

# Infrastructure-Structural Transformation Nexus in Africa: The Role of Financial Sector Development

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**ABSTRACT** | This study investigates the link between infrastructure and structural transformation in Africa as well as the mediating role of financial development on the nexus. We employ data from 24 African countries for the period 2003 to 2019 and adopt the system Generalized Method of Moments (sGMM) estimation technique. Our empirical results suggest that infrastructure and financial development foster structural transformation. However, our results show varying effects of ICT, electricity, and transport on sectoral value-added. Specifically, ICT infrastructure spurs the agricultural and manufacturing sectors value-added, electricity infrastructure aids all sectoral value-added, and transport infrastructure is important to the development of the manufacturing and services subsectors. Also, the agricultural and manufacturing sectors benefit more than the services sectors from financial-sector development. Overall, we find that infrastructure stimulates structural transformation. The net effect of the interaction of financial development and infrastructure on structural transformation appears to be zero, suggesting that financial development does not augment the nexus between infrastructure and structural transformation in Africa.

**KEYWORDS** | infrastructure, structural transformation, financial development, system GMM

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Structural transformation, the reallocation of inputs from low-productivity to high-productivity activities and sectors, is a phenomenon that accompanies the process of modern economic growth. It has been identified as a key ingredient for promoting productive employment and poverty reduction—both of which are critical for African countries given their development indexes. The process is largely characterized by a declining share of agriculture and a rising share of the manufacturing and service sectors in output and employment, spatial reallocation of labor from the traditional to the modern sector which allows for rapid urbanization, and a demographic transition from high rates of births and deaths (common in rural areas) to low rates of births and deaths (Timmer 2007; Breisinger and Diao 2008).

In almost all the countries of the world, including in Africa, change in economic structure is ubiquitous (Busse, Erdogan, and Muhlen 2019) although the pace and patterns differ. The historical pattern of transition from a traditional agricultural sector to a modern manufacturing and services sector in industrialized countries has been observed in many East Asian countries with a strong manufacturing sector leading to structural transformation. However, in Africa, the structural transformation has been marked with a declining share of agriculture in output and employment, an ailing manufacturing sector, and an emerging service sector (Alagidede et al. 2020) with a high level of informality.

Available statistics suggest that the share of manufacturing sector value-added (MVA) in Africa remains modest compared to the world's average. The manufacturing sector in Sub-Saharan Africa (SSA) lags behind other developing regions of the world. Data from the World Development Indicators (WDI) reveals that the average annual MVA as a percentage of GDP in SSA is very low, at 10.40% between 2003 and 2018 compared to 14.02% in Latin America and the Caribbean (LAC), 15.72% in South Asia and 29.43% in East Asia and Pacific (EAP). Owing to the potentials of structural transformation in fostering economic diversification and inclusive growth, accelerating the process has continued to take a center stage in policy discourses. Thus, understanding the drivers of structural transformation in Africa remains pertinent from a policy perspective.

Adequate and quality infrastructure, as well as financial-sector development, can perhaps be good policy options for transforming economic activities and sectors from traditional to modern. Indeed, sectoral and spatial reallocation will require basic infrastructure and adequate financing (Dabla-Norris et al. 2013). Infrastructure can potentially raise output per agricultural worker and facilitate the exit of labor from agriculture to other sectors and across geographical spaces. Asher and Novosad (2018) provide evidence to show that rural roads lead to a large reallocation of workers out of agriculture.

In the same vein, the availability of quality infrastructure can enhance the demand for labor in the high productivity sector since it can act as an incentive for firms to enter into high-productivity sectors such as manufacturing and tradable services. Furthermore, infrastructure improves firms' competitiveness in the manufacturing

sector by reducing transactions costs and facilitating the realization of economies of scale. For the services sector, infrastructure especially information and telecommunications (ICT) directly and indirectly enter into the “production process” (Javid 2019).

Also, a well-functioning financial system can propel structural transformation. Levine (1997) reports that Walter Bagehot in 1873 and John Hicks in 1969 attribute the industrialization in England to the capital mobilization role of the financial system, while Joseph Schumpeter in 1912 attributes it to the capacity of the financial system to spur technological innovation. Certainly, a developed financial sector that permits potential borrowers to obtain loanable funds at competitive rates can stimulate entrepreneurship and investment in high-productivity sectors. A strong financial sector would help decrease firms’ entry costs and, pertaining to human capital mobilization, allow for skill acquisition of workers who want to move from the agricultural sector to nonagricultural sectors (Nishida 2014).

This study hypothesizes that there could be a strong moderating role of financial development in augmenting or fostering the effect of infrastructure on structural transformation in Africa. Infrastructure can boost agricultural productivity, facilitate the reallocation of labor to high productivity sectors, enhance the productivity of the manufacturing sector and raise the demand for labor in the sector, while financial development can provide the capital required for investment in high productivity sectors and foster the absorption of agricultural workers to the sector.

Subsequent to the foregoing discussions, this study attempts to investigate the nexus between infrastructure and structural transformation in Africa as well as the mediating role of financial development on the link between them. Several studies have been conducted on structural transformation in Africa (Mensah et al. 2016; Kumi et al. 2017; Alagidede et al. 2020). However, none of these studies, to the best of our knowledge, has explicitly considered the role of infrastructure in structural transformation. However, when Ajakaiye and Ncube (2010) examined the effect of infrastructure on economic development in Africa, there was no recourse to structural transformation. In fact, existent studies on the mediating role of financial development in infrastructure-structural transformation nexus are hard to find. This is the gap this study attempts to fill.

This study proceeds in three ways. First, it examines the effects of infrastructure (electricity, ICT, and transport) on structural transformation (agricultural sector value-added, manufacturing sector value-added, and services sector value-added). Second, the impact of financial development on structural transformation is assessed. Third, it investigates the mediating role of financial development in the infrastructure-structural transformation nexus.

Following the introduction, the rest of the study proceeds as follows: the second section reviews the existing literature. The third presents data sources and descriptions as well as preliminary findings. The fourth contains the methodology. The fifth section presents the main empirical findings, while the last section contains the conclusion and policy implications.

## LITERATURE REVIEW

Structural transformation is widely recognized as a critical pathway for successful economic development. It is viewed in terms of a shift in the sectoral composition of output or employment in relation to primary, secondary, and tertiary activities as an economy develops. The theoretical foundation for its analysis stems from the theory of development by Lewis (1954), Kuznets (1955), and Chenery (1960), although earlier analysis of sectoral shifts in the composition of the labor force dates back to Clark (1940).

Lewis proposed a two-sector model of development where the process of structural transformation occurs through the transfer of surplus labor from the traditional agricultural sector to the modern industrial sector, and modern sector output and employment growth, which is proportional to the rate of modern sector capital accumulation. Chenery identifies the main features of the internal process of structural transformation, which includes a switch from the agricultural to the industrial sector, physical and human capital accumulation, increasing demand for manufactures, rapid urbanization, and a decline in population growth (Todaro and Smith 2012).

Two broad mechanisms that influence the observed reallocation of production resources across sectors have been advanced in the theoretical literature. According to Dabla-Norris et al. (2013), they are preferences or demand factors with income as the driver of structural transformation and relative price effects or supply factors which are generated by differential rates of productivity growth. Indeed, spatial and sectoral reallocation of labor require differences in productivity across sectors and perhaps, a sufficiently low cost of mobility.

Khandker and Samad (2017) posit that structural transformation can be triggered by external or internal forces and identifies investment in infrastructure as pivotal to unleashing the process of structural transformation on account of its capacity to reduce the cost of production and induce efficiency in production, consumption, and distribution. The availability and quality of transport infrastructure can also reduce the cost of mobility creating an incentive for migration. Hao et al. (2020) document the catalytic role of reduced migration costs in the structural transformation process in China attributing the movement of labor from agricultural to nonagricultural production to migration patterns.

Poor transport infrastructure has been highlighted as a major barrier to the adoption of improved technologies in agriculture (Suri 2011) and economic history points to the efficacy of technology-led agricultural productivity in bolstering the process of structural transformation. Therefore, the availability of quality infrastructure can enhance the process of technology adoption and foster transition from a traditional economy to an industrialized one. Gollin and

Rogerson (2014) argue that higher transportation cost drives up the overall size of agricultural workers and those in subsistence.

Sebastian and Steinbuks (2017) develop a model that analyzes the effect of public infrastructure on structural transformation in terms of its role in facilitating firm entry via a reduction in the fixed cost of production and as a complementary factor to private production inputs. In general, the model's finding is that public infrastructure as a key complementary factor accelerates the process of structural transformation. However, the effects that proliferate through fixed costs are ambiguous. Extant studies have harped on the role of technological change and innovation (Schumpeter 1934), institutions and government (Rosenstein-Rodan 1943; Murphy et al. 1989), physical and human capital accumulation (Grossman and Helpman 1991; Romer 1990), trade openness (Stokey 2001; Matsuyama 2005), and foreign direct investment (Rodriguez-Clare 1996; Markusen and Venables 1999) as important factors that influence the transition to industrialized economies.

On the empirical front, Asher and Novosad (2018), employing a fuzzy regression discontinuity design and comprehensive household and firm census microdata, examined the effect of road transport infrastructure on local economic development. Their findings suggest that rural roads facilitate the movement of workers out of agriculture but alone, they do not appear to be sufficient to transform rural economies in India.

Alagidede et al. (2020), applying the system generalized method of moments (sGMM) to data from 28 countries in Sub-Saharan Africa (SSA), spanning 1985 to 2015 find that trade and financial integration have positive and significant effects on manufacturing and agricultural sector value additions while financial integration spurs growth in the industrial sector but has no effect in the service sector in SSA.

Using linear and quantile regression methods and panel data of 168 countries over the period 1970–2010, Dabla-Norris et al. (2013) analyze the role of policy and institutional variables on structural transformation proxied by agriculture, manufacturing, and services value-added shares. Their findings reveal that country fundamentals as well as policy and institutional variables such as structural reforms, financial sector reforms, globalization, trade openness, and human and physical capital influence the patterns of structural change. Specifically, globalization has varied impact across sectors but it is most significant for the manufacturing and services sectors. An undervalued exchange rate and foreign direct investment (FDI) inflows tend to be more relevant for countries with low manufacturing shares, while tertiary education and product market reforms in agriculture and networks (electricity and telecommunications) matter more for countries with high services shares.

Similarly, Mensah et al. (2016), using data for 21 SSA countries, find that country-specific fundamentals such as natural resource and human capital endowments and institutions and policy reforms such as openness to trade, financial development, governance, and fiscal reforms are pivotal in driving structural transformation in the region.

Kumi, Ibrahim, and Yeboah (2017) examined the effects of aid and aid volatility on sectoral growth in sub-Saharan Africa (SSA). Utilizing the system generalized methods of moments (GMM) and a panel dataset of 37 countries for the period 1983–2014, the authors find that aid inflows stimulate agricultural, services, and manufacturing sector growth in SSA, but its volatility harms sectoral value additions in the non-tradable sector. In addition, financial-sector development mitigates the negative effect of aid volatility on sectoral growth in SSA. In sum, the authors report that aid can generate positive sectoral value additions conditioned on the level of the local financial sector.

Assessing the determinants of structural transformation in Africa only in the context of manufacturing share in GDP, Mijiyawa (2017) applies the system-GMM to panel data for 53 African countries spanning 1995 to 2014. The empirical evidence indicates that exchange rate depreciation, size of the domestic market, governance, particularly low level of corruption, and government effectiveness engenders manufacturing development in Africa and no evidence to suggest that FDI and urbanization matter for manufacturing development.

In sum, studies examining the effect of infrastructure on structural transformation, especially in the context of Africa, are remarkably thin. Also, the mediating role of financial development in the infrastructure-structural transformation link has scarcely been examined. This is, however, the kernel of this study.

## DATA SOURCES AND PRELIMINARY ANALYSIS

This study utilizes panel data for 24 African countries spanning 2003 to 2019. The choice of countries and period are based on the availability of relevant data. Following the existing literature (Mensah et al. 2016; Alagidede et al. 2020), agricultural sector value-added, manufacturing sector value-added, and services sector value-added (all expressed as a percentage of GDP) are used as indicators for structural transformation. For infrastructure, the study employs data on electricity, information and telecommunications technology (ICT), and transport infrastructure indexes, as well as aggregate infrastructure index obtained from the African Development Bank's (AfDB 2018) African Infrastructural Development Index (AIDI). Also, we compute a structural transformation index from all sectoral values-added using Principal Component Analysis (PCA). The computed variable is then winsorized and normalized

to range between 0 and 1. The structural transformation index value tending toward zero indicate a low level of structural transformation, while the value approaching 1 implies a high level of structural transformation. The method of winsorizing and normalizing a variable has been used by Aluko and Ibrahim (2020); Alagidede, Ibrahim, and Sare (2020); and Ibrahim and Vo (2020).

Financial development variables, broadly categorized as financial efficiency, financial depth, and financial stability, are sourced from the Global Financial Development Database (GFDD) of the World Bank. Financial efficiency variables include bank net interest margin (%), bank noninterest income and total income (%), bank overhead costs to total assets (%), bank return on assets (% after-tax), bank return on assets (% before tax), bank return on equity (% after-tax), and bank return on equity (% before tax). Financial depth variables are bank deposit to GDP (%), central bank assets to GDP (%), deposit money banks' assets to GDP (%), domestic credit to the private sector (% of GDP), liquid liabilities to GDP (%), and private credit by deposit money banks to GDP (%) while the variables used to represent financial stability include bank credit to bank deposit (% of GDP) and liquid assets to deposits. From these financial-sector variables, a single financial development index is then computed using Principal Component Analysis (PCA) and winsorized to eliminate outliers. The computed statistics are also normalized to range between 0 and 1, using the maximum and minimum method. The value of the financial development index tending toward zero indicates a low level of financial development, while the value tending toward 1 implies a high level of financial development.

