreign ownership ceilings, and restriction on equity holding by foreigners are most likely to be growth inhibiting in SSA.

A well-functioning financial system facilitates access to credit by the private sector for productive investment. Thus, we confirm the findings of Adu, Marbuah, and Mensah (2013) and Prah and Quartey (2008) that financial development is a growth catalyst. Our GMM estimates also indicate that a more liberal economy with little or no restriction to trade provides room for growth through massive inflow of working capital, goods and services, and foreign exchange earnings (Culem, 1988; Edwards, 1990). Likewise, we found evidence to support that government provision of certain public goods and essential services is needed at the early stages of economic growth and development in SSA. The positive and significant coefficient of LNGDP, from the GMM estimates also suggests that growth in preceding years influences growth in the current period, and as such, policymakers’ knowledge of historical growth patterns plays a significant role in formulating and implementing policies to achieve current and future growth targets.

**Conclusion and Policy Recommendations**

This article primarily investigated the effect of infrastructure and FDI on economic growth in SSA. The results suggest that infrastructure development of various forms play an important role in the growth of economies. Additionally, FDI proved to be growth enhancing only when it effectively interacted with the required level of economic infrastructure. This finding could mean that public provision of economic
infrastructure reduces the cost of production to multinational enterprises, thus providing an incentive to increase investment to sustain economic growth. Thus, there is enough evidence to justify the need for massive investment in economic infrastructure to provide less costly business environment for both local and multinational enterprises. There is need, therefore, for SSA policies to be aimed at simultaneously ensuring sound regulatory environment, deregulation, and consequently public–private partnership (PPP). Less restrictive regulation and deregulation incentivizes both domestic and foreign investors to participate in the provision and delivery of economic infrastructure. In doing so, the option of PPP may be considered as a mechanism for realization of most public goods. This results in faster completion of infrastructure projects, higher quality of infrastructure service delivery, and greater efficiency in governments’ investment to ensure reallocation of saved financial resources to other socioeconomic sectors. However, efforts in reducing the levels of regulation should not discard useful ones otherwise economic growth may come at the expense of sustainable development.

The study contributes to the literature by proposing a new model that incorporates the interactive effect of FDI and infrastructure development on growth.

Appendix A: Definition, Measurement, and Justifications for the Choice of Variables

Dependent Variables

Economic Growth

Economic growth can be measured in several ways. However, following other studies, we proxy it by real GDP per capita. Several studies (Aghion, Howitt, & Murtin, 2010; Arora, 2001; Barro & Lee, 1993; Barro & Sala-i-Martin, 2003; Bloom & Sachs, 1998; Ogunleye, 2011; Sachs & Warner, 1997) support the view that real GDP per capita is the most appropriate measure of economic growth, thus it is adopted as the dependent variable of the economic growth and infrastructure relation.

Independent Variables

Physical Capital and Labor

Growth theories have largely explained the importance of capital and labor in the production process. They are the basic inputs that combine with all other factors to make production possible. Labor effectively combines with capital, new methods of production, and technologies to increase production. On the other hand, expansion in the productive capacity of a firm induces rapid growth in output without any inflationary pressures. Gross capital formation as percentage of GDP and labor force was used as a proxy for physical capital and labor, respectively. Both theories and empirics support the positive effect of capital and labor on economic growth (see Hoover & Perez, 2004; Lucas, 1988; Mankiw et al., 1992; Romer, 1990; Solow, 1956; Weil, 2005).

Quality of Human Resource

An important element of human resource is the level of education. Quality of human resource is proxied by secondary school enrollment rate (gross). High levels of education reflect in a literate, numerate, skilled, and productive labor force that is able to learn and adapt to modern and sophisticated production techniques associated with
technological transfers. Following both theory and empirical literature, a higher quality of human resource impacts positively on economic growth (see Mankiw et al., 1992).

