The manufacturing output effects of infrastructure development, liberalization and governance: evidence from Sub-Saharan Africa

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Abstract
The study draws inference on the effects of infrastructure development, liberalization, and governance on manufacturing production (MVA) in Sub-Saharan Africa. In order to determine the longrun implications of these factors, and for purposes of retaining estimates efficiency and consistency in the presence of complex errors, we employed the Panel-Corrected-Standard-Error estimator on panel data spanning 2003–2018 for 30 SSA countries. The main result of this in-depth analysis shows that infrastructure development as well as governance are key to manufacturing production. While infrastructure development affects MVA positively in the longrun, an improvement in the financial openness facilitates this linkage but only between transport infrastructure on the one hand, and electricity infrastructure on the other, whereas the converse appears the case when trade liberalization is the moderating variable. Overall, regardless of the type of liberalization, manufacturing output is always higher with better institutional quality. Our findings hold after controlling to additional covariates and are robust to alternative estimation measures. Among the other important policy derivatives of our findings, we emphasize that efforts aimed at reversing Africa’s pervasive infrastructure deficit, in ways that enhance manufacturing share in GDP, must be carefully nuanced under the avoidance of the incautious liberalization policies. We render support to the regional efforts to improve infrastructure, substantially curb poor governance while vigorously promoting the rule of law, regulatory quality, government effectiveness, voice and accountability.

Keywords Manufacturing · Infrastructure · Governance · Liberalization · PCSE · SSA

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1 Introduction

The dynamic role of the manufacturing sector as an engine of growth is well-documented in literature (e.g. Chenery, 1955; Clark, 1940; Cornwall, 1977; Kaldor, 1966, 1967; Kuznets, 1966; Lewis, 1954; McCausland & Theodosiou, 2012). Recent experience in Sub-Saharan Africa suggests that despite strong economic growth over the past two decades, the manufacturing sector has marginally increased or declined, all efforts to boost the sector notwithstanding. The likes of Page (2017) observe that since the 1970s, the manufacturing and industrial development have never taken off in Sub-Saharan Africa and that the region is considered deindustrializing. Available statistics are indicative of substantial and long-lasting stagnant low levels of the sector contribution to gross domestic output. For example, data shows an overall significant drop from 16 percent in 1991 to about 10 percent by 2006, a rate consistently witnessed even in the subsequent years including 2018, but also a replication of the mid-1960s according to Yaw et al. (2016). Similarly, whereas the manufacturers import share in total merchandise exports minimally reduced from 66 percent in 2006 to 62 percent in 2018, the share of the manufacturers exports in the merchandise exports dropped from about 25 percent in 2006 to about 21 percent in 2018, rendering the export substitution and import substitution strategies questionable.

One notable revelation is that despite an increasing trend in global manufacturing value added, the contribution of manufacturing to GDP in SSA has stagnated or faced enormous contraction since the 1990s, the attractive policies, the availability of low-cost labor and an abundance of natural resources and raw materials in the region notwithstanding. In fact, if the popular view that growth in the manufacturing sector is central to Africa’s ability to meet its development goals (Landry, 2018), is anything to go by, then we concur with Niringiye et al. (2012) who posit that the implications of low and stagnant levels of manufacturing share in GDP for economic transformation and modernization, as well as the standards of living, are a serious policy challenge in need of urgent empirical attention. If manufacturing sector is key to economic growth-enhancing structural transformation, then understanding the factors that are constraining this sector is of prime importance. What drives manufacturing production in the region?

Existing literature has focused on factors like initial years of schooling (e.g. Basu & Guariglia, 2008; for the United Kingdom), government policy (Lall, 2004; for Asian Tigers), low GDP per capita, unfavorable trade conditions, and economic recession (Louri & Minoglou, 2002; for Greece), foreign direct investment (Paus & Gallagher, 2008; for Costa Rica and Mexico;), and, poor industrial technology coordination (Ciccone, 2002), albeit with differential outcome. Similarly, a plethora of Africa-specific studies lay emphasis on financial crisis (Shafaeddin, 2005), export–import ratio (Kwabena and Osei-Amponsah (2009), foreign direct investment (Azolibe, 2021; for MENA countries), and, macro-economic instability, inaccessibility to markets, and internal versus external demand (Beji & Belhadj, 2016;
Shafaeddin, 2005, on Africa). Nevertheless, the divergences in findings and the insufficiency of these factors in explaining manufacturing production particularly in SSA implies an inconclusive debate on the issue at hand.

In the current paper, we focus on the role of infrastructure development, which, despite the efforts to improve its access, quality and quantity, as a means of invigorating industrialization in SSA, particularly during the last two decades, the manufacturing share in GDP still shows very little improvement. At the same time, the region ranks consistently at the bottom of all developing regions in terms of infrastructure performance (Calderón & Servén, 2010). For example, despite the improvements in electricity access improved from 31% in 2003 to 36.5%, 50% and 51% in 2008, 2013 and 2018, respectively, scholars note with concern the poor quality electricity supply, and an uneven progress in the sub-regions of SSA. Statistics show that whereas only eight countries (Gabon, Mauritius, Reunion, Seychelles, Swaziland, South Africa, Cape Verde and Ghana) had an access rate above 80 per cent in 2016, the majority of countries had a rate below 50 per cent with some operating at a rate below 25 per cent, frequent power outages that on average happen every after four days notwithstanding (Azolibe & Okonkwo, 2020; Scott, 2015). It should be recalled that though Africa is home to almost a fifth of the world’s population, it accounts for less than 4% of global electricity use, with the majority usage recorded in North Africa, leaving more than half of SSA population (about 600 million) in dark (The Economist, 2019). The situation appears exacerbated by poor transport network. For example, by 2019 the proportion of urban population with convenient access to public transport stood at 33% compared to 50% in Latin America and the Caribbean or to 50% for the World (United Nations, 2020). These experiences, coupled with the impassable roads, low capacity ports and rail, inaccessibility to improved drinking and poor quality internet and telecommunication networks, appear to work against a conducive business environment for manufacturing, though the opposite view may not be dismissible either. On this latter antithesis, it may not be inconceivable that the near-zero level of endowment of almost all forms of public infrastructure observed for SSA, relative to other regions, may present insignificant effects from infrastructure development on the MVA. Nevertheless, amidst the observed hurdles, there are still notable improvements in infrastructure development in the region. For example, according to the African infrastructure development index (AIDI), all scores pertaining to electricity, transport, ICT, water and sanitation, improved for virtually all countries in Africa between 2016 and 2018. Also, relative to other infrastructure forms, telecommunication infrastructure has not only experienced progress across all income groups in SSA, but also doubled total access rates to sanitation (38% of population accessing the services) albeit still low relative to South Asia with 55%, Latin America and the Caribbean and East Asia (above 80%). The current study attempts to provide an in-depth evaluation of the effect of infrastructure development on the manufacturing sector output in the region.

On the empirical front, while the economic growth importance of infrastructure development cannot be underestimated (Ajakaiye & Ncube, 2010; Ansar et al., 2016; Ayogu, 2007; Calderón & Servén, 2010; Chaurey et al., 2004; Esfahania & Ramírez, 2003; Fedderke & Garlick, 2008; Hulten et al., 2006; Kanagawa & Nakata, 2008; Kodongo & Ojah, 2016; Olufemi et al., 2013; Tanguy, 2012; Tanguy
& Torero, 2011; Tatyana, 2015), there is still a missing link with regard to the extent to which infrastructure is important for the manufacturing sector production in particular. A few studies focus on industrial productivity effects of infrastructure (e.g. Gafer & Saad, 2009; Umofia et al., 2018), concentrating only on a single country and producing divergent findings. But as Kodongo and Ojah (2016) admits that in the light of existing findings of country-specific studies which suggest that certain individual infrastructure, such as electricity and ICT, have significant effects on the economy, it would be a worthwhile exercise to ascertain whether some public infrastructure is more important than others, particularly in the SSA kind of environment, a new study reflecting this suggestion is needed. Moreover, the majority focus on one element of infrastructure (e.g., Abokyi et al., 2018—electricity; Isasson, 2010—energy; Appaih-Otoo & Song, 2021—ICT; Muvawala et al., 2021; Seetanah, 2009—transport) in disregard of the multidimensional nature of infrastructure development in which electricity, transport, ICT, and, water and sanitation are all captured.

Among the exceptions is Azolibe and Okonkwo (2020) who however focus on a smaller panel of 17 countries of SSA to examine the direct role of infrastructure on the industrial sector productivity. Our interest is the manufacturing sector, as we test several hypotheses on a much larger sample of 30 countries, besides taking into account cross-sectional dependence that has been ignored in the latter study, despite being part and parcel of a panel data characteristic especially among countries that likely experience common shocks say, from deeper integration efforts among them. SSA is not an exception. But also the uniqueness of the current study is further strengthened by the inclusion of the moderating factors in the model to determine the indirect effects of the infrastructure on MVA. Specifically, we draw inference on the economic rationale that while infrastructure investment could likely boost the manufacturing sector performance, realizing its potential is expectedly dependent on institutional and economic characteristics. We focus on two such factors: liberalization and governance. Both liberalization and the institutional environment can be a powerful catalyst for infrastructure development, which linkage would in turn affect industrial productivity especially the manufacturing sector. In fact, the view that liberalization and institutions in SSA are heavily intertwined in their effect on a country’s development is nearer consensus (Chinn & Ito, 2006; Khan, 2007). If, as economists agree, governance and liberalization are among the critical factors explaining the divergence in performance across developing countries, particularly in the industrial sector, ascertaining their role in the linkage among infrastructure development and the MVA is paramount.