Other control variables include real GDP per capita, trade openness, and control of corruption. While the real GDP per capita and trade openness are sourced from the World Development Indicators (WDI), control of corruption is obtained from the World Governance Indicators. Except for control of corruption and financial development index, all other variables are naturally logged.

The descriptive statistics of the variables presented in table 1 shows that the average values of agriculture, manufacturing, and services sectors value-added are approximately 17.2 percent, 12.7 percent, and 48.2 percent, respectively, and the index of structural transformation (ST), which ranges from 0 to 1, has a mean value of 0.645. This suggests that some degree of structural transformation has occurred in Africa, although it is not similar to the historical patterns recorded in many East Asian countries where export-led manufacturing and industrialization played a major role.

The index of financial development averaged 0.41, indicating a relatively low level of financial development in Africa. With regard to infrastructure, electricity, ICT, and transport have average values of 11.73, 6.48, and 12.05, respectively, while the index of infrastructure has a mean value of about 24.76, ranging from 4.02 to 85.85. The measures of dispersion, the gap between the minimum and

**TABLE 1 |** Descriptive Statistics

| Variables  | Obs | Mean     | Std.Dev. | Min     | Max     | p1      | p99     | Skew.  | Kurt.  |
|------------|-----|----------|----------|---------|---------|---------|---------|--------|--------|
| ST         | 384 | 0.645    | 0.279    | 0.000   | 1.000   | 0.000   | 1.000   | -0.929 | 2.898  |
| AVD        | 384 | 17.168   | 9.769    | 1.828   | 42.841  | 2.048   | 40.638  | 0.177  | 2.154  |
| IVD        | 384 | 12.701   | 6.772    | 3.399   | 50.636  | 3.913   | 48.790  | 2.818  | 14.469 |
| SVD        | 384 | 48.232   | 8.168    | 28.678  | 74.359  | 29.844  | 66.998  | -0.074 | 2.737  |
| IF         | 384 | 24.763   | 18.895   | 4.023   | 85.847  | 4.478   | 85.35   | 1.456  | 4.367  |
| ELECT      | 384 | 11.726   | 16.297   | 0.151   | 82.376  | 0.176   | 79.352  | 2.759  | 11.133 |
| ICT        | 384 | 6.476    | 10.505   | 0.000   | 63.444  | 0.000   | 51.672  | 2.398  | 9.742  |
| TP         | 384 | 12.053   | 11.869   | 1.496   | 56.511  | 1.525   | 54.489  | 2.064  | 7.090  |
| FD         | 384 | 0.405    | 0.273    | 0.000   | 1.000   | 0.000   | 1.000   | 0.494  | 2.372  |
| GDPPCAP    | 384 | 2482.656 | 2348.337 | 210.804 | 10578.6 | 221.096 | 9476.67 | 1.271  | 3.665  |
| TOPEN      | 384 | 70.868   | 24.45    | 20.722  | 132.494 | 27.376  | 125.478 | 0.377  | 2.322  |
| Corruption | 384 | -0.535   | 0.595    | -1.525  | 1.217   | -1.453  | 1.027   | 0.583  | 2.968  |

Note: ST, AVD, IVD, SVD, IF, ELECT, ICT, TP, FD, GDPPCAP, TOPEN are structural transformation, agricultural value-added, industrial value-added, services value-added, infrastructure, electricity, information and communications technology, transport, financial development, real gross domestic product per capita and trade openness, respectively.

the maximum values of infrastructure indicators, as well as the standard deviation, reveal the wide disparity in infrastructural development across Africa. Precisely, the value of electricity infrastructure ranged from 0.15 to 82.38; the minimum and maximum values of ICT infrastructure are 0.00 and 63.44 respectively while transport infrastructure ranged from about 1.50 to 56.51. Similarly, the standard deviation for electricity, ICT, and transport infrastructure are 16.30, 10.51, and 12.05 respectively. This possibly connotes that some African countries are still struggling with the provision of basic infrastructural facilities needed for their growth and development (structural transformation).

From Figure 1, which shows the average sectoral value-added (% of GDP) across the selected African countries during 2003–19, it can be observed that the services sector is the most dominant in terms of value-added for all the countries. This development may not be unconnected with the rapid growth of ICT firms and ICT related economic activities, increase in financial sector activities, development of middlemen, population growth, and increase in youth entrepreneurial and other retailing activities (UNCTAD 2015). Specifically, for countries such as Algeria, Botswana, Egypt, Mauritius, Morocco, Namibia, Senegal, South Africa, Tunisia, and Zimbabwe, on average, the share of manufacturing sector value-added in GDP is higher than that of the agricultural sector. For countries such as Angola, Benin, Burundi, Congo Republic, Cote d'Ivoire, Ghana, Kenya, Malawi, Mauritania, Mozambique, Nigeria, Tanzania, Uganda, and Zambia, the agricultural sector still dominates the manufacturing sector.

Figure 2 shows the average level of infrastructure—electricity, ICT, and transport—for the period 2003 to 2019. It is evident that infrastructure is

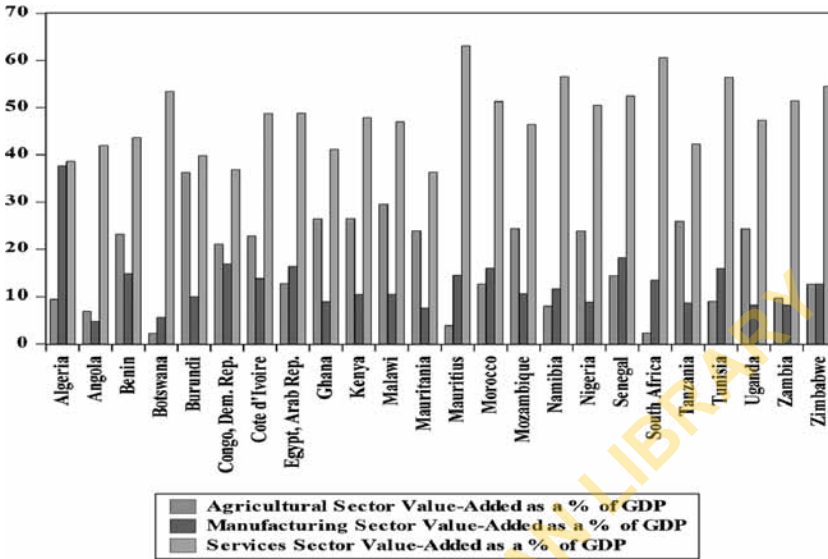


FIGURE 1 | Sectoral Value-Added Scaled by Percentage of GDP

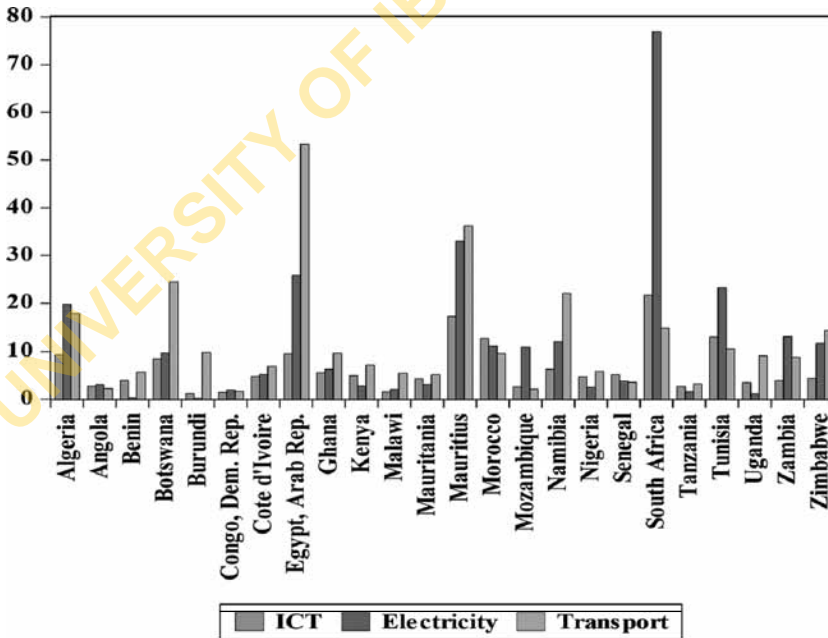


FIGURE 2 | Average Infrastructural Facilities: ICT, Electricity, and Transport

unevenly distributed across Africa. South Africa leads in terms of electricity generation and distribution, followed by Mauritius, Egypt and Tunisia, and Algeria, in that order. In the case of transport, Egypt has a better road network and transportation system compared to the rest of the selected African countries. Egypt is closely followed by Mauritius, Botswana, Namibia and Algeria, and South Africa.

Despite the surge in ICT activities in Africa, the continent is generally poor in terms of ICT provision and accessibility. However, some countries such as South Africa, Mauritius, Algeria, and Tunisia enjoy more access to ICT facilities compared with others. Generally, countries such as Angola, Benin, Burundi, Congo Democratic Republic, Cote d'Ivoire, Ghana, Kenya, Malawi, Mauritania, Nigeria, Senegal, Tanzania, and Uganda are characterized by poor infrastructural facilities. In sum, the infrastructure deficit seems to be worse in the West African, Central African and East African subregions compared to the North and Southern African subregions.

From the scatterplots below, it can be deduced that the nature of the relationship between infrastructure and sectoral value-added is inverse for agricultural value-added (percentage of GDP) and positive for manufacturing and services sectors value-added for all indicators of infrastructure. In addition, the positive association between infrastructure and services sector value-added is stronger compared to that of the manufacturing sector. In other words, infrastructure (electricity, ICT, and transport) is negatively associated with the agricultural sector value-added and positively related to the manufacturing and services sectors value-added.

Table 2 reports the results of pairwise correlation analysis among the variables of interest. From the table, it is evident that there is a negative and significant correlation between the index of structural transformation (LST) and all the indicators of infrastructure—electricity (LELECT), information and communication technology (LICT), transport (LTP), as well as the composite index of infrastructure (LIF). A negative and significant correlation is also found to exist between agricultural sector value-added (LAVD) and infrastructure. However, the correlation between the manufacturing sector value-added (LMVD) and LELECT as well as LTP is positive and significant while the association between LMVD and LICT is not statistically significant. The infrastructure indicators (LELECT, LICT, and LTP) and services sector value-added (LSVD) exhibit a positive and significant correlation. Financial development (FD) is found to be negatively and significantly correlated with LMVD and positively correlated with ICT. Among the regressors, the correlations are moderate with varying level of signs and significance. This suggests that there is no problem of multicollinearity among the regressors.

TABLE 2 | Pairwise Correlation Analysis

| Variables  | LST     | LAVD    | LIVD    | LSVD   | LIF    | LELECT | LICT   | LTP    | LFD    | LGPPCAP | LTOPEN | Corruption |
|------------|---------|---------|---------|--------|--------|--------|--------|--------|--------|---------|--------|------------|
| LST        | 1       |         |         |        |        |        |        |        |        |         |        |            |
| LAVD       | 0.995*  | 1       |         |        |        |        |        |        |        |         |        |            |
| LIVD       | 0.011   | 0.02    | 1       |        |        |        |        |        |        |         |        |            |
| LSVD       | -0.518* | -0.528* | 0.009   | 1      |        |        |        |        |        |         |        |            |
| LIF        | -0.609* | -0.635* | 0.305*  | 0.564* | 1      |        |        |        |        |         |        |            |
| LELECT     | -0.661* | -0.664* | 0.278*  | 0.519* | 0.703* | 1      |        |        |        |         |        |            |
| LICT       | -0.173* | -0.246* | -0.019  | 0.285* | 0.533* | 0.261* | 1      |        |        |         |        |            |
| LTP        | -0.497* | -0.495* | 0.223*  | 0.435* | 0.800* | 0.502* | 0.173* | 1      |        |         |        |            |
| LFD        | -0.024  | w       | -0.305* | 0.077  | 0.064  | -0.011 | 0.167* | 0.062  | 1      |         |        |            |
| LGPPCAP    | -0.825* | -0.832* | 0.082   | 0.505* | 0.742* | 0.731* | 0.313* | 0.593* | -0.043 | 1       |        |            |
| LTOPEN     | -0.433* | -0.427* | -0.06   | 0.119* | 0.180* | 0.413* | 0.09   | 0.106* | -0.094 | 0.421*  | 1      |            |
| Corruption | -0.621* | -0.619* | 0.025   | 0.450* | 0.513* | 0.486* | 0.126* | 0.503* | 0.176* | 0.637*  | 0.391* | 1          |

\* shows significance at the 0.05 level

Note: ST, AVD, IVD, SVD, IF, ELECT, ICT, TP, FD, GDPPCAP, TOPEN are structural transformation, agricultural value-added, industrial value-added, services value-added, infrastructure, electricity, information and communications technology, transport, financial development, real gross domestic product per capita and trade openness, respectively. The *Is* that precede some variables mean those variables are naturally logged.