**Infrastructure**

The core economic infrastructures in the areas of energy, transportation, and water and sewage have always played important roles in maintaining economic performance. A bulk of empirical studies support this positive impact of infrastructure on economic growth (see Égert et al., 2009; Snieska & Simkunaite, 2009; Sridhar & Sridhar, 2007). Adequate infrastructure also motivates FDI inflow by providing a favorable investment climate for profit-maximizing foreign investors through reduction in the cost of production. Thus, a foreign investor will not be motivated to move into an infrastructure-deficient economy (see Abu Bakar et al., 2012; Asiedu, 2002; Babatunde, 2011; Bellak et al., 2009; Demirhan & Masca, 2008). For the purpose of this study, we consider the effect of four major composite indices as presented in the 2018 AIDI database: (a) transport (aggregate of total paved roads measured in kilometer per 10,000 inhabitants and total road network both paved and non-paved measured in per kilometer square of exploitable land area); (b) electricity (total electricity generated in a country including imported energy measured in millions of kilowatt-hour); (c) ICT (fixed-line and mobile cellular subscriptions measured as a percentage of the population, number of internet users per 100 inhabitants, and international Internet bandwidth in megabits per second); and (d) water and sanitation (aggregate of improved water source and sanitation facilities as a percentage of population with access).

**Financial Development**

A host of literature maintains that financial development may impact growth through its effects on savings and investment decisions. Financial intermediation helps to pool financial resources from even small savers and invest them in a wide range of projects with diversified risks. The depth and development of this intermediation has been cited in literature as a source of growth as it makes funds available to potential investors. A well-functioning financial system eliminates principal-agent problems by screening and monitoring borrowers to ensure that loans and advances made to them are put to productive use. Thus, our proxy variable domestic credit to the private sector as a percentage of GDP is expected to have a positive effect on economic growth. (Adu et al., 2013; Prah & Quartey, 2008)

**Trade Openness**

Trade openness reflects the extent to which SSA economies trade with other countries, especially with the other regions of the world. It is proxied by the sum of import and export as a ratio of GDP. A more liberal economy with little or no restriction to trade provides incentive for massive inflows of goods and services and foreign exchange earnings. Consequently, the more open a country is to international trade the more attractive it is to FDI inflow to boost economic growth. Thus, we expect a priori positive relationship with economic growth (Culem, 1988; Edwards, 1990).

**Foreign Direct Investment**

Both theories and empirics support the importance of this form of investment in enhancing economic growth and development. It has been highly favored on the grounds that it basically leads to technological transfers, access to research and development, managerial know-how, and creation of market access to the global value chain to increase
employment of resources and production. The influx of capital and increase in corporate tax revenue provide the host country with additional resources for financing development projects. Again, FDI introduces greater competition in the domestic economy, thus providing an incentive for local manufacturers to increase their efficiency to enhance productivity gains. Empirical findings also support the positive significant effect of FDI on economic growth (Bachtiar, 2003; De Mello, 1997; Obwona, 2001).

**Government Expenditure**

Economic theory and empirical findings do not build a consensus on the precise relationship between government spending and economic performance. Proponents of larger government size are of the view that government provision of certain public goods such as education, health, roads, electricity, and other infrastructure is needed at the early stages of development. Advocates of smaller governments, on the other hand, believe that large government transfers economic resources from the productive and efficient investment to inefficient use by the government. Government deficit financing through borrowing from private capital market may put on upward pressure on borrowing cost of funds by firms with productive opportunities. Baily (2003) found that larger spending by the public sector contributed negatively to economic growth. On the other hand, researchers such as Lindauer and Velenchik (1992), Knoop (1999), and Yasin (2003) found that government spending has a positive effect on economic growth. We proxied government expenditure by general government consumption as a percentage of GDP.

**Regulatory Quality Index**

We include regulatory quality index as a governance indicator that could possibly affect economic growth. An improvement in this indicator is expected to enhance economic growth. This variable “reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development” (WGI, 2018). Studies have found inhospitable regulatory climate and weak institutions as inhibitors to economic growth (Djankov et al., 2006; Haidar, 2012; Jalilian et al., 2007; Nicoletti & Scarpetta, 2003).

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