Economic liberalization is a concept here defined to refer to a reduction in restrictions on international trade and capital. Unlike the previous studies, we distinguish between the financial dimension of openness, where terms like ‘financial openness’, ‘financial integration’ and ‘financial globalization’ are used regularly and often interchangeably (e.g., De Nicolo & Juvenal, 2014; Kose et al., 2009; Saadma & Steiner, 2016) and the trade dimension, also referred to in literature as ‘trade openness’, ‘economic integration’, ‘trade liberalization’ and ‘globalization’ (Gräbner, et al., 2018; Weiss, 2002). Since the mid-1990s and the subsequent period that SSA has been grappling with efforts to improve and reverse its pervasive infrastructure
deficit, the process for opening up trade and the capital account to the international community has been intensively pursued, with trade openness (measured as trade share in GDP) increasing from 68% in 2003 to 73% in 2013 before reducing to 67% in 2018 and averaging 61% during the period 2003–2018. On the other hand, the region’s score in financial openness was at a lower index of −0.43 (lower) in 2003 and moved to a higher score of −0.37 (higher) in 2018, though the period average score is −0.45. In essence, and based on the outward-looking theory of industrialization, though criticized recently for its detrimental effects on economic growth of developing countries (Bbale & Nnyanzi, 2016; Nnyanzi & Bbale, 2016), liberalization could allow the cushioning of economies against country-specific shocks (Krebs, Krishna & Maloney, 2005; Nnyanzi, 2015, 2016) in addition to the potential to create a favorable business environment (Shafaeddin, 2005). And, because it allows access to imported inputs at free trade prices, access to technology and capital as well as a more competitive exchange rate, it can boost industry growth.

However, in the case of relatively closed economies, the majority of SSA countries inclusive, manufacturers may not get exposed to the new technologies and best practices adopted internationally and, as a consequence, continue to use obsolete technology at high cost, which in turn are likely to hamper growth in the manufacturing sector. We contend that apart from the potential direct effect of liberalization on MVA, the relationship between infrastructure and manufacturing is likely moderated by the region’s level of openness. Existing empirics have mainly analyzed economic growth effects of liberalization (e.g. Amoasah, 2018; Shafaeddin, 2009, 2010), but largely ignored the sectoral development effects of the same, and the manufacturing sector in particular. Moreover, the distinction between two direct measures of openness above highlighted but also referred to as de jure (a policy variable) and de facto dimensions, is often ignored in the analysis. According to Gräbner et al. (2018), the two measure different facets of openness, which need not be consistent for a given country. In the current analysis, we bridge this literature gap.

Economic openness aside, the issue of infrastructure development has often been heavily tied to institutional characteristics of countries (e.g. Ogbaro, 2019; Sahni, Nsiah & Fayissa, 2021; Zergawu et al., 2020), albeit with variations in empirical evidence. In fact, the concept of good governance, according to the World Bank report on Assessing Aid, has been introduced as an important idea by several European donors (Hoebink, 2006) and supported by the African Development Bank, both of which are good funders of infrastructure development in SSA. Implicitly, good governance is a necessary condition for good infrastructure delivery, and vice versa. For, also according to institutional economics, the presence of well-defined property rights, rule of law, transparency, absence of corruption and political stability, inter alia, are central to a friendly business environment as well as a stimulant to entrepreneurship. Therefore, industrialization and the manufacturing sector in particular, is likely to blossom amidst good governance. On the other hand, and as argued in Saha and Sen (2020), the possibility that poor institutional quality can be good for investments and growth, may not be far fetched. The authors focus on the East-Asian paradox, where some Asian countries, despite poor institutional quality scores, have registered tremendous improvements in growth. The case for SSA, therefore needs to be well-ascertained. Here, it ought to be recalled that the good
governance approach began to be adopted as the mainstream development agenda in the 1990s, partly due to the observation that the high cost of doing business in the region, and therefore inadequate investment in the manufacturing sector, was likely exacerbated by poor institutional quality, in addition to substantial gaps in port, road and power infrastructure (Deloitte, 2016). Tybout (2000) specifically alludes to Africa’s notoriously high levels of corruption and bureaucratic restrictions as stumbling blocks in the economic development of Africa. By the year 2020 for example, the cost to obtain a permanent electrical connection in Sub-Saharan Africa, according to World Bank (2020), was 3 times higher than the global average, attributing it partly to high levels of corruption. We therefore deem it important to ascertain both the role of institutional environment in the manufacturing performance in SSA, as well as the joint effect of the former with infrastructure development on the sector output. Table 6 (Appendix), provides summarized statistics on the levels of technological infrastructure and governance in SSA.

In summary, our contribution to literature centers around three specific objectives. First, the study examines the manufacturing output effects of infrastructure development, both aggregated and disaggregated. The latter includes electricity, transport, ICT, and, water and sanitation infrastructure, which are prioritized by the African Development Bank. In the second objective we explore the manufacturing output effect of liberalization. Lastly, the quantitative effect of institutional quality on MVA is analyzed. But also, as a nuance, we evaluate the moderating role of liberalization and governance in the relationship between infrastructure development and MVA. Generally, it is important to note that in achieving these objectives, the uniqueness of the study hinges on its attempt to address several issues that have been apparently overlooked in the previous empirical literature. In particular, the latter studies have rarely taken into consideration the problem of cross-sectional dependence in panel data analysis. Given that SSA countries have formally engaged into deeper integration in the recent decades, that took the form of regional groupings, there is a big possibility to have experienced common shocks that would affect them in a similar way. We employ therefore the panel corrected standard error (PCSE) technique popularly known for taking care of such challenges. Also, the introduction of infrastructure development, both in aggregate and their disaggregated form, liberalization, and institutional quality indicators into the manufacturing sector model is a nuance in evaluating the dynamics of the sector in a region that has largely been ignored in the existing empirics, save a few, perhaps due to data issues.

The analysis is expected to add to existing literature on the subject and to provide complimentary evidence to guide policy makers take a holistic approach to industrial policy, and particularly with regard to manufacturing. It is envisaged that the study findings would be handy for the SSA region in need of accelerating the development of their manufacturing sector that are additionally being hit hard by the Covid-19 pandemic, if they are to meet the UN 2030 target set under sustainable development goal (SDG 9), and scale up investment in scientific research and innovation, but also achieve the African Development Banks’s mission espoused in its High 5s transformative agenda, for the period 2015–2025. By providing quantitative evidence regarding the three critical factors, viz., infrastructure development,
liberalization and governance, and how they link with the manufacturing production, the current study helps focus policy direction.

Our findings provide evidence to support the validity of the aforementioned hypotheses. First, infrastructure access is found critical in enhancing the contribution of the manufacturing sector output to GDP, though a disaggregation of the index only provides evidence in support of a positive significant role of transport infrastructure, as opposed to the other sub-indices, with further analysis revealing a supportive role of electricity access in rural areas. On the other hand, we note significant detrimental effects of both *de-jure* and *de-facto* measures of liberalization on the manufacturing value added share of GDP in the SSA region, whereas the effect of the aggregated governance index is found significantly helpful in enhancing MVA. The influence of either liberalization or governance on the infrastructure-manufacturing relationship is found significantly strong.

The remainder of this study is organized as follows: Sect. 2 presents the literature on the determinants of industrial sector performance in general and the manufacturing value added output in particular. In Sect. 3, we then present the methodology, data sources and empirical models. Our empirical results and concluding remarks are presented and interpreted in Sect. 4, while Sect. 5 entails the concluding remarks.

### 2 Empirical literature review

A recent study by Azolibe and Okonkwo (2020), using a panel least square estimation technique on panel data of SSA region spanning from 2003 to 2018, finds the quantity and quality of telecommunication infrastructure to be the major factor that influences industrial sector productivity. The authors attribute the relatively low level of industrial sector productivity in the region to poor electricity and transport infrastructure, underutilization of water supply as well as sanitation infrastructure. On the other hand, and still on Africa as a region during the period 1990–2011, a previous study by Anyanwu (2018), using the IV-SLS technique with year and sub-regional fixed effects, finds that social infrastructure has variant effects on manufacturing output. While Primary education has an inverted U-shaped relationship and Secondary education has a negative significant relationship, it is only tertiary education that is found to exhibit a significant positive association. Conversely, the author does not find any significant role of ICT infrastructure, proxied by mobile phone and fixed phone subscriptions. Among the other factors, trade openness, FDI stock, social and political globalization, and energy use intensity, are found to exhibit differential impacts. Ahmed (2016) records similar findings on the role of social infrastructure on manufacturing firms’ productivity for Pakistan, though only positive for urban areas and negative for the rural regions. An earlier study by the same author (Anyanwu, 2017), focusing on North Africa and following a similar technique, however, records among other findings ICT infrastructure/technology, trade openness and inward stock of FDI, to exert significant positive effect on manufacturing value added output, while the converse is found true for political globalization, and civil violence, inter alia.
On the other hand, a similar study on Ghana by Abokyi et al. (2018) spanning a period 1971–2014 however, reveals results obtained from the ARDL Bounds test, in confirmation of the hypothesis that infrastructure development in terms of electric consumption negatively impacts manufacturing sector output. The author attributes this finding to the continuous nosediving in the average share of industrial sector’s electricity consumption in Ghana. Elsewhere in Isaksson (2010) however, when the issues of reverse causality, endogeneity bias and omitted state-dependent variables bias are addressed, findings based on data for 79 developed and developing countries during the period 1970–2000, a supportive role of energy infrastructure as a significant force in propelling industrial development is notably strong, though, as the author document, this impact is observed larger for the poorest economies and fast-growing Asian Tigers relative to other income groups. On the other hand, Sharma and Sehgal (2010) and Goel (2002) both focus on India in a panel data framework collected during 1994–2006 and time series data for 1965–1966/1998–1999, respectively to show that infrastructure significantly enhances manufacturing productivity. To confirm the latter findings, a related study by Mitra et al. (2016), applies a Fully Modified OLS, panel Cointegration, and System GMM estimators on the Indian data for the period 1994–2010 to report a strongly positive effect of infrastructure and ICT on the manufacturing sector performance total factor productivity and technical efficiency. Nevertheless, the observed effect appears stronger in industries that are more prone to foreign competition, viz., Transport Equipment, Textile, Chemicals, Metal & Metal Products, which are more exposed to foreign competition. Related findings of a positive infrastructure effect can equally be traced in Wan and Zhang (2017) who use survey data from Chinese manufacturing firms, and also in Satya et al. (2004) where 12 two-digit Canadian manufacturing industries during the period 1961–1995, and strong evidence tilts towards public capital infrastructure as important for the productivity of manufacturing industries.