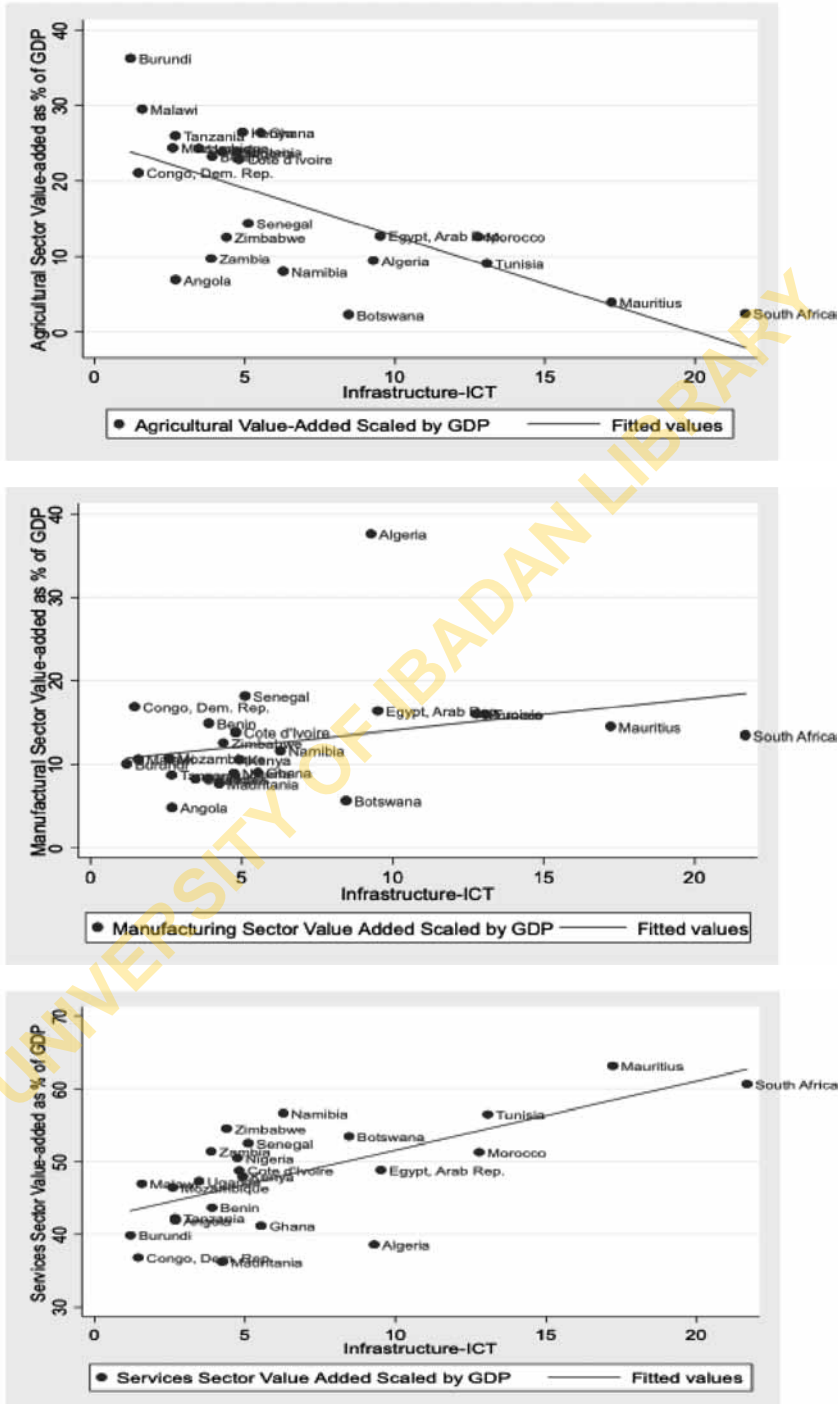


FIGURE 3 | Scatter plot of ICT and sectoral value-added.

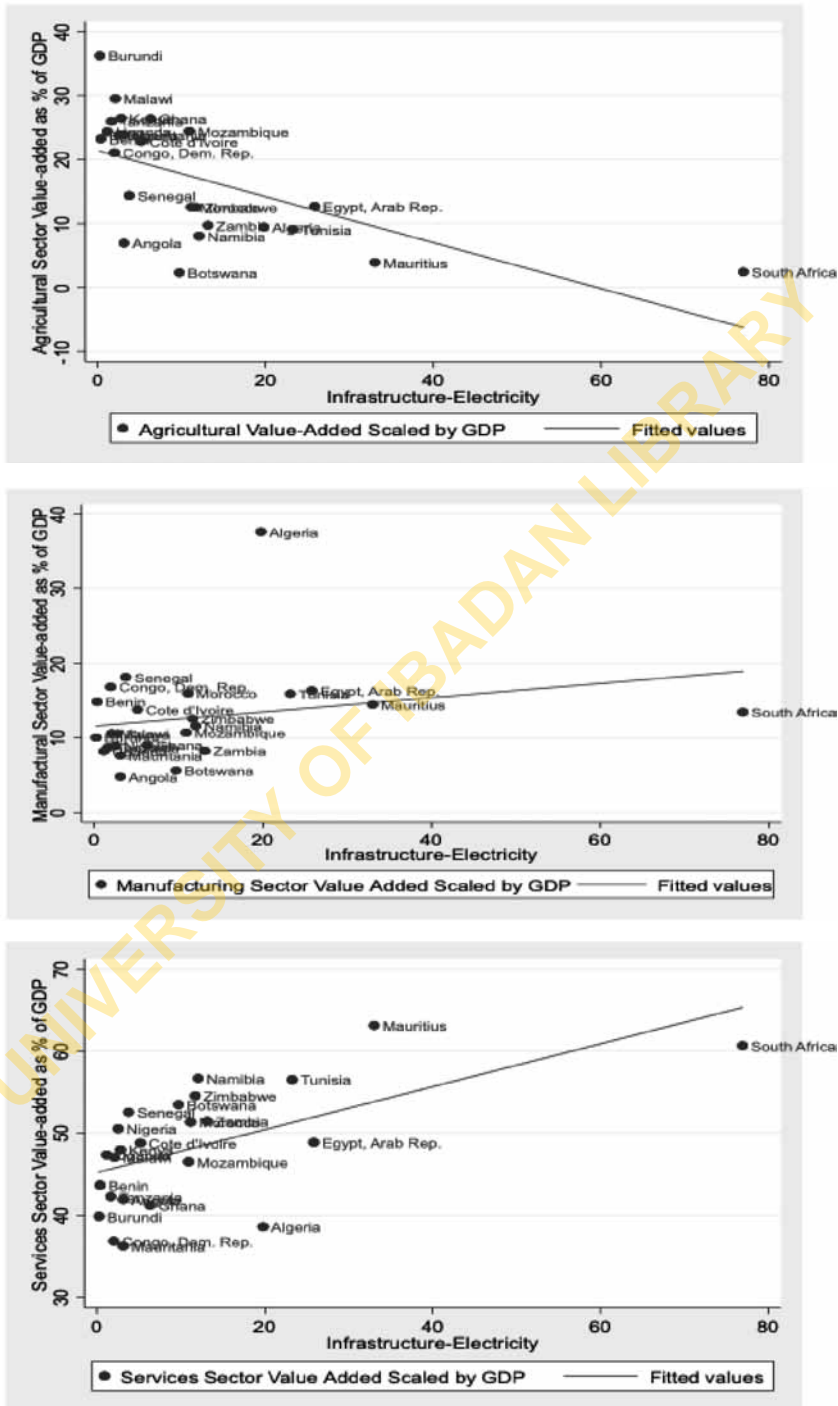


FIGURE 4 | Scatter plot of electricity and sectoral value-added.

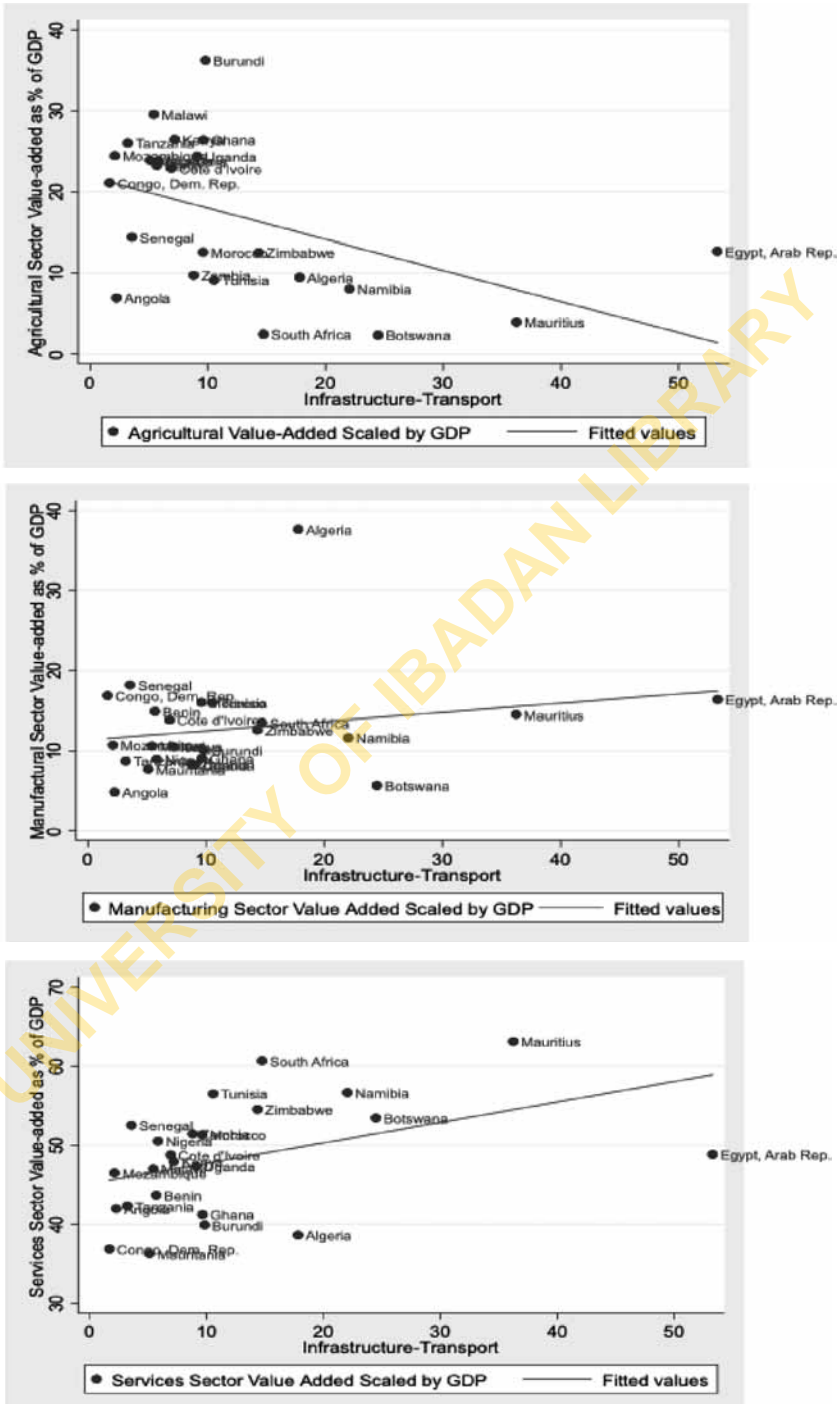


FIGURE 5 | Scatter plot of transport and sectoral value-added.

## METHODOLOGY

One of the objectives of this study is to examine the effect of infrastructure on structural transformation in Africa. Given this, we specify our reference point model as follows:

$$LST_{it} = \beta_0 + \beta_1 LST_{it-1} + \beta_2 LIF_{it} + \beta_3 FD_{it} + \beta_4 Z_{it} + \varepsilon_{it} \quad (1)$$

where LST represents structural transformation indicators, LIF is the infrastructure indicator, FD denotes financial development, Z represents a set of control variables, and  $\varepsilon$  is the stochastic error term. Structural transformation indicators include a computed index of structural transformation (LST) and its components—agricultural sector value-added (LAVD), manufacturing sector value added (LMVD) and services sector value-added (LSVD); termed sectoral value-added (SVA). Also, infrastructure indicators consist of a composite index of infrastructure (LIF) and the vector of its components which include electricity (LELECT), ICT (LICT), and transport (LTP).

Equation 1 implies that structural transformation ( $LST_{it}$ ) depends on its lag ( $LST_{it-1}$  and other variables  $LIF_{it}$ ,  $FD_{it}$  and  $Z_{it}$ ). The structural transformation depends on its lag because it is believed that structural transformation occurs over time or rather persists over time. Thus, it implies that countries with a high level of structural transformation in the past and even in the present tend to have a structural transformation in the future.

Following existing studies such as Mensah et al. 2016, Alagidede et al. 2020, and Ibrahim and Vo 2020, we use real GDP per capita (LGDPPCAP), trade openness (LTOPEN), and control of corruption (CC) as control variables. All variables except control of corruption and normalized financial development index are in natural log form. In light of this, equation 1 is respecified below as:

$$LST_{it} = \beta_0 + \beta_1 LST_{it-1} + \beta_2 LIF_{it} + \beta_3 FD_{it} + \beta_4 LGDPPCAP_{it} + \beta_5 LTOPEN_{it} + \beta_6 CC_{it} + \varepsilon_{it} \quad (2)$$

A priori, it is expected that  $\beta_1$  will either be greater than or less than 0. If  $\beta_1 < 0$ , it signifies that the past and present structural transformation among the countries under consideration does not persist into the future. In other words, countries do not experience structural transformation in the future. However, if  $\beta_1 > 0$ , then the past and present structural transformation persist into the future, implying that countries with a high level of structure tend to have a high structural transformation in the future.