In addition to Anyanwu (2018), who documents a differential impact of trade openness on MVA, Shafaeddin (2010) focuses on developing countries to argue for trade liberalization as essential factor in industrial sector development but only at later stages when an industry reaches a certain level of maturity. In addition, the author points to varying effects of the same, dependent on the region under analysis. Relatedly, Clavijo et al. (2012) finds trade liberalization to positively influence manufacturing performance in Colombia, and a similar effect on industrial production is recorded elsewhere for Nigeria (Adamu & Dogan, 2016). Conversely, López (2017), using panel data of eight Latin American countries for period 1985–2014, documents among other findings a fall in the average effective tariff in the region as the main economic explanation of the premature reduction in the manufacturing share. Similarly, the positive effect of institutional quality on industrial output can be traced in Grigorian (2000)—in 27 Asian and Latin American countries.

By and large, the differential impact of either infrastructure, liberalization or institutional quality on manufacturing output suggests the need for further in-depth analysis of the issue.
3 Methodology and data

3.1 Model

The theoretical basis of our model is inspired by the conventional Cobb–Douglas aggregate production function which includes capital (K), labour (L) and technology as the main drivers of production.

\[ Y = AK^\alpha L^\beta \]  

Since \( Y \) (aggregate output) constitutes among others, manufacturing production \( (Y_1) \), other forms of industrial production besides manufacturing \( (Y_2) \), agriculture production \( (Y_3) \), services sector output \( (Y_4) \), augmenting Eq. (1) to specifically reflect this disaggregation would result into Eq. (2):

\[ Y_i = A_i K_i^\alpha L_i^\beta \quad \text{where } i = 1, \ldots, n \]  

Corresponding to \( (Y_1) \), the manufacturing output subcomponent, is \( A_1 \), the efficiency factors or total factor productivity. The latter incorporates all the factors that would improve manufacturing production besides the conventionally known capital and labour. In the present case, we consider this component to capture three variables of interest, viz., infrastructure development \( (INFR) \), liberalization \( (LIB) \), and governance \( (INST) \), as well as other exogenous factors \( (C) \), i.e. \( A_1 = f(INFR, LIB, INST, C) \). Assuming a panel data environment, this can be rewritten as:

\[ A_{it} = INFR_{it}^{\lambda}, LIB_{it}^{\phi}, INST_{it}^{\beta}, C_{it} \]  

Substituting Eq. (3) in (2) produces Eq. (4):

\[ Y_{it} = INFR_{it}^{\lambda}LIB_{it}^{\phi}INST_{it}^{\beta}C_{it}K_{it}^\alpha L_{it}^\beta \]  

Linearizing Eq. (4), after including all control variables (capita and labor and the others identified in literature) gives us an estimatable model of the form:

\[ \ln Y_{it} = c + \lambda \ln INFR_{it} + \phi \ln LIB_{it} + \beta INST_{it} + \delta \sum_i CV_{it} + \epsilon_{it} \]  

In summary, denoting the explanatory variables of focus as \( EXP \), the manufacturing output \( (Y_1) \), as \( MAN \) and the other control variables as \( CV \), the augmented manufacturing production function can be written as follows:

\[ MAN_{it} = \alpha_{it} + \pi_i \sum \exp \mu_{it} + \delta_i \sum CV_{it} + \epsilon_{it} \]  

Equation (6) is our final equation for estimation. The control variables selected include GDP per capita (to capture economic development), real exchange rate (to capture macroeconomic instability), investment (to capture capital development), employment (to capture labor).
3.2 Data description and sources

The study uses a panel of 30 countries from SSA, the choice of which depended on data availability: Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Congo, Rep., Cote d’Ivoire, Ethiopia, Gabon, Gambia, The, Ghana, Kenya, Lesotho, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia. The study period covers 16 years (2003–2018), beginning in 2003 when AIDI data collection commenced. Data on infrastructure, obtained from African Development Bank database that contains the African infrastructure development index (AIDI) of the African Development Bank (AfDB, 2020), comprising of the aggregate infrastructure development index (AIDI) and four other sub-indices including electricity composite index (ECI), transport composite index (TCI), ICT composite index (ICTCI) and water and sanitation composite index (WSCI). The index indicates the status of infrastructure development in terms of access, quantity and quality across the African continent. Countries are ranked based on points from 1 to 100, with higher points indicating higher levels of infrastructure development and vice versa. Excluded countries from the sample lacked sufficient data on infrastructure development index (e.g. South Sudan), manufacturing share in GDP (e.g. Equatorial Guinea, Eritrea, Guinea-Bissau), inter alia.

As earlier on mentioned, the liberalization is two-fold: a de facto measure and a de jure measure. The latter is sourced from Chinn-Ito (2006–updated 2018) (KAOPEN), selected for its capacity to measure both the intensity and extensity of capital controls via an evaluation of a country’s legal framework. The measure therefore reflects a country’s willingness to be open as expressed by the reduction or removal of: restrictions and controls on the current or capital account transactions, the existence of multiple exchange rates, and the requirements of surrendering export proceeds. The index ranges from value 2.33, “most financially open” to −1.92, the “least financial open” score. Thus, a higher index value of KAOPEN indicates a higher level of capital account openness and less legal restrictions on a country’s cross-border capital transactions. On the other hand, de facto measures are outcome-oriented indicators, reflecting a country’s actual degree of integration into the world economy. We adopt trade share in GDP, and FDI inflows both of which are commonly used in literature. Data on this and the manufacturing value added (% GDP), as well as other control variables, viz., GDP per capita, real exchange rate, investment (gross fixed capital formation, % of GDP), and employment in industrial sector, is sourced from the World Bank World Development Indicators (WDI) (World Bank, 2019, 2020; IMF, 2021) (Table 1).

Regarding institutional quality, we consider the individual effects of each governance as well as an aggregate effect of one computed indicator. However, in order to avoid multicollinearity, the latter is obtained from the six indicators by using the Principal Component Analysis (PCA) technique that has been used extensively in the existing empirics (e.g. Dragos et al., 2016; Emara & Chiu, 2016; Sharma & Sehgel, 2010). Nevertheless, it is important to note that WGI project reports aggregate and individual governance indicators for six dimensions of governance: Voice and Accountability (VA), Political Stability and Absence of Violence (PS),
Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL) and Control of Corruption (CC). Among the measures is the Rank measure that entails a percentile rank among all countries and ranges from 0 (lowest) to 100 (highest) rank). The alternative is the Estimate measure, where estimate of governance ranges from approximately −2.5 (weak) to 2.5 (strong) governance performance. Data is from the World Bank World Governance Indicators (World Bank, 2020).

### 3.3 Estimation procedure

For the estimation procedure, given the nature of our data, we have all reasons to worry about cross-sectional dependence, serial autocorrelation, and heteroscedasticity problems that usually affect panel data (Bai et al., 2021; De Hoyos & Sarafidis, 2006a, 2006b; Reed & Ye, 2011; Sarafidis & Wansbeek, 2012; Hurlin & Mignon, 2006). The appropriate estimation technique would therefore depend on how these complex issues are resolved. As we show shortly, we zero down to the
3.3.1 Cross-sectional dependence, serial autocorrelation, and, heteroscedasticity

According to Pesaran (2004), panels normally suffer from interdependences, and so, there is clearly a need for testing for cross-sectional dependence when the cross-sectional dimension (N) is large and the panel’s time dimension (T) is small. In such short dynamic panel-data models, the likes of Sarafidis and Robertson (2006) show that in the presence of cross-sectional dependence in the disturbances, all estimation procedures that rely on Instrumental Variables and the generalized method of moments (GMM) (e.g. Anderson & Hsiao, 1981; Arellano & Bond, 1991; Blundell & Bond, 1998; Hsiao, 2014) are inconsistent as N grows large, for fixed T (Hoyos & Sarafidis, 2006a, 2006b). Moreover, as the latter authors argue, if cross-sectional dependence is caused by the presence of common factors (e.g. common shocks), which are unobserved (and the effect of these components is therefore felt through the disturbance term) but uncorrelated with the included regressors, the conventional standard fixed-effects (FE) and random-effects (RE) estimators are consistent, albeit not efficient, and the estimated standard errors are biased. In the present case, our N is large (N = 30) and T is small (T = 16). First, we test for cross-sectional dependence using Pesaran’s CD test (2004) in order to determine the appropriate estimation technique. The test is an improvement on Breusch and Pagan’s (1980) LM test that is discredited for its likelihood to exhibit substantial size distortions when N is large and T is finite. Alternative tests include Friedman’s (1937) test statistic and the statistic proposed by Frees (1995). However, as Pesaran, Ullah, and Yamagata (2006) show, the latter test may not work well in models with explanatory variables when N is large. Moreover, as Carabante-Ordóñez (2017) avers, a limitation of the Friedman test is the inability to allocate replications of the complete rankings from the same panelists. Nevertheless, the three tests are complementary and not competitive, though both Friedman’s and Freé’s tests are fit for unbalanced panel. Since in our case we have a balanced panel, we employ the Pesaran’s CD test recommended by Pesaran (2004) especially where the cross-sectional size is larger than the time dimension. The results from the cross-sectional dependence test are shown in Table 2.

Similarly, panel data is likely to suffer from auto-correlation, a problem known to occur when unobserved shocks to economic relationships exhibit a great probability to stay for more than a single period. Therefore, ignoring it would lead to inefficient estimates and biased standard errors (Baltagi, 2008). We employ the Wooldridge (2002) test of autocorrelation, as it requires relatively few assumptions in addition to being easy to implement (Drukker, 2003). The latter author provides simulation results showing that the test has good size and power properties in reasonably sized samples.

Finally, panel data also requires checking for heteroskedasticity which arises when the variance of the disturbance differs across samples; so the test involves
checking for uniform variation. The PCSE estimator adopted for the study tests heteroskedasticity within panels.

### 3.3.2 Panel corrected standard error estimator

On the basis of the above findings indicating that the error variance matrix reveals autocorrelation, heteroscedasticity and correlation across panels, a popular Prais-Winsten estimation with panel corrected standard errors (PCSE), suggested by Beck and Katz (1995), was carried out to offer efficiency and consistency. Nonetheless, a related technique that would equally achieve the same purpose of overcoming group-wise heteroscedasticity, time-invariant cross-sectional dependence as well as serial correlations is the Feasible Generalized Least Squares (FGLS) estimator earlier proposed by Parks (1967). In fact, Monte Carlo simulations have revealed that both FGLS and PCSE estimators are robust to the three econometric problems above mentioned (Bai et al., 2021). However, as argued in Reed and Ye (2011), the FGLS estimator has been found to severely underestimate standard errors in finite samples and cannot be used when the number of cross-sections (N) are greater than the number of periods (T). Under such circumstances, Beck and Katz (1995) proposed the PCSE estimator, which is a modification of the full GLS-Parks estimator that preserves the Prais-Winsten weighting of observations for autocorrelation, but uses a sandwich estimator to incorporate cross-sectional dependence when calculating standard errors.

Since our sample comprises of a larger N (30) compared to T (16), the automatic choice is the PCSE. PCSE models are both heteroskedastic and contemporaneously correlated across panels, with or without autocorrelation. However, since the empirical literature has found the two estimators majorly identical with common attributes, except when the number of time periods doubles the number of cross-sections, (Reed & Ye, 2011), we also present the results from FGLS as an alternative measure to check for robustness of our findings. Although Reed and Webb (2010) find that the PCSE estimator falls short of the claims made by Beck and Katz, they still sided with the authors in terms of PCSE’s superiority

### Table 2 Cross-sectional dependence

| Variables | lnGDPPC | lnRER | lnFDI | WSS | lnCapital | lnTROPEN | ECI_urb | ECI_rur | lnCC |
|-----------|---------|-------|-------|-----|-----------|----------|--------|--------|------|
| Pesaran CD | 65.08*  | 43.17* | 4.09*  | 70.8*| 10.59*    | 6.34*    | 47.77* | 38.57* | −0.44|
| P-value   | 0.00    | 0.00   | 0.00   | 0.00| 0.00      | 0.00     | 0.00   | 0.00   | 0.66 |

| Variables | lnGE | lnPS | lnRQ | lnRL | lnVA | AIDI | ICT | TCI | ECI |
|-----------|------|------|------|------|------|------|-----|-----|-----|
| Pesaran CD | 1.5  | 3.68*| 4.8* | 4.83*| 4.32*| 80.2*| 80.7*| 6.37*| 23.7*|
| P-value    | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Under the null hypothesis of cross-section independence CD ~ N(0,1); * represents 1% level of significance

Source: Author’s calculations
over FGLS particularly with regard to standard errors improvement when \( N \) is larger than \( T \).

### 4 Results and discussion

#### 4.1 Cross-sectional dependence

As Table 2 shows, results exhibit sufficient evidence to reject the null hypothesis of cross-sectional independence, implying that all the variables, with the exception of CC and GE, exhibit cross-sectional dependence.

#### 4.2 Direct effects of infrastructure, liberalization and governance

As the results presented in Table 3 show, infrastructure development is a very important driver of the manufacturing sector output. Specifically, if we improve infrastructure by 1 (unit), we’d expect the contribution of the manufacturing sector to GDP to increase by 0.9 percent, other factors constant. However, at a disaggregated level, this outcome appears supported only by the transport infrastructure, the coefficient of which is observed similar to that of the overall infrastructure index both in magnitude and direction at 1% level of significance. Conversely, we note a detrimental effect of water supply and sanitation on MVA. In Specification (3) for example, increasing the index by 1 unit would result into a reduction in MVA by 0.5 percent. This finding is in line with Azolibe and Okwonko (2020) for industrial productivity. It is possible that in SSA, contrary to the economic theory expectation, increasing investments in water and sanitation has not led to lower input costs for the manufacturing firms using these services. Consequently, production and employment could have in turn reduced while prices increased. All this implies a possible adverse effect of WSS on the manufacturing firms output. Relatedly, and in agreement with Azolibe and Okwonko (2020), the finding confirms a previous report of the African Union (2014) in which it is observed that despite the region’s rich endowment of ample water resources, these are still underdeveloped, unsustainably managed as well as underutilized, with only 5 percent of agriculture using irrigation. Given that Agriculture constitutes the main source of supply of raw materials to the industrial sector, an observed ineffective utilization of water supply for irrigation purposes would lead to shortage in the supply of raw materials to the industrial sectors. Hence, the possibility of a negative relationship between water and sanitation index and MVA observed in the data is justified.

On the other hand, there is not enough evidence in this study to support the hypothesis that either ICT or electricity infrastructure in general have direct effects on MVA. However, Models (4) and (5) Table 3 reveal the MVA importance of access to electricity in rural areas and, to a lesser level of significance, in urban regions. In the former case, an improvement in rural electricity access
|                | (1)     | (2)     | (3)     | (4)     | (5)     | (6)     | (7)     | (8)     | (9)     |
|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| lnLabor        | 0.135** | 0.112** | 0.112** | 0.091*  | 0.035   | 0.093*  | 0.091** | 0.102** | 0.104** |
|                | (0.058) | (0.047) | (0.052) | (0.047) | (0.048) | (0.049) | (0.042) | (0.044) | (0.047) |
| lnGDPPC        | 0.024   | −0.092**| 0.034   | 0.018   | 0.025   | −0.038  | −0.014  | −0.012  | −0.024  |
|                | (0.033) | (0.040) | (0.031) | (0.032) | (0.034) | (0.032) | (0.025) | (0.028) | (0.030) |
| lnRER          | 0.012   | −0.112  | −0.018  | −0.013  | 0.009   | −0.081  | −0.087  | −0.063  | −0.087  |
|                | (0.088) | (0.085) | (0.105) | (0.100) | (0.098) | (0.089) | (0.091) | (0.090) | (0.096) |
| lnCapital      | 0.017   | 0.036***| 0.026*  | 0.023   | 0.022   | 0.040***| 0.028** | 0.034***| 0.028** |
|                | (0.015) | (0.013) | (0.015) | (0.018) | (0.014) | (0.013) | (0.013) | (0.012) | (0.014) |
| lnFDI          | −0.009  | −0.007  | −0.015* | −0.011  | −0.010  | −0.012  | −0.014* | −0.014* | −0.016* |
|                | (0.008) | (0.007) | (0.009) | (0.008) | (0.008) | (0.008) | (0.007) | (0.008) | (0.009) |
| lnTROPEN       | −0.122**| −0.100**| −0.103* | −0.101* | −0.089* | −0.102**| −0.080* | −0.094* | −0.074  |
|                | (0.055) | (0.047) | (0.054) | (0.052) | (0.052) | (0.051) | (0.049) | (0.048) | (0.051) |
| TCI            | 0.009***| 0.011***| 0.010***|         |         |         |         |         |         |
|                | (0.002) | (0.002) | (0.002) |         |         |         |         |         |         |
| ECI            | 0.002   | 0.002   | 0.001   |         |         |         |         |         |         |
|                | (0.002) | (0.002) | (0.002) |         |         |         |         |         |         |
| ICT            | 0.001   | 0.002   | 0.001   |         |         |         |         |         |         |
|                | (0.002) | (0.002) | (0.002) |         |         |         |         |         |         |
| WSS            | −0.005***| −0.006***| −0.005***|         |         |         |         |         |         |
|                | (0.002) | (0.001) | (0.002) |         |         |         |         |         |         |
| KAOPEN         | −0.048***|         |         |         |         |         |         |         |         |
|                | (0.012) |         |         |         |         |         |         |         |         |
| AIDI           | 0.009***|         |         |         |         |         |         |         |         |

Table 3 Effects of infrastructure development, liberalization, and governance
|               | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       | (7)       | (8)       | (9)       |
|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| KAOPEN        |           |           |           |           |           |           |           |           |           |
|               |           |           |           |           |           |           |           |           |           |
| AIDI          |           |           |           |           |           |           |           |           |           |
|               |           |           |           |           |           |           |           |           |           |
| AIDI          |           |           |           |           |           |           |           |           |           |
|               |           |           |           |           |           |           |           |           |           |
| ECI_urb       |           |           |           | 0.002***  |           |           |           |           |           |
|               |           |           |           | (0.001)   |           |           |           |           |           |
| ECI_rur       |           |           |           |           | 0.004***  |           |           |           |           |
|               |           |           |           | (0.001)   |           |           |           |           |           |
| INST          |           |           |           |           |           | 0.042***  |           |           |           |
|               |           |           |           |           |           | (0.011)   |           |           |           |
| lnCC          |           |           |           |           |           |           | 0.016     |           |           |
|               |           |           |           |           |           | (0.042)   | (0.022)   |           |           |
| lnPS          |           |           |           |           |           |           |           | −0.027    |           |
|               |           |           |           |           |           |           |           | (0.022)   |           |
| lnRQ          |           |           |           |           |           |           |           |           | 0.096*    |
|               |           |           |           |           |           |           |           | (0.057)   |           |
| lnVA          |           |           |           |           |           |           |           |           | 0.077***  |
|               |           |           |           |           |           |           |           | (0.027)   |           |
| lnRL          |           |           |           |           |           |           |           |           | 0.116***  |
|               |           |           |           |           |           |           |           | (0.040)   |           |
| lnGE          |           |           |           |           |           |           |           |           | 0.127***  |
|               |           |           |           |           |           |           |           | (0.033)   |           |
| Constant      | 1.806***  | 2.126***  | 1.736***  | 1.846***  | 1.949***  | 1.865***  | 1.303***  | 1.347***  | 1.464***  |
| Observations  | 459       | 459       | 459       | 459       | 458       | 459       | 459       | 459       | 459       |
| R− squared    | 0.650     | 0.657     | 0.630     | 0.645     | 0.666     | 0.640     | 0.628     | 0.638     | 0.632     |
| Wald chi2     | 101.2***  | 91.14***  | 324.9***  | 284.9***  | 288.7***  | 89.30***  | 152.4***  | 89.74***  | 92.18***  |
|                  | (1)         | (2)         | (3)         | (4)         | (5)         | (6)         | (7)         | (8)         | (9)         |
|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| KAOPEN           |             |             |             |             |             | INST        | INST        | INST        | INST        |
| AIDI             | Yes         | Yes         | Yes         | Yes         | Yes         | Yes         | Yes         | Yes         | Yes         |
| AIDI             |             |             |             |             |             |             |             |             |             |
| ECI_urb          |             |             |             |             |             | INST        | INST        | INST        | INST        |
| ECI_rur          |             |             |             |             |             |             |             |             |             |
| INST             |             |             |             |             |             |             |             |             |             |
| INST             |             |             |             |             |             |             |             |             |             |

CD Test          182.96*** | 181.8*** | 144.5*** | 145.7*** | 150.6*** | 167*** | 140.1*** | 197.3*** | 159.8***

Wooldridge.Test  182.96*** | 181.8*** | 144.5*** | 145.7*** | 150.6*** | 167*** | 140.1*** | 197.3*** | 159.8***

INST stands for governance quality. The rest of the variables are explained in Table 6. Standard errors in parentheses; ***p < 0.01, **p < 0.05, *p < 0.1
Source: Author’s calculations
by one unit is expected to result into an increase in manufacturing production by 4 percent. The relevant coefficient is statistically significant at 1 percent. A similar change in urban electricity access however would produce a significant change of 0.2 percent in MVA, though the relevant coefficient is observed weakly significant at 10 percent, albeit in the positive direction. The finding is in line with previous studies such as Chenedum and Nnadi (2016), Isaksson (2010), and, Maweje and Maweje (2016).