With respect to the infrastructure index (LIF),  $\beta_2$  is expected to be greater than 0, which implies that  $LIF_{it}$  increases  $LST_{it}$ .  $FD_{it}$  and  $LGDPCCAP_{it}$  are expected to positively influence  $LST_{it}$  (that is  $\beta_3$  and  $\beta_4 > 0$ ).  $LTOPEN_{it}$  can be positively or negatively related to  $LST_{it}$  depending on the structure of the economy ( $\beta_5 > 0$ ), while  $CC_{it}$  is expected to negatively affect  $LST_{it}$  ( $\beta_6 < 0$ ).

This study also hypothesizes that the effect of infrastructure on structural transformation is enhanced by the level of financial development in Africa. More precisely, it is expected that a well-developed financial system will enhance the effect of infrastructure on structural transformation, while a poorly developed financial sector will inhibit the nexus. Therefore, a part of the objectives of this study is to investigate the enhancing role of financial development in the infrastructure-structural transformation nexus in Africa. In line with the foregoing proposition, an interaction term ( $FD*IF$ ) is introduced into equation 2 as follows:

$$LST_{it} = \beta_0 + \beta_1 LST_{it-1} + \beta_2 LIF_{it} + \beta_3 FD_{it} + \beta_4 L(FD*IF)_{it} + \beta_5 LGDPCCAP_{it} + \beta_6 LTOPEN_{it} + \beta_7 CC_{it} + \varepsilon_{it} \quad (3)$$

where  $\beta_4$  is now the coefficient of the interactive term (LFD and LIF) that indicates whether or not financial development improves or worsens the impact of infrastructure on structural transformation. Hence, a positive and significant  $\beta_3$  indicates complementarity between financial development and infrastructure.  $\varepsilon_{it} = \chi_i + \phi_t + v_{it}$  where  $\chi_i$  denotes unobserved country-specific fixed effects,  $\phi_t$  is the time effects, and  $v_{it}$  is the error term assumed to be normally distributed with zero mean and constant variance ( $v_{it} \sim N(0, \delta^2)$ ).

Estimating equation 3 above using the Pooled Ordinary Least Squares (POLS) or other static estimation methods will grossly bias the empirical results owing to the challenge of identification of causal effect. The equations to be estimated include lagged structural transformation ( $LST_{it-1}$ ) as part of the independent variable, and this violates the assumption of strict exogeneity of independent variables; thus, POLS becomes inapplicable (Roodman 2009). Similarly, an endogeneity problem can arise from simultaneity bias. While it is logical to expect that the availability and adequacy of infrastructure will spur structural transformation, arguably, the spatial and sectoral reallocation of inputs from low-productivity to high-productivity activities and sectors may necessitate the provision of more infrastructure for sustained economic transformation. In other words, infrastructure can affect structural transformation, but the pace of a country's structural transformation can also influence the provision of infrastructure.

To overcome the endogeneity problem, we use a two-step system Generalised Method of Moments (sGMM) proposed by Arellano and Bover (1995) and Blundell and Bond (1998). The sGMM follows two main approaches. First, it uses the lagged differences of the dependent variable as instruments for level equations. Second, the lagged levels of the dependent variable are also used as instruments for the first-differenced equations (Arellano and Bover 1995). However, there is a caveat in using sGMM due to the multiplicity or proliferation of instruments. To obviate the instrument proliferation problem, this study follows the suggestion of Roodman (2009a; 2009b), which is to reduce the instrument count.

## EMPIRICAL RESULTS

In this section, we present and discuss the main results of this study. The results are divided into four parts presented in tables 3–6. In table 3, the effect of ICT and its interaction with financial development on sectoral value-added are reported. Table 4 shows the results of the impact of electricity and its interaction with financial development on sectoral value-added; table 5 documents the results of transport and its interaction with financial development on sectoral value-added, while the results of the effect of the index of infrastructure and its interaction with financial development on the structural transformation index are presented in table 6.

Before discussing the main estimation results, it is important to present the results of diagnostic tests that establish the validity or otherwise of the two-step sGMM. The results reported in tables 3–6 indicate that the number of instruments does not exceed the number of groups—a condition required to circumvent the issue of instrument proliferation. Also, the null hypothesis of the second-order serial correlation is rejected based on the p-values. This suggests that our models do not suffer from second-order serial autocorrelation (AR(2)). The Hansen test of overidentification results show that the instruments used are valid. Similarly, Sargan's overidentification test results also suggest that in most cases the models are not overidentified and the instruments are valid.

In all the results reported in tables 3–6, we find that the lagged index of structural transformation and its components—sectoral value-added (SVA)—have positive and significant effects on the current value of structural transformation. This suggests that there is persistence in structural transformation. That is, the past level of structural transformation improves the current level of structural transformation. Put differently, African countries with initially high levels of sectoral value-added, thus structural transformation, will continue to have higher levels of sectoral value-added and structural transformation in the future.

## The Effects of ICT and Its Interaction with Financial Development on Sectoral Value-Added

The results in table 3 indicate that ICT has a positive and significant impact on the agricultural sector value-added and manufacturing sector value-added. However, we find no evidence that ICT impacts the value-added of the services sector, because its coefficient, though positive, is not statistically significant. Specifically, a percentage increase in ICT usage raises agricultural sector and manufacturing sector value-added by 0.006% and 0.003%, respectively. Our finding of a positive effect of ICT on agricultural sector value-added is consistent with those of Chavula (2014) and Ali et al. (2016). Chavula (2014) concludes that ICT enhances agricultural productivity in Africa; Ali et al. (2016) find a positive effect of ICT on agricultural production in the Kapiri Mposhi district of Central Province in Zambia. Similarly, Anyanwu (2017) affirms that one of the key drivers of manufacturing sector value-added in North African countries is ICT. The possible explanation offered is that ICT usage enhances the productivity of factors of production and thus leads to more production (Abri and Mahmoudzadeh 2015).

Introducing financial development into the model slightly changes the results as ICT only exerts a positive and significant effect on agricultural sector value-added. Although, the effects of ICT on manufacturing sector value-added and services sector value-added are positive, albeit the effects are not statistically significant.

When we include the multiplicative interactive term ( $FD*ICT$ ) and other control variables, ICT still has a positive and significant effect on the agricultural sector value-added and manufacturing sector value-added. However, we still do not find evidence that ICT influences services sector value-added. We also find that financial development has positive effects on the agricultural sector value-added and manufacturing sector value-added. There are strands of empirical evidence that shows that financial development promotes sectoral value-added, especially agricultural and manufacturing outputs (Shahbaz, Shabbir, and Buttm 2013; Aminu, Raifu, And Oloyede 2019; Raifu and Aminu 2019; Zakaria, Jun, and Khan 2019). Shahbaz et al, (2013) found the positive effect of financial development on agricultural production in Pakistan. The same finding was documented by Raifu and Aminu (2019) for Nigeria.

In the case of manufacturing output, Aminu et al. (2019) confirmed the positive effect of financial development on manufacturing output in Nigeria. Xu and Pal (2011) found that financial development enhances the total factor productivity of the manufacturing sector in India. However, we do not find any significant effect of financial development on services sector value-added. This may sound surprising because it is expected that financial development should raise the productivity of all sectors including the services sector. Besides, the financial

System GMM Results

TABLE 3 | Effects of ICT Infrastructure and Its Interaction with Financial Development on Structural Transformation

| Variable     | 1                   |                     |                     | 2                    |                      |                      | 3                    |                      |                     |                     |                     |                     |
|--------------|---------------------|---------------------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|---------------------|---------------------|---------------------|---------------------|
|              | Agricultural Sector |                     |                     | Manufacturing Sector |                      |                      | Services Sector      |                      |                     |                     |                     |                     |
| Lag SVA      | 1.077***<br>(0.280) | 1.059***<br>(0.040) | 1.010***<br>(0.021) | 1.028***<br>(0.134)  | 1.018***<br>(0.012)  | 1.036***<br>(0.022)  | 1.021***<br>(0.040)  | 0.995***<br>(0.022)  | 0.867***<br>(0.079) | 0.844***<br>(0.075) | 0.878***<br>(0.053) | 0.755***<br>(0.010) |
| LICT         | 0.006***<br>(0.001) | 0.005***<br>(0.002) | 0.024*<br>(0.005)   | 0.027***<br>(0.012)  | 0.003**<br>(0.001)   | 0.002<br>(0.002)     | 0.027***<br>(0.010)  | 0.031***<br>(0.007)  | 0.001<br>(0.001)    | 0.001<br>(0.002)    | -0.005<br>(0.008)   | -0.010<br>(0.009)   |
| FD           |                     | 0.020<br>(0.034)    | 0.083<br>(0.052)    | 0.115**<br>(0.064)   | 0.014<br>(0.033)     | 0.014<br>(0.033)     | 0.099**<br>(0.039)   | 0.099***<br>(0.025)  | -0.011<br>(0.028)   | -0.011<br>(0.028)   | -0.036<br>(0.029)   | -0.057<br>(0.039)   |
| L(ICT*FD)    |                     | -0.020<br>(0.013)   | -0.020<br>(0.013)   | -0.025**<br>(0.011)  | -0.026***<br>(0.009) | -0.026***<br>(0.009) | -0.030***<br>(0.007) | -0.030***<br>(0.007) | 0.006<br>(0.007)    | 0.006<br>(0.007)    | 0.006<br>(0.007)    | 0.011<br>(0.009)    |
| LGPPPCAP     |                     |                     |                     | 0.029<br>(0.067)     | 0.029<br>(0.067)     | 0.029<br>(0.067)     | 0.010**<br>(0.004)   | 0.010**<br>(0.004)   |                     |                     |                     | 0.018**<br>(0.008)  |
| Corruption   |                     |                     |                     | -0.013<br>(0.066)    | -0.013<br>(0.066)    | -0.013<br>(0.066)    | -0.031**<br>(0.012)  | -0.031**<br>(0.012)  |                     |                     |                     | 0.024*<br>(0.014)   |
| Logged TOPEN |                     |                     |                     | -0.020<br>(0.039)    | -0.020<br>(0.039)    | -0.020<br>(0.039)    | 0.009<br>(0.012)     | 0.009<br>(0.012)     |                     |                     |                     | -0.022<br>(0.024)   |
| Constant     | -0.209**<br>(0.076) | -0.171<br>(0.107)   | -0.094**<br>(0.044) | -0.293<br>(0.959)    | -0.051<br>(0.030)    | -0.104*<br>(0.057)   | -0.131<br>(0.113)    | -0.203*<br>(0.107)   | 0.518<br>(0.308)    | 0.616**<br>(0.298)  | 0.501**<br>(0.214)  | 0.966*<br>(0.491)   |
| F-Stat.      | 953.23              | 333.02              | 1198.42             | 5282.71              | 3639.76              | 713.85               | 213.140              | 799.82               | 105.45              | 101.99              | 211.12              | 142.09              |
| p-value      | (0.000)             | (0.000)             | (0.000)             | (0.000)              | (0.000)              | (0.000)              | (0.000)              | (0.000)              | (0.000)             | (0.000)             | (0.000)             | (0.000)             |
| Observation  | 360                 | 360                 | 345                 | 345                  | 360                  | 360                  | 345                  | 345                  | 360                 | 360                 | 345                 | 345                 |

/continued

TABLE 3 | continued

| Variable           | 1                   |                   |                   | 2                    |                   |                   |                   |                   |                   | 3                 |                   |                   |                   |  |  |
|--------------------|---------------------|-------------------|-------------------|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|--|
|                    | Agricultural Sector |                   |                   | Manufacturing Sector |                   |                   |                   |                   |                   | Services Sector   |                   |                   |                   |  |  |
| No. of Instrument. | 8                   | 15                | 22                | 19                   | 14                | 14                | 18                | 22                | 19                | 14                | 20                | 16                | 21                |  |  |
| No. of groups      | 24                  | 24                | 24                | 24                   | 24                | 24                | 24                | 24                | 24                | 24                | 24                | 24                | 24                |  |  |
| AR(1)              | -3.230<br>(0.001)   | -3.260<br>(0.001) | -3.160<br>(0.002) | -2.970<br>(0.003)    | -2.740<br>(0.006) | -2.750<br>(0.006) | -2.750<br>(0.006) | -2.530<br>(0.011) | -2.540<br>(0.011) | -2.72<br>(0.007)  | -2.670<br>(0.008) | -2.720<br>(0.006) | -2.660<br>(0.008) |  |  |
| p-value            |                     |                   |                   |                      |                   |                   |                   |                   |                   |                   |                   |                   |                   |  |  |
| AR(2)              | -0.030<br>(0.302)   | -0.107<br>(0.286) | -0.620<br>(0.533) | -0.660<br>(0.507)    | 0.140<br>(0.890)  | 0.180<br>(0.850)  | 0.180<br>(0.850)  | -0.090<br>(0.932) | -0.090<br>(0.927) | -1.060<br>(0.288) | -1.070<br>(0.283) | -1.180<br>(0.239) | -1.170<br>(0.241) |  |  |
| Sargan Test        | 1.930<br>(0.859)    | 9.290<br>(0.595)  | 22.090<br>(0.181) | 13.280<br>(0.275)    | 6.960<br>(0.802)  | 16.060<br>(0.310) | 25.650<br>(0.081) | 7.420<br>(0.764)  | 17.860<br>(0.085) | 24.570<br>(0.078) | 14.020<br>(0.232) | 22.460<br>(0.049) |                   |  |  |
| Hansen Test        | 1.160<br>(0.948)    | 12.270<br>(0.344) | 20.400<br>(0.254) | 11.780<br>(0.381)    | 6.640<br>(0.827)  | 13.590<br>(0.481) | 13.800<br>(0.681) | 5.960<br>(0.876)  | 17.980<br>(0.082) | 19.710<br>(0.233) | 9.150<br>(0.608)  | 13.800<br>(0.388) |                   |  |  |
| p-value            |                     |                   |                   |                      |                   |                   |                   |                   |                   |                   |                   |                   |                   |  |  |
| Wald Test          | 33.320<br>(0.000)   | 8.980<br>(0.001)  | 3.780<br>(0.024)  | 2.310<br>(0.069)     | 5.260<br>(0.0312) | 0.580<br>(0.569)  | 2.720<br>(0.068)  | 8.320<br>(0.000)  | 0.150<br>(0.704)  | 0.210<br>(0.813)  | 0.690<br>(0.570)  | 3.750<br>(0.009)  |                   |  |  |

Notes: Standard errors are in parenthesis in the main estimation, \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1. SVA, ICT, FD, GDPPCAP and TOPEN are sectoral value-added, Information and Communications Technology, financial development, real gross domestic product per capita and trade openness, respectively.

sector is categorized as part of the services sector, hence the expected positive nexus. However, we can offer two intuitive explanations for the observed phenomenon. First, the size and depth of the financial sector in Africa, though growing, is still relatively low (measured by the level of financial development) compared to the overall size of services sectors (measured by the absolute value of sectoral output or sectoral value-added expressed as a percentage of GDP). Second, most of the businesses in the services sector aside from the financial and entertainment sectors are small-scale businesses with small start-up capital and characterized by a high level of informality (Alagidede et al. 2020). Thus, they do not have collateral like big companies in the manufacturing sector required by banks to access funds. Thus, many of them rely on traditional thrift, local lenders, family, or friends to finance their businesses. Consequently, the bulk of funds from the financial sector usually go to the manufacturing and agricultural sectors instead of the services sector. Nonetheless, it would be useful to assess the impact of financial sector development on the service sector excluding the financial sector.