Regarding our second objective, Table 3 reveals that both the de jure and de facto forms of economic liberalization are detrimental to the manufacturing contribution to GDP. The baseline results in Specification (1) provide evidence indicating that if we trade integration improves by one percent, we would expect MVA to reduce by $-0.12$ percent. Similarly, an increase in financial openness by one unit would yield change in MVA by $-4.8$ percent. By implication, data points to larger disastrous effects of financial liberalization relative to trade openness on the MVA. The impact in both models is actually statistically significant at 1% even when we control for employment, real exchange rate undervaluation, and the level of a country’s economic development. These findings are consistent with López (2017), Bogliacini (2013), and Shafeddin (2005) among others. The latter for example finds trade liberalization to have led to deindustrialization of SSA countries. It is likely that because in the Sub-Saharan Africa region most industries are relatively small, they will suffer losses in competing with international firms that have the monopoly of proper financial resources, advanced technology and top management skills. Also, SSA countries have had to suffer from enormous capital inflows that these countries are not prepared to absorb given their underdeveloped financial systems. Hence, the inverse effect on the manufacturing sector, particularly on the import side.

On the other hand, Table 3 provides overwhelming evidence of a positive direct effect of institutional quality on the manufacturing contribution to total output. The relevant coefficient in Specification (6), given as 0.042, is statistically significant at 1 percent. By implication, an improvement in the institutional quality by one unit is expected to produce a change in MVA by about 4.2 percent. At an individual level, we note if we increase governance effectiveness or rule of law or voice and accountability or regulatory quality by one percent each, we expect MVA to increase by 0.127%, 0.116% 0.077% and 0.096% respectively. As evident in Specifications (7) through (9), all the coefficients are statistically significant at 1 percent, except for the latter indicator which is weakly significant at 10 percent. We shortly explore the possibility that institutional quality could influence the MVA effect of infrastructure development.

Finally, the effect of the other control variables is worth-noting. First, as expected, labour has positive effect on manufacturing output. In Table 3, Column 1, for example, an increase in labor employed in the manufacturing sector would lead to an increase in manufacturing output by about 0.14 percent. This positive relationship between labour and MVA shows that the importance of labor-intensive skills in the manufacturing production cannot be underestimated in Sub-Saharan Africa. Azolibe and Okonkwo (2020) similarly record a positive effect of labour on industrial productivity, albeit insignificant. An increase in capital by one percent is expected for example to lead to an increase in MVA by 0.04 percent, showing that the impact of
gross fixed capital formation is strongly significant, as the relevant coefficient shows (Column 2, Table 3). However, this is the case when infrastructure development is controlled for, as well as in other models where disaggregated governance indicators are under control. On the other hand, foreign direct investment does not appear to benefit MVA as it exhibits a negative coefficient in all models and weakly significant (Columns 3, 7–9).

4.3 Interaction effects

In this paper we further examined the joint effect of infrastructure development and either liberalization or governance on MVA. The aim was to find out if the infrastructure-manufacturing relationship varies with the dimension of openness or governance indicator. Table 4 contains results that provide several interesting findings regarding these interactions. First, we note that only the capital account liberalization moderates the relationship between infrastructure development and MVA. The interaction coefficients in all models (1), (2) and (4) are positive and significant, implying that the effect of infrastructure development will increase as financial liberalization improves, suggesting that the more open a country is to the international world, the greater the significance of infrastructure development. Alternatively put, the combined action of capital account and infrastructure is greater than the sum of the individual effects. Statistically, the total marginal effect ($0.011 + 0.002[18.48] = 0.05$) is positive and larger than the one in the non-interacted model (0.009). A deeper analysis of the individual infrastructure development indices further reveals that it is only transport (TCI), electricity (ECI) and Water and Sanitation (WSS) infrastructure that appear to gain from the improvement of financial liberalization in their effects on the manufacturing sector output. Perhaps, as argued earlier on, it is possible that liberalization in SSA has led to increased imported inputs and advanced technology in the form of transport and electricity infrastructure which in turn boosted manufacturing output. On the other hand, the interaction effect of TCI on MVA in the presence of trade openness is negative. Simply put, the increase of trade integration will decrease the significance of transport infrastructure effect. And since the effect of TCI is positive (Model 3), its effect will be less positive with increasing trade liberalization. It is noteworthy that given that the direct effects of ICT on MVA were insignificant, the ICT variable couldn’t be used as an interaction. The interaction effect of WSS and financial openness on the one hand and trade openness on the other is in both cases positive (Table 4, Columns 5 and 6) implying that the effect of WSS infrastructure on MVA will increase as a country achieves greater liberalization.

Turning to our second moderator variable, Table 5 displays a negative interaction effect in all Specifications (1) to (7), both for the aggregated governance indicator and all other individual indicators. By implication, the effect of infrastructure development on the MVA will get smaller as institutional quality improves. Given that the effect of infrastructure development is positive, its impact will be less positive with better governance. This might look surprising and somewhat counterintuitive but probably less unexpected in the case of SSA. It is highly probable that the observed
|             | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------|
|             | AIDI*KAOPEN | TCI*KAOPEN | TCI*TROPEN | ECI*KAOPEN | WSS*KAOPEN | WSS*TROPEN |
| TROPEN      | −0.122*** | −0.120**  | 0.043     | −0.125**  | −0.578***  | −1.202***  |
|             | (0.046)   | (0.052)   | (0.073)   | (0.053)   | (0.066)   | (0.284)   |
| KAOPEN      | −0.090*** | −0.073*** | −0.071*** | −0.459*** |           |           |
|             | (0.022)   | (0.014)   | (0.013)   | (0.162)   |           |           |
| AIDI        | 0.011***  |           |           |           |           |           |
|             | (0.002)   |           |           |           |           |           |
| AIDI*KAOPEN | 0.002***  |           |           |           |           |           |
|             | (0.001)   |           |           |           |           |           |
| TCI         |           | 0.007***  | 0.082***  |           |           |           |
|             |           | (0.001)   | (0.017)   |           |           |           |
| TCI*KAOPEN  |           | 0.002***  |           |           |           |           |
|             |           | (0.001)   |           |           |           |           |
| TCI*TROPEN  |           | −0.018*** |           |           |           |           |
|             |           | (0.004)   |           |           |           |           |
| ECI         |           |           |           | 0.004*    |           |           |
|             |           |           |           | (0.002)   |           |           |
| ECI*KAOPEN  |           |           |           | 0.002**   |           |           |
|             |           |           |           | (0.001)   |           |           |
| WSS         |           |           |           |           | −0.002    | −0.018*** |
|             |           |           |           |           | (0.001)   | (0.005)   |
| WSS*KAOPEN  |           |           |           |           | 0.095**   |           |
|             |           |           |           |           | (0.039)   |           |
| WSS*TROPEN  |           |           |           |           |           | 0.159**   |
Models include only technological infrastructure, constant, capital, labor, FDI, GDP per capita and real exchange rate, all in logs. TROPEN is in logs. ICT Index was not interacted with infrastructure as its direct effect was insignificant in Table 2. Standard errors in parentheses; ***p < 0.01, **p < 0.05, *p < 0.1

Source: Author’s calculations

|                | (1) AIDI*KAOPEN | (2) TCI*KAOPEN | (3) TCI*TROPEN | (4) ECI*KAOPEN | (5) WSS*KAOPEN | (6) WSS*TROPEN |
|----------------|-----------------|----------------|----------------|----------------|----------------|----------------|
| Observations   | 459             | 459            | 459            | 459            | 459            | 459            |
| R− squared     | 0.672           | 0.662          | 0.650          | 0.659          | 0.98           | 0.98           |
| Wald chi2      | 160.4***        | 157***         | 173.7***       | 146.8***       | 5290***        | 3978***        |
| Pesaran CD Test| Yes             | Yes            | Yes            | Yes            | Yes            | Yes            |
| Wooldridge Test| 182.8***        | 184.3***       | 179.7***       | 188.7***       | 309.8***       | 299.4*         |