With regard to the interactive term, our results, which are contrary to a priori expectations, show that the interactive effects of ICT and financial development on agricultural sector value-added and manufacturing sector value-added are negative and statistically significant, while the effect on services sector value-added is not significant. This implies that improvement in ICT, though it is positively related to growth in the agriculture and manufacturing sectors, becomes negative in countries with high level of financial development.

### The Effect of Electricity and Its Interaction with Financial Development on Sectoral Value-Added

Table 4 reports the results of electricity infrastructure and its interaction with financial development on sectoral value-added. As shown in the table, when we regress each sectoral value-added on electricity, we find that only the positive effect of electricity on the services sector value-added is statistically significant. This suggests that an increase in investment in electricity generation and supply would spur services sector value-added by 0.010%.

When we control for financial development, we find that electricity now has positive effects on all sectoral value-added, albeit at varying levels of significance. For instance, the effects of electricity on the agricultural sector value-added, manufacturing sector value-added, and services sector value-added are statistically significant at 5%, 10%, and 1%, respectively. In terms of ranking, as shown in the table, the impact of electricity on the manufacturing sector value-added is greater than the agricultural sector value-added and services sector value-added. Theoretically, it is believed that electricity generation, supply, and consumption should spur economic activity, particularly at sectoral levels. Consequently, some studies have documented

**TABLE 4 | Effects of Electricity Infrastructure and Its Interaction with Financial Development on Structural Transformation**

| Variable     | 1                   |                     | 2                    |                     | 3                   |                     |                     |                     |                     |                     |                      |                      |
|--------------|---------------------|---------------------|----------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------------|----------------------|
|              | Agricultural Sector |                     | Manufacturing Sector |                     | Services Sector     |                     |                     |                     |                     |                     |                      |                      |
| Lag SVA      | 1.033***<br>(0.067) | 1.049***<br>(0.011) | 1.030***<br>(0.082)  | 1.095***<br>(0.044) | 0.919***<br>(0.053) | 1.024***<br>(0.008) | 0.989***<br>(0.076) | 0.997***<br>(0.023) | 0.866***<br>(0.024) | 0.881***<br>(0.011) | 1.091***<br>(0.012)  | 0.802***<br>(0.030)  |
| Log ELECT    | 0.009<br>(0.023)    | 0.011**<br>(0.004)  | 0.024<br>(0.029)     | 0.019**<br>(0.008)  | 0.007<br>(0.005)    | 0.016*<br>(0.009)   | 0.020**<br>(0.008)  | 0.023***<br>(0.005) | 0.010***<br>(0.003) | 0.006***<br>(0.001) | 0.028***<br>(0.007)  | -0.009*<br>(0.004)   |
| FD           |                     | 0.050***<br>(0.014) | 0.090**<br>(0.035)   | 0.146***<br>(0.025) |                     | 0.040*<br>(0.022)   | 0.070*<br>(0.036)   | 0.024**<br>(0.010)  |                     | -0.011**<br>(0.005) | -0.087***<br>(0.020) | -0.062***<br>(0.014) |
| Log ELECT*FD |                     | -0.015*             | -0.023***            |                     |                     | -0.022***           |                     | 0.103***            |                     |                     | 0.019**              | 0.012***             |
| Log GDPPCAP  |                     |                     | (0.008)              | (0.005)             |                     | (0.036)             |                     | (0.021)             |                     | (0.008)             |                      | (0.004)              |
| Corruption   |                     |                     |                      | 0.082***            |                     |                     |                     | 0.019***            |                     |                     |                      | 0.012***             |
| Log TOPEN    |                     |                     |                      | (0.024))            |                     |                     |                     | (0.005)             |                     |                     |                      | (0.003)              |
| Constant     | -0.123<br>(0.216)   | -0.184**<br>(0.021) | -0.165<br>(0.269)    | -0.934**<br>(0.345) | 0.174<br>(0.121)    | -0.113**<br>(0.018) | -0.033<br>(0.189)   | -0.288**<br>(0.104) | 0.503***<br>(0.086) | 0.458***<br>(0.045) | -0.276***<br>(0.057) | 0.804***<br>(0.116)  |
| F-Stat.      | 4404.55             | 8110.33             | 4153.994             | 8884.68             | 2250.12             | 206421.31           | 1871.52             | 12278.97            | 4349.57             | 2301.43             | 9808.04              | 1730.94              |
| p-value      | (0.000)             | (0.000)             | (0.000)              | (0.000)             | (0.000)             | (0.000)             | (0.000)             | (0.000)             | (0.000)             | (0.000)             | (0.000)              | (0.000)              |
| Observation  | 360                 | 360                 | 345                  | 345                 | 360                 | 360                 | 345                 | 345                 | 360                 | 360                 | 345                  | 345                  |

/continued

TABLE 4 | continued

| Variable           | 1                   |                   |                   | 2                    |                   |                   | 3                 |                   |                   |                   |
|--------------------|---------------------|-------------------|-------------------|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                    | Agricultural Sector |                   |                   | Manufacturing Sector |                   |                   | Services Sector   |                   |                   |                   |
| No. of Instrument. | 14                  | 20                | 12                | 18                   | 16                | 21                | 16                | 22                | 23                | 22                |
| No. of groups      | 24                  | 24                | 24                | 24                   | 24                | 24                | 24                | 24                | 24                | 24                |
| AR(1)              | -3.160<br>(0.002)   | -3.250<br>(0.001) | -3.03<br>(0.002)  | -2.720<br>(0.007)    | -2.740<br>(0.006) | -2.540<br>(0.011) | -2.770<br>(0.006) | -2.740<br>(0.006) | -2.770<br>(0.006) | -2.780<br>(0.005) |
| AR(2)              | -1.030<br>(0.302)   | -1.080<br>(0.282) | -0.660<br>(0.511) | 0.170<br>(0.867)     | -0.200<br>(0.841) | -0.040<br>(0.967) | -1.090<br>(0.274) | -1.070<br>(0.283) | -1.090<br>(0.275) | -1.180<br>(0.239) |
| Sargan Test        | 14.480              | 14.240            | 6.250             | 9.720                | 14.200            | 9.150             | 15.910            | 22.400            | 24.230            | 16.820            |
| p-value            | (0.208)             | (0.285)           | (0.511)           | (0.837)              | (0.716)           | (0.762)           | (0.254)           | (0.215)           | (0.148)           | (0.266)           |
| Hansen Test        | 14.480              | 16.940            | 7.84              | 14.980               | 15.650            | 8.440             | 15.53             | 20.21             | 20.340            | 16.240            |
| p-value            | (0.207)             | (0.152)           | (0.347)           | (0.453)              | (0.617)           | (0.814)           | (0.275)           | (0.321)           | (0.314)           | (0.299)           |
| Wald Test          | 0.150               | 9.220             | 2.880             | 2.190                | 2.960             | 31.710            | 13.62             | 30.030            | 66.54             | 15.290            |
| p-value            | (0.707)             | (0.001)           | (0.058)           | (0.152)              | (0.072)           | (0.000)           | (0.001)           | (0.000)           | (0.000)           | (0.000)           |

Notes: Standard errors are in parenthesis in the main estimation, \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1. SVA, ELECT, FD, GDPPCAP and TOPEX are sectoral value-added, electricity, financial development, real gross domestic product per capita, and trade openness, respectively.

the positive effect of electricity on growth and sectoral growth. For example, Burke, Stern, and Bruns (2018) find that the access and usage of electricity are positively correlated with the development of the economy. The same positive effect of electricity consumption on the economic growth of four Asian countries (Pakistan, India, Bangladesh, and Sri Lanka) is documented by Raza et al. (2016). At the sectoral level, Soytaş and Sari (2007) conclude that the energy and manufacturing industry in Turkey have a long-term relationship, while Worika and Umofia (2017) find a positive effect of electricity infrastructure on industrial sector value-added in Nigeria. These empirical findings, which are in tandem with ours, are not surprising because electricity generation and supply are indispensable for production, for it is considered one of the inputs to production (Hu and Hu 2013; Burke, Stern, and Bruns 2018). Thus, when the electricity is adequately generated and supplied, it raises the level of productivity across different sectors of the economy.

The introduction of the multiplicative interaction term of financial development and electricity changes the signs of effects of financial development on agricultural and manufacturing sectors value-added. The positive effect of financial development on services sector value-added remains unchanged. We, however, find that the interaction of financial development with electricity yields negative and significant effects on agriculture and manufacturing sectors value-added and a positive effect on services sector value-added. This suggests that, while electricity and financial development positively influence agriculture and manufacturing sectors value-added, the association is negative in countries with a high level of financial development. Similarly, the relationship between electricity and services sector value-added is positive in financially developed countries.

### 5.3. The Effects of Transport and Its Interaction with Financial Development on Sectoral Sector Value-Added

In table 5, when we regress each sectoral value-added on transport, our results reveal that transport exerts a positive and significant effect on manufacturing sector value-added and services sector value-added. Specifically, an improvement in the transport system, say, by 1%, will result in an increase in the manufacturing and services sector value-added by 0.08% and 0.007% respectively. That transport has a positive effect on manufacturing sector value-added and services sector value-added is not surprising, since most of the transport infrastructural facilities are located in the urban areas where most of the manufacturing and services firms are also located. Several studies have also shown that the existence of a good transport system aids economic activity, particularly facilitating manufacturing sector productive activity (see Deng 2013; Melo et al. 2015). The positive effect of transport on agricultural sector value-added is not statistically significant. The lack of a robust

**TABLE 5 | Effects of Transport Infrastructure and Its Interaction with Financial Development on Structural Transformation**

| Variable       | 1                   |                     |                      | 2                    |                      |                      | 3                   |                      |                     |                     |                     |
|----------------|---------------------|---------------------|----------------------|----------------------|----------------------|----------------------|---------------------|----------------------|---------------------|---------------------|---------------------|
|                | Agricultural Sector |                     |                      | Manufacturing Sector |                      |                      | Services Sector     |                      |                     |                     |                     |
| Lag SVA        | 1.025***<br>(0.007) | 1.028***<br>(0.011) | 1.020***<br>(0.004)  | 1.078***<br>(0.026)  | 1.027***<br>(0.009)  | 1.014***<br>(0.030)  | 0.976***<br>(0.032) | 0.958***<br>(0.018)  | 0.926***<br>(0.013) | 0.901***<br>(0.014) | 0.712***<br>(0.070) |
| Log TP         | 0.002<br>(0.007)    | 0.004<br>(0.009)    | 0.015**<br>(0.007)   | -0.001<br>(0.009)    | 0.008*<br>(0.004)    | 0.016*<br>(0.009)    | 0.032**<br>(0.012)  | 0.007**<br>(0.003)   | 0.009***<br>(0.002) | 0.007**<br>(0.003)  | -0.006<br>(0.008)   |
| Log FD         |                     | 0.042***<br>(0.008) | 0.097***<br>(0.005)  | 0.126***<br>(0.025)  | 0.020**<br>(0.009)   | 0.073***<br>(0.020)  | 0.086***<br>(0.030) | -0.013***<br>(0.003) | -0.022*<br>(0.011)  | -0.047<br>(0.031)   |                     |
| Log TP*FD      |                     |                     | -0.018***<br>(0.005) | -0.023***<br>(0.004) | -0.024***<br>(0.005) | -0.027***<br>(0.007) |                     |                      |                     | 0.003<br>(0.003)    | 0.015*<br>(0.008)   |
| Log<br>GDPPCAP |                     |                     |                      | 0.078***<br>(0.014)  |                      |                      | 0.010**<br>(0.004)  |                      |                     |                     | 0.018***<br>(0.006) |
| Corruption     |                     |                     |                      |                      |                      |                      |                     |                      |                     |                     | 0.021***<br>(0.006) |
| Log TOPEN      |                     |                     |                      | -0.022<br>(0.015)    |                      |                      | 0.015<br>(0.010)    |                      |                     |                     | -0.018<br>(0.013)   |
| Constant       | -0.085**<br>(0.032) | -0.112**<br>(0.048) | -0.120***<br>(0.028) | -0.735***<br>(0.229) | 0.207**<br>(0.098)   | -0.058***<br>(0.030) | -0.191**<br>(0.088) | 0.154**<br>(0.066)   | 0.278***<br>(0.048) | 0.381***<br>(0.057) | 1.090***<br>(0.266) |
| F-Stat.        | 56599.30            | 16431.13            | 75892.73             | 25481.70             | 275.04               | 9916.42              | 762.49              | 5147.02              | 2519.17             | 4082.81             | 285.32              |
| p-value        | (0.000)             | (0.000)             | (0.000)              | (0.000)              | (0.000)              | (0.000)              | (0.000)             | (0.000)              | (0.000)             | (0.000)             | (0.000)             |
| Observation    | 360                 | 360                 | 345                  | 360                  | 360                  | 345                  | 383                 | 360                  | 360                 | 345                 | 345                 |

*/continued*

TABLE 5 | continued

| Variable           | 1                   |                   |                   | 2                    |                   |                   |                   |                   |                   | 3                 |                   |                   |  |  |  |
|--------------------|---------------------|-------------------|-------------------|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|--|--|
|                    | Agricultural Sector |                   |                   | Manufacturing Sector |                   |                   |                   |                   |                   | Services Sector   |                   |                   |  |  |  |
| No. of Instrument. | 19                  | 16                | 23                | 21                   | 18                | 20                | 19                | 21                | 18                | 21                | 22                | 13                |  |  |  |
| No. of groups      | 24                  | 24                | 24                | 24                   | 24                | 24                | 24                | 24                | 24                | 24                | 24                | 24                |  |  |  |
| AR(1)              | -3.280<br>(0.001)   | -3.270<br>(0.001) | -3.180<br>(0.001) | -3.210<br>(0.001)    | -2.770<br>(0.006) | -2.750<br>(0.006) | -2.540<br>(0.011) | -2.560<br>(0.010) | -2.770<br>(0.006) | -2.730<br>(0.006) | -2.670<br>(0.008) | -2.690<br>(0.007) |  |  |  |
| AR(2)              | -1.030<br>(0.301)   | -1.080<br>(0.281) | -0.650<br>(0.516) | -0.730<br>(0.464)    | 0.180<br>(0.857)  | 0.240<br>(0.813)  | -0.110<br>(0.912) | -0.100<br>(0.922) | -1.020<br>(0.308) | -1.050<br>(0.295) | -1.210<br>(0.227) | -1.250<br>(0.210) |  |  |  |
| Sargan Test        | 24.960<br>(0.071)   | 20.800<br>(0.053) | 25.050<br>(0.124) | 11.670<br>(0.555)    | 15.290<br>(0.431) | 20.200<br>(0.211) | 12.010<br>(0.606) | 11.620<br>(0.559) | 30.600<br>(0.010) | 24.450<br>(0.108) | 27.970<br>(0.045) | 9.810<br>(0.081)  |  |  |  |
| Hansen Test        | 20.200<br>(0.211)   | 16.920<br>(0.153) | 19.030<br>(0.390) | 15.680<br>(0.267)    | 11.980<br>(0.681) | 11.930<br>(0.749) | 12.360<br>(0.577) | 8.780<br>(0.789)  | 16.620<br>(0.342) | 19.340<br>(0.309) | 17.910<br>(0.394) | 7.120<br>(0.212)  |  |  |  |
| Wald Test          | 0.120<br>(0.733)    | 15.750<br>(0.000) | 25.300<br>(0.000) | 33.770<br>(0.000)    | 4.100<br>(0.055)  | 7.190<br>(0.04)   | 13.700<br>(0.000) | 5.930<br>(0.001)  | 6.430<br>(0.018)  | 75.030<br>(0.000) | 42.580<br>(0.000) | 5.160<br>(0.002)  |  |  |  |

Notes: Standard errors are in parenthesis in the main estimation, \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1. SVA, TP, FD, GDPPCAP and TOPEN are sectoral value-added, transport, financial development, real gross domestic product per capita, and trade openness, respectively.

link between transport and agricultural sector productivity could be alluded to the poor condition of rural roads and the absence of railway services across African countries. In fact, the dilapidating state of roads in many African rural communities tends to increase the costs of transporting agricultural inputs and output to and from the farm. This constitutes a bottleneck to agricultural production as well as the spatial and sectoral allocation of input (Bryan, Chowdury, and Mobarak 2014).

With the introduction of financial development and the interactive term, financial development exerts a significant positive influence on agricultural sector value-added and manufacturing sector value-added. The impact of financial development on services sector value-added is, however, negative and statistically significant. Surprisingly, the interaction of financial development with transport yields a positive and significant effect on service sector value-added. Conversely, the interaction of financial development with transport has a negative and significant effect on the agricultural sector value-added and manufacturing sector value-added.

### The Effect of Infrastructure and Its Interaction with Financial Development on Structural Transformation

In this section, we report the results of the effect of the composite infrastructure index and its interaction with financial development on structural transformation. The results are presented in table 6. In the first column, we first run a regression of structural transformation and infrastructure alone. As shown in the table, it is apparent that infrastructure has a positive and significant effect on structural transformation. More precisely, an increase in investment in infrastructure by a percentage would ginger or spur structural transformation by 0.007%. Our finding is in line with a priori expectation. Investment in infrastructure is expected to lead to economic growth and structural transformation. Besides, it also finds empirical support in the existing studies (see Mensah et al. 2016; Jha and Afrin 2017, Sebastian and Steinbuks 2017; Moneke 2020). Mensah et al. (2016) show that one of the determinants of structural transformation in Africa is investment in infrastructure. Jha and Afrin (2017) corroborate Mensah et al.'s finding by concluding that all forms of public investment including capital investment in infrastructure determine the sectoral shares in the course of structural transformation. Likewise, Sebastian, and Steinbuks (2017) argue that public infrastructure serves as a driving force of structural transformation.

When we account for financial development, we find that infrastructure still has a positive and significant effect on structural transformation. However, we do not find a significant effect of financial development on structural transformation. When the interactive term is introduced, the positive effect of infrastructure on structural transformation becomes negative and statistically significant. However, financial development now positively and significantly influences structural transformation, and the interactive effect of financial development and infrastructure

**TABLE 6 |** The Effect Infrastructure and Its Interaction with Financial Development on Structural Transformation

| Variable                       | Structural Transformation | Structural Transformation | Structural Transformation | Structural Transformation |
|--------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| Lag Structural Transformation  | 1.025***<br>(0.010)       | 1.027***<br>(0.010)       | 0.885***<br>(0.019)       | 0.928***<br>(0.010)       |
| Log infrastructure (IF)        | 0.007**<br>(0.003)        | 0.009***<br>(0.002)       | -0.039***<br>(0.006)      | -0.028***<br>(0.004)      |
| Log Financial Development (FD) |                           | 0.005<br>(0.003)          | 0.012***<br>(0.005)       | 0.004<br>(0.003)          |
| Interactive IF*FD              |                           |                           | 0.032**<br>(0.005)        | 0.026***<br>(0.004)       |
| Log GDP per Capita             |                           |                           |                           | 0.000<br>(0.002)          |
| Corruption                     |                           |                           |                           | 0.007<br>(0.004)          |
| Log Trade Openness             |                           |                           |                           | -0.015***<br>(0.003)      |
| Constant                       | -0.037***<br>(0.014)      | -0.046***<br>(0.011)      | 0.109***<br>(0.022)       | 0.131***<br>(0.026)       |
| F-Stat.                        | 9644.75                   | 11350.04                  | 75847.87                  | 45276.37                  |
| p-value                        | (0.000)                   | (0.000)                   | (0.000)                   | (0.000)                   |
| Observation                    | 360                       | 360                       | 330                       | 345                       |
| Diagnostic Test                |                           |                           |                           |                           |
| No. of Instrument.             | 19                        | 22                        | 20                        | 23                        |
| No. of groups                  | 24                        | 24                        | 24                        | 24                        |
| AR(1)                          | -3.600<br>(0.000)         | -3.600<br>(0.000)         | -3.570<br>(0.000)         | -3.540<br>(0.000)         |
| p-value                        |                           |                           |                           |                           |
| AR(2)                          | -0.850<br>(0.394)         | -0.840<br>(0.399)         | -0.660<br>(0.507)         | -0.700<br>(0.486)         |
| p-value                        |                           |                           |                           |                           |
| Sargan Test                    | 46.86<br>(0.000)          | 42.120<br>(0.001)         | 31.980<br>(0.006)         | 28.38<br>(0.019)          |
| p-value                        |                           |                           |                           |                           |
| Hansen Test                    | 19.690<br>(0.234)         | 20.880<br>(0.285)         | 19.140<br>(0.208)         | 18.490<br>(0.238)         |
| p-value                        |                           |                           |                           |                           |
| Wald Test                      | 5.530<br>(0.028)          | 10.640<br>(0.001)         | 19.180<br>(0.000)         | 12.230<br>(0.000)         |
| p-value                        |                           |                           |                           |                           |

Note: Standard errors are in parenthesis in the main estimation, \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1

is positively and significantly associated with structural transformation. This connotes that, although the index of infrastructure is negatively associated with structural transformation, it has a positive relationship with structural transformation in countries with high financial development.

### The Effect of Control Variables on Sectoral Value-Added and Structural Transformation

Our control variables are real GDP per capita, trade openness, and control of corruption. From table 6, it can be observed that real GDP per capita has no effect on structural transformation in Africa. However, evidence from the disaggregated measures of structural transformation—sectoral value-added—suggests that real GDP per capita has a positive and significant effect on all the sector value-added—agricultural sector value-added, manufacturing sector value-added, and services sector value-added. This implies that the higher the level of income, the higher the value additions at the sectoral level.

Also, from table 6, we do not find a significant effect of control of corruption on structural transformation. In terms of sectoral value-added, our empirical results indicate that corruption also does not have a significant impact on the agricultural sector value-added. However, corruption is detrimental to the manufacturing sector as it lowers the value-added of the sector. This supports the assertion that corruption in any economy is an anathema to economic growth and development (Mauro 1995; Obamuyi and Olayiwola 2019). In the case of the services sector, it is found that the services sector value-added is positively influenced by the control of corruption and manufacturing sectors in terms of value-added. In other words, control of corruption helps in stimulating services sector productive activities.

Furthermore, our findings suggest that trade openness hurts structural transformation in Africa. However, the effect of opening the region to trade is not similar across sectors. From table 3, we observe that trade openness fosters manufacturing sector development and adversely affects agricultural sector value-added and services sector value-added. A probable explanation for this result may be found in the composition or structure of trade of most African countries, which comprise export of mostly primary (including agricultural) commodities whose prices are highly susceptible to the vagaries of the international market and the imports of intermediate goods for industrialization.

## CONCLUSION AND POLICY RECOMMENDATIONS

This study examines whether financial sector development enhances the nexus between infrastructure and structural transformation using data for 24 African

countries for the period 2003 to 2019. Structural transformation is proxied by agricultural sector value-added, manufacturing sector value-added, and services sector value-added—all expressed in percentage of GDP. Three infrastructure variables—ICT, electricity, and transport—were used and a financial development index was computed from three broad financial sector variables such as financial depth, financial efficiency, and financial stability. We also compute an overall index of structural transformation from the aforementioned three sectoral value-added variables. The computed index is winsorized to remove outliers and thereafter normalized using minimum and maximum method that ranges the indexes from 0 to 1.

Our results show varying effects of ICT, electricity, and transport on sectoral value-added. Precisely, we find that of all infrastructural facilities considered, ICT matters for agricultural sector value-added and manufacturing value-added; electricity is important for all sectoral value-added, while transport infrastructure improves manufacturing sector and services sectors value-added. With respect to the impact of financial development, our results show that the agricultural sector value-added and manufacturing sector value-added benefit more from financial sector development than services sector value-added. In fact, financial development, at best, has an insignificant relationship with the services sector and at worst, negatively influences the services sector in terms of value added. More so, both services sector value-added and manufacturing sector value-added benefit from the interaction between financial development and electricity. Overall, infrastructure is found to have a positive effect on structural transformation. Even though we find that the interactive effect of financial development and infrastructure is found to have a positive and significant effect on structural transformation, the net effect, however, appears to nil. Thus, we do find evidence that supports the fact that financial development would moderate upward the relationship between infrastructure and structural transformation in Africa. We attribute our finding to the low level of financial development in Africa. Hence, governments in Africa may not be able to raise enough funds from the domestic financial sector to finance its infrastructure development that will lead to structural transformation.

The implication of our findings is straight forward. Infrastructure is critical and indispensable to structural transformation. Besides, it is a fact that African governments need funds to finance or provide infrastructural facilities that would guarantee the desirable structural transformation. However, given the low level of financial development in the continent, it could be practically impossible for governments to raise enough funds to meet the goal of infrastructural development for Africa. In light of this, there is a need for governments to find other strategies with low costs to raise funds for the infrastructural development of the African continent. One of these strategies that can be adopted is the Public-Private Partnership for infrastructural development. This would be the easiest and least costly way to deliver infrastructural facilities to the African continent considering the costs of external sources of finance, especially the burden of debt accumulation.