(continued)
Table 5  Effect of infrastructure via governance

|                | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       | (7)       | (8)       | (9)       | (10)      | (11)      |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| AIDI*INST      | 0.188***  | 0.179***  | 0.024*    | -0.005    | 0.847***  | 0.179***  | 0.024*    | -0.005    | 0.847***  | 0.015     | 0.013     |
| (lnAIDI)       | 0.301***  | 0.936***  | 1.019***  | 0.940***  | 1.082***  | 1.234***  | 1.154***  | (0.083)   | (0.312)   | (0.239)   | (0.167)   |
| lnCC           | 0.408**   | 0.408**   | 0.408***  | 0.198     | (0.075)   | (0.198)   | (0.198)   | (0.075)   | (0.198)   | (0.198)   | (0.198)   |
| AIDI*CC        | -0.070*** | -0.070*** | -0.174**  | -0.216*** | -0.216*** | -0.216*** | -0.216*** | (0.015)   | (0.015)   | (0.015)   | (0.015)   |
| lnGE           |           |           | 0.577***  | (0.155)   |           |           |           |           |           |           |           |
| AIDI*GE        |           |           | -0.216*** | (0.057)   |           |           |           |           |           |           |           |
| lnPS           |           |           | 0.400***  | (0.089)   |           |           |           |           |           |           |           |
| AIDI*PS        |           |           | -0.207*** | (0.037)   |           |           |           |           |           |           |           |
| lnRQ           |           |           | 0.640***  | (0.181)   |           |           |           |           |           |           |           |
| AIDI*RQ        |           |           | -0.228*** | (0.065)   |           |           |           |           |           |           |           |
| lnRL           |           |           |           |           |           |           |           |           |           | 0.595***  | (0.214)   |
|                | (1)   | (2)     | (3)    | (4)    | (5)    | (6)     | (7)    | (8)     | (9)    | (10)   | (11)   |
|----------------|-------|---------|--------|--------|--------|---------|--------|---------|--------|--------|--------|
| AIDI*RL        |       | -0.262*** |       |       |        |         |        |         |        |        |        |
|                |       | (0.082)  |       |       |        |         |        |         |        |        |        |
| lnVA           |       | 0.682*** |       |       |        |         |        |         |        |        |        |
|                |       | (0.134)  |       |       |        |         |        |         |        |        |        |
| AIDI*VA        |       | -0.236***|       |       |        |         |        |         |        |        |        |
|                |       | (0.050)  |       |       |        |         |        |         |        |        |        |
| lnTCI          |       | 0.148*** |       |       |        |         |        |         |        |        |        |
|                |       | (0.050)  |       |       |        |         |        |         |        |        |        |
| TCI*INST       |       | -0.112***|       |       |        |         |        |         |        |        |        |
|                |       | (0.010)  |       |       |        |         |        |         |        |        |        |
| lnECI          |       | -0.038***|       |       |        |         |        |         |        |        |        |
|                |       | (0.011)  |       |       |        |         |        |         |        |        |        |
| ECI*INST       |       | -0.020***|       |       |        |         |        |         |        |        |        |
|                |       | (0.004)  |       |       |        |         |        |         |        |        |        |
| lnICTCI        |       | -0.005   |       |       |        |         |        |         |        |        |        |
|                |       | (0.006)  |       |       |        |         |        |         |        |        |        |
| ICT*INST       |       | -0.003*  |       |       |        |         |        |         |        |        |        |
|                |       | (0.002)  |       |       |        |         |        |         |        |        |        |
| lnWSSCI        |       | 0.040    |       |       |        |         |        |         |        |        |        |
|                |       | (0.076)  |       |       |        |         |        |         |        |        |        |
| WSS*INST       |       | -0.213***|       |       |        |         |        |         |        |        |        |
|                |       | (0.019)  |       |       |        |         |        |         |        |        |        |
| Observations   | 459   | 459      | 459    | 459    | 459    | 459     | 459    | 459     | 458    | 459    | 459    |
| R–squared      | 0.989 | 0.989    | 0.990  | 0.990  | 0.988  | 0.990   | 0.988  | 0.990   | 0.988  | 0.988  | 0.989  |
Table 5 (continued)

|                | (1)  | (2)  | (3)  | (4)  | (5)  | (6)  | (7)  | (8)  | (9)  | (10) | (11) |
|----------------|------|------|------|------|------|------|------|------|------|------|------|
| Wald chi2      | 7271*** | 6677*** | 5640*** | 6551*** | 9183*** | 5155*** | 5809*** | 7681*** | 7551*** | 4789*** | 9829*** |
| Pesaran CD Test| YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  |
| Wooldridge Test| 276.7*** | 304.9*** | 282.3*** | 278.1*** | 277.5*** | 300.8*** | 274.9*** | 284.9*** | 287.8*** | 271.5*** | 285.1*** |

Models include a constant, labor, capital, GDP per capita, real exchange rate and FDI, all in logs; ***p < 0.01, **p < 0.05, *p < 0.1; Standard errors in parentheses

Source: Authors’ calculations
outcome is because the apparent improvement in governance is not sufficient enough to offset the negative effects of poor institutions, such as high levels of corruption and red tape, that have for long been associated with infrastructure projects in the region (Sobják, 2018). The author admits that transport and energy infrastructure in Sub-Saharan Africa are deterred by the high level of corruption risks, which in turn discourages the mutually beneficial match of high return projects for private investors as well as closing Africa’s infrastructure gap, consequently affecting manufacturing sector that is overly dependent on infrastructure development. Our findings are in line with previous works by Egger and Winner (2007) and Saha and Sen (2020). In the present case, SSA infrastructure projects are more likely surviving on corruption and other distortions in governance, perhaps viewing it as a ‘blessing in disguise’ on account that it can help reduce the costs of inefficient border controls as well as overcome more deeply rooted shortcomings and inefficiencies, such as low bureaucratic quality (De Jong & Bogmans, 2011). Under these circumstances, any improvement in anti-corruption measures for example would likely reduce the positive contribution of infrastructure on the MVA.

Relatedly, the results in Table 5, show the effects of interacting disaggregated infrastructure development index with the composite governance quality index. The interaction effect is everywhere negative (Columns 8–11) implying that the increase in governance quality will decrease the significance of infrastructure development on MVA. In Column 8, given that the coefficient on transport infrastructure is significantly positive, the negative interaction coefficient means that its effect will be less positive with increasing institutional quality. A similar interpretation holds for water and sanitation infrastructure. However, for electricity, its effect will be less negative with increasing quality of governance. The interaction effect of ICT infrastructure and governance can be interpreted in a similar way.

4.4 Robustness checks

In order to carry out a sensitivity analysis of our findings, several robustness checks were carried out. First, there is a possibility that the findings are driven by two outliers (South Africa and Nigeria) in terms of economic size. We therefore drop both countries one by one from the sample and re-estimate the relevant models. Unsurprisingly, the original findings are not substantially altered. Second, it could be argued that different estimators could offer varied results. We therefore employ an alternative estimation technique, namely, feasible generalized least squares (FGLS) technique to re-estimate our baseline model. Still, the results offer no substantial differences with the PCSE outcomes. We have not presented the results due to space and high similarity with the latter but they are available on request.
5 Concluding remarks

We set out to investigate the both the direct and joint effect of infrastructure development, liberalization and governance on manufacturing sector output. The results suggest a positively significant relationship between manufacturing value added and infrastructure development. The transport infrastructure in particular appears to dominate this effect, whereas evidence exists in support of the role of access to electricity in urban and rural areas, but only strongly significant in the latter. Our results also indicate that governance is crucial for MVA, and therefore beneficial to all SSA countries. On the other hand, while trade and financial liberalization exhibit direct detrimental effects on the contribution of manufacturing to total output, the joint effect of infrastructure development and the latter appear to depend significantly on growing financial liberalization. This is particularly the case for transport and electricity infrastructure, while trade openness is a detriment in the transport infrastructure-manufacturing linkage. Similarly, the contribution of infrastructure development to MVA dwindles with improving institutional quality.

These findings emphasize the need for countries to promote infrastructure development as an aggregate indicator comprising transport, electricity, ICT and water and sanitation infrastructure, in order to facilitate the manufacturing sector contribution to total output. The transport infrastructure should however be given more prominence as it directly and significantly relates to manufacturing value added. We particularly commend the SSA key focus over the next decade on transport infrastructure access and quality in terms of roads, rail, ports, and air transport, as a right step in the right direction. The observed direct adverse effects of liberalization on MVA, however, is an invitation to policy makers to be cautious on capital account openness and to design trade related strategies tailored towards revamping the low exports. The efforts to improve overall governance quality should be enhanced further with implementable policies, as the data has clearly and unambiguously rendered support for the hypothesis that better institutional quality relate to larger share of the manufacturing sector to a country’s income. In particular, SSA countries should render support to policies that promote government effectiveness, the rule of law, voice and accountability as well as regulatory quality. An integral well-coordinated approach is required.

This study is not without limitations, and some issues require further consideration. First, an analysis of the causality between infrastructure or governance or economic liberalization and MVA would also be worthwhile undertaking. This wasn’t the subject of our analysis but would add to the understanding of the linkages among these factors. Second, in the current study, we limited ourselves only to two-way interactions, but higher-order interactions would be included to determine deeper interrelationships, though it should be noted that such interactions are notoriously hard to interpret and rarely used in practice. Also, future studies could examine non-linearity possibility of the models as well as accompanying threshold levels for infrastructure and governance in determining manufacturing sector production.

Appendix

See Table 6.
TABLE 6  Level of Technological Infrastructure and Governance to SSA

|                      | 2003   | 2010   | 2018   |
|----------------------|--------|--------|--------|
| **ICT**              |        |        |        |
| *Telecommunication Density* |        |        |        |
| Fixed and mobile telephones per 100 people (median) | 6.4    | 46.1   | 83     |
| *Internet Density*   |        |        |        |
| (Number of users per 100 people (median)) | 1.1    | 6.8    | 26.3   |
| *Fixed broadband*    |        |        |        |
| Number of subscriptions per 100 people (median) | 0.1 (2007) | 0.2   | 0.5    |
| **Electricity**      |        |        |        |
| Electricity power consumption ((Kwh per capita)) | 512.9  | 508.2  | 487.3 (2014) |
| Access to electricity (% of population) | 31.2   | 33.7   | 45.8   |
| Access to electricity, urban (% of urban population) | 65     | 67.9   | 75.9   |
| Access to electricity, rural (% of rural population) | 31.2   | 33.7   | 45.8   |
| **Transport**        |        |        |        |
| Road Density (km of road per sq. km of land area (median)) | 0.11 (2005) | 0.9 (2014) |
| Railroad Density (km of road per sq. km of land area (median)) | 0.004 (2005) | 0.002 (2014) |
| **Governance Indicators** |        |        |        |
| Control of corruption | 37.4   | 36.3   | 35.9   |
| Government effectiveness | 31.9   | 33.7   | 35.3   |
| Political stability | 33.9   | 40.5   | 38.2   |
| Regulatory quality | 35.2   | 37.5   | 36.1   |
| Rule of law | 36.5   | 36.7   | 37.4   |
| Voice and accountability | 39.7   | 37.7   | 39.1   |

International Telecommunications Union’s World Telecommunication/ICT indicators; World Bank, World Development indicators. International Energy Agency; World Energy Outlook; International Road Federation, World Road statistics

*LAC* Latin America and the Caribbean, *MENA* Middle East and North Africa, *SSA* Sub-Saharan Africa

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**Author contributions**  JBN initiated the idea, developed it and wrote the draft manuscript. SK contributed to the literature review and to the final text. JS worked on the methodology and data issues. AN read and provided comments for improvement.