## APPENDIX

| <b>Algeria</b>  |    |          |         |          |          |
|-----------------|----|----------|---------|----------|----------|
|                 | N  | Mean     | sd      | min      | max      |
| stl             | 16 | 0.511    | 0.087   | 0.354    | 0.653    |
| agv gdp         | 16 | 9.450    | 1.780   | 6.587    | 12.220   |
| man gdp         | 16 | 37.614   | 9.716   | 22.137   | 50.636   |
| sev gdp         | 16 | 38.597   | 6.051   | 30.181   | 48.094   |
| aidi            | 16 | 40.235   | 10.621  | 28.150   | 55.793   |
| elect           | 16 | 19.771   | 5.020   | 13.599   | 28.830   |
| ict             | 16 | 9.284    | 10.915  | 0.000    | 32.588   |
| trp             | 16 | 17.806   | 0.916   | 16.545   | 19.256   |
| fdn             | 16 | 0.279    | 0.151   | 0.000    | 0.463    |
| gdp cap         | 16 | 4497.783 | 249.784 | 3991.010 | 4830.120 |
| tradp           | 16 | 65.484   | 6.246   | 55.879   | 76.686   |
| corr            | 16 | -0.582   | 0.071   | -0.692   | -0.473   |
| <b>Angola</b>   |    |          |         |          |          |
| stl             | 16 | 0.394    | 0.111   | 0.237    | 0.574    |
| agv gdp         | 16 | 6.918    | 1.852   | 4.805    | 10.203   |
| man gdp         | 16 | 4.821    | 1.184   | 3.399    | 7.235    |
| sev gdp         | 16 | 41.954   | 5.043   | 34.338   | 48.991   |
| aidi            | 16 | 12.397   | 4.051   | 7.300    | 19.038   |
| elect           | 16 | 3.108    | 1.474   | 1.415    | 5.816    |
| ict             | 16 | 2.689    | 3.288   | 0.000    | 9.179    |
| trp             | 16 | 2.249    | 0.205   | 1.929    | 2.600    |
| fdn             | 16 | 0.449    | 0.147   | 0.183    | 0.680    |
| gdp cap         | 16 | 3380.822 | 427.657 | 2423.290 | 3843.200 |
| tradp           | 16 | 90.142   | 23.769  | 51.144   | 122.446  |
| corr            | 16 | -1.326   | 0.081   | -1.444   | -1.145   |
| <b>Benin</b>    |    |          |         |          |          |
| stl             | 16 | 0.837    | 0.028   | 0.786    | 0.888    |
| agv gdp         | 16 | 23.226   | 1.140   | 21.346   | 25.237   |
| man gdp         | 16 | 14.853   | 2.982   | 11.874   | 20.447   |
| sev gdp         | 16 | 43.653   | 4.148   | 37.164   | 47.635   |
| aidi            | 16 | 11.715   | 3.127   | 8.252    | 16.228   |
| elect           | 16 | 0.347    | 0.156   | 0.204    | 0.751    |
| ict             | 16 | 3.907    | 4.634   | 0.000    | 12.803   |
| trp             | 16 | 5.678    | 1.035   | 4.567    | 7.470    |
| fdn             | 16 | 0.188    | 0.111   | 0.000    | 0.440    |
| gdp cap         | 16 | 784.724  | 53.350  | 723.372  | 897.199  |
| tradp           | 16 | 57.568   | 9.870   | 45.817   | 79.574   |
| corr            | 16 | -0.593   | 0.136   | -0.857   | -0.383   |
| <b>Botswana</b> |    |          |         |          |          |
| stl             | 16 | 0.012    | 0.021   | 0.000    | 0.078    |
| agv gdp         | 16 | 2.298    | 0.298   | 1.828    | 2.819    |
| man gdp         | 16 | 5.645    | 0.451   | 4.950    | 6.387    |

|                         |    |          |         |          |          |
|-------------------------|----|----------|---------|----------|----------|
| sev gdp                 | 16 | 53.436   | 4.921   | 45.597   | 59.523   |
| aidi                    | 16 | 31.369   | 3.905   | 24.727   | 36.793   |
| elect                   | 16 | 9.708    | 6.195   | 1.031    | 23.289   |
| ict                     | 16 | 8.454    | 10.500  | 0.001    | 28.446   |
| trp                     | 16 | 24.466   | 3.160   | 16.518   | 27.034   |
| fdn                     | 16 | 0.758    | 0.225   | 0.410    | 1.000    |
| gdp cap                 | 16 | 6798.034 | 901.288 | 5493.140 | 8031.010 |
| tradp                   | 16 | 95.496   | 13.358  | 73.872   | 122.554  |
| corr                    | 16 | 0.957    | 0.121   | 0.751    | 1.217    |
| <b>Burundi</b>          |    |          |         |          |          |
| stl                     | 16 | 0.992    | 0.022   | 0.930    | 1.000    |
| agv gdp                 | 16 | 36.222   | 4.453   | 28.547   | 42.841   |
| man gdp                 | 16 | 10.053   | 0.959   | 8.675    | 11.885   |
| sev gdp                 | 16 | 39.877   | 5.680   | 33.827   | 49.365   |
| aidi                    | 16 | 14.342   | 0.333   | 13.874   | 15.112   |
| elect                   | 16 | 0.227    | 0.064   | 0.151    | 0.408    |
| ict                     | 16 | 1.192    | 1.742   | 0.000    | 6.201    |
| trp                     | 16 | 9.804    | 1.222   | 8.553    | 11.719   |
| fdn                     | 16 | 0.438    | 0.261   | 0.083    | 0.901    |
| gdp cap                 | 16 | 228.223  | 9.613   | 210.804  | 245.327  |
| tradp                   | 16 | 38.110   | 5.783   | 27.376   | 47.200   |
| corr                    | 16 | -1.182   | 0.177   | -1.453   | -0.892   |
| <b>Congo, Dem. Rep.</b> |    |          |         |          |          |
| stl                     | 16 | 0.802    | 0.020   | 0.764    | 0.836    |
| agv gdp                 | 16 | 21.067   | 2.183   | 18.370   | 26.054   |
| man gdp                 | 16 | 16.843   | 1.459   | 14.917   | 19.487   |
| sev gdp                 | 16 | 36.863   | 4.594   | 31.701   | 44.515   |
| aidi                    | 16 | 6.132    | 1.572   | 4.023    | 8.165    |
| elect                   | 16 | 1.964    | 0.097   | 1.816    | 2.123    |
| ict                     | 16 | 1.452    | 2.017   | 0.000    | 5.889    |
| trp                     | 16 | 1.667    | 0.137   | 1.496    | 1.864    |
| fdn                     | 16 | 0.157    | 0.156   | 0.000    | 0.570    |
| gdp cap                 | 16 | 349.952  | 47.082  | 282.647  | 418.739  |
| tradp                   | 16 | 68.217   | 13.901  | 47.963   | 90.748   |
| corr                    | 16 | -1.383   | 0.080   | -1.525   | -1.244   |
| <b>Cote d'Ivoire</b>    |    |          |         |          |          |
| stl                     | 16 | 0.831    | 0.033   | 0.789    | 0.888    |
| agv gdp                 | 16 | 22.838   | 2.242   | 19.769   | 28.781   |
| man gdp                 | 16 | 13.804   | 1.379   | 12.307   | 16.851   |
| sev gdp                 | 16 | 48.756   | 5.025   | 42.575   | 54.733   |
| aidi                    | 16 | 16.101   | 2.880   | 12.788   | 21.960   |
| elect                   | 16 | 5.143    | 0.438   | 4.725    | 6.134    |
| ict                     | 16 | 4.805    | 6.565   | 0.000    | 21.972   |
| trp                     | 16 | 6.910    | 0.396   | 6.307    | 7.622    |
| fdn                     | 16 | 0.404    | 0.270   | 0.071    | 0.866    |
| gdp cap                 | 16 | 1315.485 | 170.273 | 1131.440 | 1692.540 |
| tradp                   | 16 | 81.777   | 12.163  | 59.044   | 95.070   |
| corr                    | 16 | -0.880   | 0.307   | -1.241   | -0.419   |

| <b>Egypt, Arab Rep.</b> |    |          |         |          |          |
|-------------------------|----|----------|---------|----------|----------|
| stl                     | 16 | 0.619    | 0.023   | 0.579    | 0.652    |
| agv gdp                 | 16 | 12.675   | 1.307   | 11.225   | 15.287   |
| man gdp                 | 16 | 16.349   | 0.577   | 15.370   | 17.304   |
| sev gdp                 | 16 | 48.825   | 3.580   | 44.690   | 54.483   |
| aidi                    | 16 | 63.674   | 17.429  | 43.126   | 85.847   |
| elect                   | 16 | 25.821   | 4.782   | 18.474   | 33.543   |
| ict                     | 16 | 9.509    | 10.781  | 0.001    | 28.493   |
| trp                     | 16 | 53.277   | 1.484   | 50.748   | 56.511   |
| fdn                     | 16 | 0.420    | 0.329   | 0.045    | 1.000    |
| gdp cap                 | 16 | 2522.773 | 263.235 | 2048.220 | 2907.320 |
| tradp                   | 16 | 49.467   | 11.931  | 30.247   | 71.681   |
| corr                    | 16 | -0.639   | 0.075   | -0.779   | -0.515   |
| <b>Ghana</b>            |    |          |         |          |          |
| stl                     | 16 | 0.873    | 0.067   | 0.777    | 0.976    |
| agv gdp                 | 16 | 26.380   | 6.728   | 18.272   | 37.952   |
| man gdp                 | 16 | 9.026    | 2.023   | 5.661    | 11.745   |
| sev gdp                 | 16 | 41.204   | 7.026   | 28.678   | 48.181   |
| aidi                    | 16 | 18.074   | 6.634   | 10.680   | 28.835   |
| elect                   | 16 | 6.287    | 1.099   | 4.672    | 8.013    |
| ict                     | 16 | 5.529    | 7.164   | 0.000    | 21.743   |
| trp                     | 16 | 9.634    | 3.273   | 5.445    | 16.108   |
| fdn                     | 16 | 0.744    | 0.251   | 0.186    | 1.000    |
| gdp cap                 | 16 | 1385.277 | 273.034 | 1011.400 | 1807.060 |
| tradp                   | 16 | 77.468   | 13.009  | 61.687   | 99.670   |
| corr                    | 16 | -0.128   | 0.114   | -0.367   | 0.039    |
| <b>Kenya</b>            |    |          |         |          |          |
| stl                     | 16 | 0.880    | 0.078   | 0.771    | 1.000    |
| agv gdp                 | 16 | 26.445   | 4.275   | 20.520   | 34.829   |
| man gdp                 | 16 | 10.557   | 1.518   | 7.741    | 12.790   |
| sev gdp                 | 16 | 47.929   | 2.753   | 41.982   | 50.744   |
| aidi                    | 16 | 15.298   | 6.815   | 7.887    | 25.604   |
| elect                   | 16 | 2.774    | 0.367   | 2.086    | 3.307    |
| ict                     | 16 | 4.922    | 6.370   | 0.000    | 19.628   |
| trp                     | 16 | 7.189    | 3.180   | 4.628    | 12.094   |
| fdn                     | 16 | 0.478    | 0.192   | 0.177    | 0.827    |
| gdp cap                 | 16 | 982.042  | 120.547 | 811.427  | 1202.130 |
| tradp                   | 16 | 51.754   | 8.565   | 36.181   | 64.479   |
| corr                    | 16 | -0.961   | 0.075   | -1.094   | -0.852   |
| <b>Malawi</b>           |    |          |         |          |          |
| stl                     | 16 | 0.922    | 0.019   | 0.898    | 0.959    |
| agv gdp                 | 16 | 29.529   | 2.979   | 25.927   | 36.223   |
| man gdp                 | 16 | 10.597   | 1.530   | 9.213    | 13.949   |
| sev gdp                 | 16 | 46.993   | 4.532   | 38.898   | 53.005   |
| aidi                    | 16 | 15.127   | 2.846   | 11.506   | 21.018   |
| elect                   | 16 | 2.069    | 0.301   | 1.739    | 2.633    |
| ict                     | 16 | 1.574    | 2.059   | 0.000    | 6.218    |
| trp                     | 16 | 5.423    | 0.638   | 3.817    | 6.406    |