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Availability of data and materials  The study uses data on several variables spanning a period 2003–2018 for 30 SSA countries. All data is available from the relevant sources, including the World Bank World Development Indicators, accessible at https://data.worldbank.org; World Bank Governance Indicators; African Development Bank infrastructure development index; Chinn and Ito KAOPEN index.

Declarations

Conflict of interest  The authors of this manuscript declare no conflict of interest.

References

Abokyi, E., Appiah-Konadu, P., Sikayena, I., & Oteng-Abayie, E. F. (2018). Consumption of electricity and industrial growth in the case of Ghana. *Journal of Energy, 2018*, 1–11. https://doi.org/10.1155/2018/8924835

Adamu, F., & Dogan, E. (2016). Trade openness and industrial growth: Evidence from Nigeria. *Panoeconomicus, 64*(00), 29–29. https://doi.org/10.2298/PAN150130029A

African Development Bank Report (AfDB) (2020). African Infrastructure Development Index 2019. https://www.afdb.org/en/documents/economic-brief-africa-infrastructure-development-index-aidi-2020-july-2020 African Union (AU) (2014) (2014). The Africa Water Vision for 2025: Equitable and sustainable use of water for socioeconomic development. Addis Ababa.

Ahmed, R. (2016) Social infrastructure and productivity of manufacturing firms—Evidence from Pakistan. Discussion Paper No. 16–038, ZEW - Centre for European Economic Research, Mannheim.

Ajakaiye, O., & Ncube, M. (2010). Infrastructure and economic development in Africa. *Journal of African Economies, 19*(1), 3–12.

Amoasah, F. (2018) Trade liberalization and economic growth: A study on Ghana, Nigeria and Cote d’Ivoire, FIW Working Paper, No. 188, FIW - Research Centre International Economics, Vienna. http://hdl.handle.net/10419/194223

Anderson, T. W., & Hsiao, C. (1981). Estimation of dynamic models with error components. *Journal of the American Statistical Association, 76*, 598–606. https://doi.org/10.2307/2287517

Ansar, A., Flyvbjerg, B. A., & Lunn, D. (2016). Does infrastructure investment lead to economic growth or economic fragility? Evidence from China. *Oxford Review of Economic Policy, 32*(3), 360–390. https://doi.org/10.1093/oxrep/grw022

Anyanwu, J. C. (2017). Manufacturing value added development in North Africa: Analysis of key drivers. *Asian Development Policy Review, 5*(4), 281–298.

Anyanwu, J. C. (2018). Does human capital matter in manufacturing value added development in Africa? *Asian Journal of Economic Modelling, 6*(3), 294–317.

Appiah-Otoo, L., & Song, N. (2021). The impact of ICT on economic GROWTH-COMPARING rich and poor countries. *Telecommunications Policy*. https://doi.org/10.1016/j.telpol.2020.102082

Arellano, M., & Bond, S. (1991). Some test of specification for panel data: Monte Carlo evidence and application to employment equations. *Review of Economic Studies, 58*, 277–297. https://doi.org/10.2307/2297968

Ayogu, M. (2007). Infrastructure and economic development in Africa: A review. *Journal of African Economies, 16*, 75–126. https://doi.org/10.1093/jae/ejm024

Azolibe, C. B. (2021). Does foreign direct investment influence manufacturing sector growth in Middle East and North African region? *International Trade, Politics and Development, 5*(1), 71–85. https://doi.org/10.1108/ITTPD-04-2020-0010

Azolibe, C. B., & Okonkwo, J. J. (2020). Infrastructure development and industrial sector productivity in Sub-Saharan Africa. *Journal of Economics and Development, 22*(1), 91–109. https://doi.org/10.1108/JED-11-2019-0062

Bai, J., Cho, S. H., & Liao, Y. (2021). Feasible generalized least squares for panel data with cross-sectional and serial correlations. *Empirical Economics, 60*, 309–326.

Baltagi, B. (2008). *Econometric Analysis of Panel Data*. John Wiley & Sons.
Basu, P., & Guariglia, A. (2008). Foreign Direct Investment, inequality, and growth. *Journal of Macroeconomics*, 29, 824–839.

Bbale, J. M., & Nnyanzi, J. B. (2016). How do liberalization, institutions and human capital development affect the nexus between domestic private investment and foreign direct investment? Evidence from Sub-Saharan Africa. *Global Economy Journal*, 16(3), 569–598. https://doi.org/10.1515/gej-2015-0057

Beck, N., & Katz, J. N. (1995). What to do (and not to do) with time series cross-section data. *American Political Science Review*, 89, 634–647.

Beji, S., & Belhadj, A. (2016). The determinants of industrialization: Empirical evidence for Africa. *European Scientific Journal*. https://doi.org/10.19044/esj.2015.0057

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87, 115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

Bogliaccini, J. A. (2013). Trade liberalization, deindustrialization, and inequality. *Latin American Research Review*, 48, 79–105.

Breusch, T., & Pagan, A. (1980). The Lagrange multiplier test and its application to model specification in econometrics. *Review of Economic Studies*, 47, 239–253.

Calderón, C., & Servén, L. (2010). Infrastructure and economic development in Sub-Saharan Africa. *Journal of African Economics*, 19(1), 13–87. https://doi.org/10.1093/jae/eip022

Carabante-Ordóñez, K.M. (2017). Statistical and technical methodologies for duplicated multiple-samples preference and attribute intensity sensory ranking test. LSU Doctoral Dissertations. 4141. https://digitalcommons.lsu.edu/gradschool_dissertations/4141

Chenery, H. B. (1955). The role of industrialization in development programs. *The American Economic Review*, 45(2), 40–57.

Chinedum, E. I., & Nnadi, K. U. (2016). Electricity supply and output in Nigerian manufacturing sector. *Journal of Economics and Sustainable Development*, 7(6), 154–163.

Chinn, M. D., & Ito, H. (2006). What matters for financial development? Capital controls, institutions, and interactions. *Journal of Development Economics*, 81(1), 163–192.

Ciccone, A. (2002). Agglomeration effects in Europe European economic review. *Elsevier*, 46(2), 213–227.

Cornwall, J. (1977). *Modern Capitalism. It's Growth and Transformation*. St. Martin’s Press.

Deloitte (2016). “Global Manufacturing Competitiveness Index,” (https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-manufacturing-competitiveness-index.html).

Dragos, S. L., Mare, C., & Drule, A. M. (2016). Overall governance index for developed and emerging European life insurance markets. *International Journal of Academic Research in Business and Social Sciences*, 6(10), 381–391.

Drukker, D. M. (2003). Testing for serial correlation in linear panel-data models. *The Stata Journal*, 3(2), 168–177.

Egger, P., & Winner, H. (2007). How corruption influences foreign direct investment: A panel data study. *Economic Development and Cultural Change*, 54(2), 459–486.

Emara, N., & Chiu, M. (2016). The impact of governance environment on economic growth: The case of Middle Eastern and North African countries. *Journal of Economics*, 3(1), 24–37.

Esfahania, H. S., & Ramírez, M. T. (2003). Institutions, infrastructure and economic growth. *Journal of Development Economics*, 70, 443–477.

Fedderke, J., & Garlick, R. (2008). *Infrastructure Development and Economic Growth in south Africa: A Review of the Accumulated Evidence, Economic Research Southern Africa, Policy Paper*, 12. University of Cape Town.
Frees, E. W. (1995). Assessing cross-sectional correlation in panel data. *Journal of Econometrics*, 69, 393–414.

Friedman, M. (1937). The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the American Statistical Association*, 32, 675–701.

Gafer, T. I., & Saad, B. A. (2009). An empirical analysis of the effect of infrastructure on industrialization in Nigeria, 1980–2005. *Journal of International Economic Review*, 2(1/2), 135–149.

Goel, D. (2002) Impact of infrastructure on productivity: Case of Indian registered manufacturing. Centre for Development Economics Working Paper No. 106.

Gräbner, C., P. Heimberger, J. Kapeller and F. Springholz (2018) Measuring economic openness: A review of existing measures and empirical practices. Institute for Comprehensive Analysis of the Economy Working Paper Series, No. 84, Johannes Kepler University Linz.

Grigorian, D.A. and A. Martinez. (2000). Industrial growth and the quality of institutions: What do (Transition) economies have to gain from the rule of law? Policy Research Working Paper; No. 2475. World Bank, Washington, DC.

Hoebink, P. (2006). European donors and good governance: condition or goal? *European Journal of Development Research*, 18(1), 131–161. https://doi.org/10.1080/09578810600576768

Hoyos, R. E., & Sarafidis, V. (2006b). Testing for cross-sectional dependence in panel-data models. *The Stata Journal*, 6(4), 482–496.

Hsiao, C. (2014). *Analysis of Panel Data* (3rd ed.). Cambridge University Press.

Hulten, C. R., Bennathan, E., & Srinivasan, S. (2006). Infrastructure, externalities, and economic development: A study of the Indian manufacturing industry. *The World Bank Economic Review*, 20(2), 291–308. https://doi.org/10.1093/wber/lhj007

Hurlin, C. & Mignon, V. (2006). Second generation panel unit root tests. 2007. halshs00159842

IMF. Financial Development Index Database. 2021. Available online: https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B (accessed on 10 July, 2021).

Isaksson, A. (2010). Energy Infrastructure and Industrial Development. UNIDO Research and Statistics Working Paper 12/2009.

Kaldor, N. (1966). *Causes of the Slow Rate of Economic Growth of the United Kingdom*. Cambridge University Press.

Kaldor, N. (1967). *Strategic Factors in Economic Development*. Cornell University Press.

Kanagawa, M., & Nakata, T. (2008). Assessment of access to electricity and the socio-economic impacts in rural areas of developing countries. *Energy Policy*, 36(6), 2016–2029.

Khan, M.H. (2007). Governance, economic growth and development since the 1960s. UN/DESA Working Paper No. 54, ST/ESA/2007/DWP54. https://www.un.org/esa/ desa/papers/2007/wp54_2007.pdf

Kodongo, O., & Ojah, K. (2016). Does infrastructure really explain economic growth in SSA. *Review of Development Finance*, 6, 105–125.

Kose, M. A., Prasad, E. S., Rogoff, K., & Wei, S.-J. (2009). Financial globalization: A reappraisal. *IMF Staff Papers*, 56(1), 8–62.

Krebs, T., Krishna, P. and Maloney, W. (2005). ‘Trade policy, income risk, and welfare. Policy Research Working Paper Series 3622, The World Bank.

Kuznets, S. (1966). *Modern Economic Growth*. Yale University Press.

Kwabena, A., & Osei-Ampomsah, C. (2009). Determinants of the output of the manufacturing industry in Ghana from 1974 to 2006. *Ghana Policy Journal*, 3(2009), 79–89.

Lall, S. (2004) Reinventing industrial strategy: The role of government policy in building industrial competitiveness. UNCTAD, G-24 Discussion Paper series, April.

Landry, S. (2018). *The potential of manufacturing and industrialization in Africa: Trends, opportunities, and strategies*. Brookings Institution.

Lewis, W. A. (1954) Economic development with unlimited supplies of labour. The Manchester School May, pp. 139–191.

López, M. H. (2017). Trade liberalization and premature deindustrialization in Colombia. *Economic Structures*. https://doi.org/10.1186/s40008-017-0095-6

Louri, H., & Minoglou, I. P. (2002). A hesitant evolution: industrialisation and de-industrialisation in Greece over the long run. *Journal of European Economic Studies*, 31(2), 321–348.

Maweje, J., & Maweje, D. N. (2016). Electricity consumption and sectoral output in Uganda: An empirical investigation. *Journal of Economic Structures*, 5(21), 2016. https://doi.org/10.1186/s40008-016-0053-8
McCausland, D. W., & Theodossiou, I. (2012). Is manufacturing still the engine of growth? *Journal of Post Keynesian Economics, 35*(1), 79–93.

Mitra, A., Sharma, C., & Véghanzonès-Varoudakis, M. (2016). Infrastructure, information & communication technology and firms' productive performance of the Indian manufacturing. *Journal of Policy Modeling, 38*(2), 353–371.

Muvawala, J., Sebukeera, H., & Ssebulime, K. (2021). Socio-economic impacts of transport infrastructure investment in Uganda: Insight from frontloading expenditure on Uganda’s urban roads and highways. *Research in Transportation Economics*. https://doi.org/10.1016/j.retrec.2020.100971

Niringije, A., Ogwal, M., Ochai, M. and Mukasa, I. (2012). The effects of investment climate on manufacturing firms’ growth in Uganda. ICBE-RF Research Report No. 19/12: Dakar.

Nnyanzi, J. B. (2015). Financial openness, capital flows and risk sharing in Africa. *Global Economy Journal, 15*(1), 51–82.

Nnyanzi, J. B. (2016). Trade openness and risk sharing in SSA: Do institutions and financial depth matter? *Global Economy Journal, 16*(1), 161–187. https://doi.org/10.1515/gej-2015-0013

Nnyanzi, J. B., & Bbale, J. M. (2016). How do liberalization, institutions and human capital development affect the Nexus between domestic private investment and foreign direct investment? Evidence from Sub-Saharan Africa. *Global Economy Journal, 16*(3), 569–598. https://doi.org/10.1515/gej-2015-0057

Ogbaro, E. O. (2019). Threshold effects of institutional quality in the infrastructure-growth Nexus. *Journal of Quantitative Methods, 3*(2), 2019.

Olufemi, E. A., Olatunbosun, A. J., Olasode, O. S., & Adeniran, I. G. (2013). Infrastructural development and its effect on economic growth: The Nigerian perspective. *European Scientific Journal, 9*(31), 431–452.

Page, J. (2017). Industrial policy in Africa: From state leadership to the investment climate, in African Development Bank, *Industrialize Africa—Strategies, policies, institutions, and financing*, African Development Bank Group, 27 November 2017.

Parks, R. W. (1967). Efficient estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated. *Journal of the American Statistical Association, 62*, 500–509.

Paus, E., & Gallagher, K. P. (2008). Missing links: Foreign investment and industrial development in Costa Rica and Mexico. *Studies in Comparative International Development, 43*, 1.

Pesaran, M. (2004). General diagnostic tests for cross section dependence in panels. Cambridge Working Paper in Economics: IZA Discussion Paper, (1240).

Pesaran, M. H., A. Ullah, and T. Yamagata. (2006). A bias-adjusted test of error cross section dependence. http://www.econ.cam.ac.uk/faculty/pesaran/PUY10May06.pdf.

Reed, W. R., & Webb, R. (2010). The PCSE estimator is good-just not as good as you think. *J Time Ser Econ, 2*(1), 1–26. https://doi.org/10.2202/1941-1928.1032

Reed, W. R., & Ye, H. (2011). Which panel data estimator should i use? *Applied Economics, 43*(8), 985–1000. https://doi.org/10.1080/00036840802600087

Saadma, T., & Steiner, A. (2016). *Measuring de-facto financial openness: A new index* (Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016 No. F16-V3). Kiel and Hamburg: ZBW.

Saha, S., & Sen, K. (2020). The corruption-growth relationship: Does the political regime matter? *Journal of Institutional Economics, 17*(2), 243–266.

Sahni, H., Nsiaah, C. and Fayissa, B. (2021). Institutional quality, infrastructure and economic growth in Africa (February 3, 2021). Journal of African Development (forthcoming), Special issue on Infrastructure & Finance in Africa. Available at SSRN: https://ssrn.com/abstract=3778399

Sarafidis, V., and D. Robertson. (2006). On the impact of cross section dependence in short dynamic panel estimation. http://www.econ.cam.ac.uk/faculty/robertson/csd.pdf.

Sarafidis, V., & Wansbeek, T. (2012). Cross-sectional dependence in panel data analysis. *Econometric Reviews, 31*, 483–531. https://doi.org/10.1080/07474938.2011.611458

Satya, P., Balbir, S., & Pravat, B. (2004). Public infrastructure and the productive performance of Canadian manufacturing industries. *Southern Economic Journal, 70*(4), 998–1011.

Scott, A. (2015). Building electricity supplies in Africa for growth and universal access. Background paper for Power, People, Planet: Seizing Africa’s energy and climate opportunities. New Climate Economy, London and Washington, D.C. Available at: http://newclimateeconomy.report/misc/working-papers.
Seetanah, B. (2009). A sector-wise panel data study on the link between transport infrastructure and FDI in Mauritius. Paper presented at 9th Global Conference on Business & Economics, Cambridge, UK, October 17.

Shafaeddin, M. (2010) Trade liberalization, industrialization and development: Experience of recent decades. MPRA Paper No. 26355. Online at https://mpra.ub.uni-muenchen.de/26355/

Shafaeddin, M. (2005). Trade liberalization and economic reform in developing countries the IMF. World Bank and Policy Reform, 155(1), 2–20.

Shafaeddin, M. (2009). The Impact of the Global Economic Crisis on Industrialization of Least Developed Countries. MPRA Paper 18788. University Library of Munich.

Sharma, C., & Sehgal, S. (2010). Impact of infrastructure on output, productivity and efficiency: Evidence from the Indian manufacturing industry. Indian Growth and Development Review, 3(2), 100–121.

Sobják, A. (2018). Corruption risks in infrastructure investments in Sub-Saharan Africa. 2018 OECD Global Anti-corruption and Integrity Forum. https://www.oecd.org/corruption/integrity-forumacademic-papers/Sobjak.pdf

Tanguy, B. and M. Torero (2011). Randomizing the “Last Mile”: A methodological note on using a voucher-based approach to assess the impact of infrastructure projects. IFPRI Discussion Papers 1078, International Food Policy Research Institute (IFPRI).

Tanguy, B. (2012). Impact analysis of rural electrification projects in Sub-Saharan Africa. World Bank Research Observer, 27(1), 33–51.

Tatyana, P. (2015). Assessing the impact of infrastructure on economic growth and global competitiveness. Procedia Economics and Finance, 23, 168–175.

The Economist (2019). More than half of sub-Saharan Africans lack access to electricity. Available at: https://www.economist.com/graphic-detail/2019/11/13/more-than-half-of-sub-saharan-africans-lack-access-to-electricity.

Tybout, J. R. (2000). Manufacturing firms in developing countries: How well do they do, and why? Journal of Economic Literature, 38(1), 11–44.

Umofia, N., Orji, K. E., & Worika, I. L. (2018). Infrastructural development and the Nigerian industrial sector performance. International Journal of Scientific Engineering and Research, 9(6), 331–335.

United Nations (2020). https://unstats.un.org/sdgs/report/2020/goal-11/

Wan, G., & Zhang, Y. (2017). The direct and indirect effects of infrastructure on firm productivity: Evidence from Chinese manufacturing. China Economic Review, 49, 143–153.

Weiss, J. (2002). Industrialization and Globalization: Theory and Evidence from Developing Countries (2nd ed.). Routledge.

World Bank (2019). World Governance Indicators. http://info.worldbank.org/governance/wgi/Home/Documents

World Bank (2020). Doing business fact sheet: Sub-Saharan Africa.

Yaw, A., David B., Tim, K. and Dirk, W. V. (2016). Public and private sector collaboration for economic transformation. Supporting Economic Transformation (SET) Paper Series for the African Transformation Forum in Kigali 14–15 March, 2016.

Zergawu, Y. Z., Walle, Y. M., & Giménez-Gómez, J.-M. (2020). The joint impact of infrastructure and institutions on economic growth. Journal of Institutional Economics, 16(4), 481–502. https://doi.org/10.1017/S1744137420000016

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