|                   |    |          |          |          |           |
|-------------------|----|----------|----------|----------|-----------|
| fdn               | 16 | 0.788    | 0.139    | 0.514    | 1.000     |
| gdp cap           | 16 | 459.071  | 52.455   | 372.531  | 516.754   |
| tradp             | 16 | 61.755   | 9.680    | 48.788   | 78.269    |
| corr              | 16 | -0.611   | 0.139    | -0.768   | -0.405    |
| <b>Mauritania</b> |    |          |          |          |           |
| stl               | 16 | 0.841    | 0.069    | 0.725    | 0.939     |
| agv gdp           | 16 | 23.851   | 4.834    | 17.092   | 34.439    |
| man gdp           | 16 | 7.663    | 1.279    | 4.982    | 9.543     |
| sev gdp           | 16 | 36.266   | 3.078    | 29.844   | 40.583    |
| aidi              | 16 | 10.661   | 3.963    | 5.181    | 16.195    |
| elect             | 16 | 3.087    | 0.593    | 2.021    | 4.064     |
| ict               | 16 | 4.245    | 4.946    | 0.000    | 13.083    |
| trp               | 16 | 5.103    | 0.914    | 1.908    | 5.925     |
| fdn               | 16 | 0.054    | 0.056    | 0.000    | 0.142     |
| gdp cap           | 16 | 1256.452 | 102.172  | 1028.620 | 1369.190  |
| tradp             | 16 | 107.861  | 14.952   | 68.262   | 132.494   |
| corr              | 16 | -0.684   | 0.212    | -0.928   | -0.031    |
| <b>Mauritius</b>  |    |          |          |          |           |
| stl               | 16 | 0.193    | 0.061    | 0.108    | 0.297     |
| agv gdp           | 16 | 3.908    | 0.807    | 2.777    | 5.276     |
| man gdp           | 16 | 14.484   | 1.949    | 11.364   | 18.030    |
| sev gdp           | 16 | 63.115   | 3.203    | 57.368   | 67.413    |
| aidi              | 16 | 58.770   | 12.875   | 42.102   | 76.787    |
| elect             | 16 | 33.017   | 4.664    | 24.968   | 39.800    |
| ict               | 16 | 17.214   | 19.455   | 0.002    | 51.672    |
| trp               | 16 | 36.228   | 0.869    | 34.804   | 37.649    |
| fdn               | 16 | 0.188    | 0.137    | 0.000    | 0.472     |
| gdp cap           | 16 | 8187.292 | 1416.235 | 6162.120 | 10578.600 |
| tradp             | 16 | 110.859  | 9.493    | 94.854   | 127.063   |
| corr              | 16 | 0.358    | 0.121    | 0.201    | 0.560     |
| <b>Morocco</b>    |    |          |          |          |           |
| stl               | 16 | 0.617    | 0.026    | 0.574    | 0.670     |
| agv gdp           | 16 | 12.565   | 0.807    | 10.863   | 13.923    |
| man gdp           | 16 | 15.971   | 0.810    | 15.093   | 17.780    |
| sev gdp           | 16 | 51.310   | 1.170    | 49.742   | 53.520    |
| aidi              | 16 | 40.224   | 17.382   | 19.075   | 64.884    |
| elect             | 16 | 11.140   | 2.078    | 7.396    | 14.340    |
| ict               | 16 | 12.772   | 13.973   | 0.001    | 34.912    |
| trp               | 16 | 9.600    | 0.654    | 8.795    | 10.516    |
| fdn               | 16 | 0.295    | 0.143    | 0.055    | 0.526     |
| gdp cap           | 16 | 2847.402 | 367.413  | 2235.420 | 3361.220  |
| tradp             | 16 | 76.689   | 8.884    | 58.328   | 87.990    |
| corr              | 16 | -0.285   | 0.102    | -0.437   | -0.130    |
| <b>Mozambique</b> |    |          |          |          |           |
| stl               | 16 | 0.855    | 0.035    | 0.788    | 0.891     |
| agv gdp           | 16 | 24.391   | 1.564    | 22.508   | 27.510    |
| man gdp           | 16 | 10.710   | 2.607    | 8.026    | 14.972    |
| sev gdp           | 16 | 46.461   | 2.329    | 40.753   | 48.656    |

|                |    |          |         |          |          |
|----------------|----|----------|---------|----------|----------|
| aidi           | 16 | 9.068    | 2.311   | 5.879    | 12.495   |
| elect          | 16 | 10.908   | 1.028   | 9.076    | 12.317   |
| ict            | 16 | 2.596    | 3.647   | 0.000    | 11.862   |
| trp            | 16 | 2.112    | 0.082   | 1.930    | 2.254    |
| fdn            | 16 | 0.550    | 0.199   | 0.241    | 1.000    |
| gdp cap        | 16 | 482.428  | 85.200  | 347.157  | 591.439  |
| tradp          | 16 | 84.979   | 21.735  | 62.255   | 131.986  |
| corr           | 16 | -0.614   | 0.135   | -0.875   | -0.437   |
| <b>Namibia</b> |    |          |         |          |          |
| stl            | 16 | 0.452    | 0.049   | 0.381    | 0.550    |
| agv gdp        | 16 | 8.030    | 1.470   | 5.904    | 10.583   |
| man gdp        | 16 | 11.598   | 1.255   | 9.730    | 13.653   |
| sev gdp        | 16 | 56.651   | 2.327   | 51.495   | 59.540   |
| aidi           | 16 | 26.817   | 1.683   | 24.696   | 28.882   |
| elect          | 16 | 12.041   | 1.222   | 9.884    | 14.229   |
| ict            | 16 | 6.274    | 7.652   | 0.001    | 21.970   |
| trp            | 16 | 22.037   | 3.655   | 17.137   | 27.188   |
| fdn            | 16 | 0.494    | 0.274   | 0.140    | 1.000    |
| gdp cap        | 16 | 5476.897 | 658.486 | 4234.550 | 6412.100 |
| tradp          | 16 | 100.012  | 12.996  | 82.349   | 125.478  |
| corr           | 16 | 0.311    | 0.096   | 0.159    | 0.608    |
| <b>Nigeria</b> |    |          |         |          |          |
| stl            | 16 | 0.844    | 0.034   | 0.789    | 0.932    |
| agv gdp        | 16 | 23.811   | 3.592   | 19.990   | 33.827   |
| man gdp        | 16 | 8.922    | 1.377   | 6.553    | 12.061   |
| sev gdp        | 16 | 50.503   | 5.254   | 39.146   | 59.785   |
| aidi           | 16 | 14.497   | 5.157   | 8.609    | 22.365   |
| elect          | 16 | 2.507    | 0.336   | 1.938    | 2.838    |
| ict            | 16 | 4.743    | 5.512   | 0.000    | 15.061   |
| trp            | 16 | 5.827    | 0.320   | 5.343    | 6.440    |
| fdn            | 16 | 0.260    | 0.190   | 0.000    | 0.724    |
| gdp cap        | 16 | 2212.063 | 287.946 | 1682.100 | 2563.900 |
| tradp          | 16 | 36.102   | 9.322   | 20.722   | 53.278   |
| corr           | 16 | -1.130   | 0.125   | -1.362   | -0.892   |
| <b>Senegal</b> |    |          |         |          |          |
| stl            | 16 | 0.665    | 0.041   | 0.610    | 0.742    |
| agv gdp        | 16 | 14.367   | 1.289   | 11.980   | 16.562   |
| man gdp        | 16 | 18.144   | 2.127   | 15.468   | 22.952   |
| sev gdp        | 16 | 52.519   | 1.146   | 50.371   | 54.052   |
| aidi           | 16 | 18.238   | 5.362   | 11.522   | 25.965   |
| elect          | 16 | 3.746    | 0.516   | 2.675    | 4.694    |
| ict            | 16 | 5.109    | 6.063   | 0.000    | 16.885   |
| trp            | 16 | 3.561    | 0.151   | 3.313    | 3.779    |
| fdn            | 16 | 0.325    | 0.202   | 0.000    | 0.803    |
| gdp cap        | 16 | 1309.363 | 104.156 | 1162.850 | 1546.520 |
| tradp          | 16 | 59.909   | 5.458   | 51.642   | 69.442   |
| corr           | 16 | -0.231   | 0.235   | -0.638   | 0.059    |

| South Africa |    |          |         |          |          |
|--------------|----|----------|---------|----------|----------|
| stl          | 16 | 0.027    | 0.025   | 0.000    | 0.070    |
| agv gdp      | 16 | 2.420    | 0.296   | 2.089    | 3.052    |
| man gdp      | 16 | 13.478   | 1.946   | 11.601   | 17.296   |
| sev gdp      | 16 | 60.650   | 0.606   | 59.069   | 61.389   |
| aidi         | 16 | 60.990   | 13.401  | 45.879   | 79.635   |
| elect        | 16 | 76.926   | 2.883   | 71.778   | 82.376   |
| ict          | 16 | 21.673   | 24.878  | 0.004    | 63.444   |
| trp          | 16 | 14.732   | 3.412   | 12.921   | 23.441   |
| fdn          | 16 | 0.413    | 0.143   | 0.160    | 0.679    |
| gdp cap      | 16 | 7237.936 | 406.821 | 6266.020 | 7582.700 |
| tradp        | 16 | 59.578   | 5.536   | 51.078   | 72.865   |
| corr         | 16 | 0.158    | 0.211   | -0.116   | 0.568    |
| Tanzania     |    |          |         |          |          |
| stl          | 16 | 0.877    | 0.047   | 0.819    | 0.954    |
| agv gdp      | 16 | 25.978   | 1.757   | 23.245   | 30.040   |
| man gdp      | 16 | 8.710    | 0.656   | 7.504    | 9.549    |
| sev gdp      | 16 | 42.288   | 2.974   | 36.397   | 45.993   |
| aidi         | 16 | 8.435    | 2.885   | 5.172    | 12.543   |
| elect        | 16 | 1.628    | 0.309   | 1.165    | 2.017    |
| ict          | 16 | 2.680    | 3.331   | 0.000    | 10.272   |
| trp          | 16 | 3.203    | 0.397   | 2.752    | 3.952    |
| fdn          | 16 | 0.462    | 0.216   | 0.064    | 0.845    |
| gdp cap      | 16 | 765.223  | 117.098 | 583.314  | 959.355  |
| tradp        | 16 | 42.126   | 8.433   | 29.057   | 56.166   |
| corr         | 16 | -0.549   | 0.157   | -0.774   | -0.233   |
| Tunisia      |    |          |         |          |          |
| stl          | 16 | 0.501    | 0.054   | 0.414    | 0.593    |
| agv gdp      | 16 | 9.086    | 0.791   | 7.535    | 10.369   |
| man gdp      | 16 | 15.917   | 0.926   | 14.275   | 18.141   |
| sev gdp      | 16 | 56.483   | 1.814   | 53.599   | 59.235   |
| aidi         | 16 | 46.108   | 16.506  | 26.779   | 68.982   |
| elect        | 16 | 23.249   | 3.736   | 18.149   | 29.000   |
| ict          | 16 | 13.061   | 14.138  | 0.001    | 33.912   |
| trp          | 16 | 10.537   | 0.540   | 9.918    | 11.279   |
| fdn          | 16 | 0.200    | 0.186   | 0.018    | 0.564    |
| gdp cap      | 16 | 3988.141 | 367.402 | 3226.650 | 4401.060 |
| tradp        | 16 | 98.811   | 8.944   | 82.390   | 114.355  |
| corr         | 16 | -0.114   | 0.128   | -0.304   | 0.160    |
| Uganda       |    |          |         |          |          |
| stl          | 16 | 0.854    | 0.037   | 0.782    | 0.908    |
| agv gdp      | 16 | 24.341   | 1.499   | 21.385   | 26.236   |
| man gdp      | 16 | 8.223    | 1.157   | 6.365    | 10.542   |
| sev gdp      | 16 | 47.302   | 1.484   | 45.312   | 52.032   |
| aidi         | 16 | 15.090   | 3.883   | 10.469   | 20.622   |
| elect        | 16 | 1.129    | 0.153   | 0.875    | 1.431    |

|                 |    |          |         |          |          |
|-----------------|----|----------|---------|----------|----------|
| ict             | 16 | 3.467    | 4.011   | 0.000    | 10.296   |
| trp             | 16 | 9.085    | 1.198   | 6.378    | 10.374   |
| fdn             | 16 | 0.537    | 0.157   | 0.256    | 0.765    |
| gdp cap         | 16 | 612.408  | 83.069  | 464.436  | 710.082  |
| tradp           | 16 | 46.259   | 5.779   | 35.460   | 56.258   |
| corr            | 16 | -0.931   | 0.111   | -1.085   | -0.779   |
| <b>Zambia</b>   |    |          |         |          |          |
| stl             | 16 | 0.487    | 0.163   | 0.081    | 0.668    |
| agv gdp         | 16 | 9.707    | 4.052   | 2.576    | 15.617   |
| man gdp         | 16 | 8.267    | 1.177   | 6.187    | 10.148   |
| sev gdp         | 16 | 51.414   | 2.633   | 47.455   | 56.220   |
| aidi            | 16 | 18.234   | 2.837   | 14.423   | 22.289   |
| elect           | 16 | 13.121   | 1.041   | 12.231   | 15.598   |
| ict             | 16 | 3.873    | 4.759   | 0.001    | 12.988   |
| trp             | 16 | 8.802    | 1.703   | 4.933    | 13.309   |
| fdn             | 16 | 0.437    | 0.229   | 0.061    | 0.801    |
| gdp cap         | 16 | 1428.977 | 232.297 | 1033.310 | 1672.350 |
| tradp           | 16 | 70.052   | 8.854   | 56.121   | 84.597   |
| corr            | 16 | -0.460   | 0.117   | -0.656   | -0.284   |
| <b>Zimbabwe</b> |    |          |         |          |          |
| stl             | 16 | 0.591    | 0.123   | 0.422    | 0.818    |
| agv gdp         | 16 | 12.519   | 4.882   | 7.144    | 21.198   |
| man gdp         | 16 | 12.569   | 2.561   | 8.184    | 16.335   |
| sev gdp         | 16 | 54.520   | 7.549   | 44.487   | 74.359   |
| aidi            | 16 | 22.719   | 1.467   | 20.151   | 24.716   |
| elect           | 16 | 11.698   | 0.996   | 9.765    | 13.432   |
| ict             | 16 | 4.387    | 5.699   | 0.000    | 15.742   |
| trp             | 16 | 14.336   | 3.402   | 11.953   | 22.985   |
| fdn             | 16 | 0.393    | 0.345   | 0.000    | 1.000    |
| gdp cap         | 16 | 1074.966 | 181.423 | 725.576  | 1322.340 |
| tradp           | 16 | 70.353   | 17.245  | 48.336   | 109.522  |
| corr            | 16 | -1.336   | 0.057   | -1.405   | -1.236   |

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