**Closing the infrastructure deficit in Sub-Saharan Africa: Is there a role for domestic bond markets?**

**Abstract**

We investigate the relationship between public debt markets development and infrastructure deficit (financing gap) in Sub-Saharan Africa. Employing the panel threshold regression (PTR) model on data of 40 countries, covering 2003-2016, we document a nonlinear (single-triple threshold) relationship between public debt markets development and infrastructure financing gap. Our results show that these fledgling government and corporate debt markets play a complimentary role in the financing of infrastructure; and interestingly, with corporate public debt markets eliciting greater reduction in infrastructure financing gap than government public debt markets. Taking together all our findings, African governments should implement policies that promote the development of both sovereign and corporate bond markets, with emphasis on quickly deepening corporate bond markets, in order to facilitate a more impactful financing of infrastructure that would be due to a better financially enabled private sector investors.

***Key words***: Public debt markets; Infrastructure; Financing gap; Threshold regression; Africa

***JEL Classification*:** C24; H54; O18; O55

# **1.0 Introduction**

Recent studies suggest that African countries have substantial infrastructure deficits, which are regarded as a binding constraint on their economic growth (Calderon, Cantu & Chuhan-Pole, 2018; Kodongo & Ojah, 2016). To narrow or close the large deficits and potentially attain the transformative growth potential which fuller infrastructure provisioning promises, the African region needs to bridge its infrastructure financing gap, estimated at US$ 45.5 billion annually until 2040 (ACCA & CPA Canada, 2019).[[1]](#footnote-2) Traditionally, African countries have tended to finance their infrastructure development through budgetary allocations (funded by domestic tax revenues) and official development assistance. However, many countries in the region have not been able to operate at optimal tax capacity due to several reasons, including structural constraints, large informal sectors, weak labour force data, and dominance of nonmonetary sectors such as subsistence agriculture (see e.g., Glenday, Bharali & Wang, 2019). Similarly, official development flows have been dwindling lately due largely to international credit constraints arising from a volatile global economy and dynamics in the global geopolitical landscape (Gutman, Sy & Chattopadhyay, 2015; Mu, Phelps & Stotsky, 2013).

Consequently, African countries are being encouraged to explore alternative ways to raise long-term capital for bridging their infrastructure financing gap (Collier & Cust, 2015; Kodongo, 2013; Mu et al., 2013). One of the key alternative approaches being advocated for both developed and developing countries is the mobilization of private finance through public debt markets (Hyun, Park & Tian, 2019; Regan, 2017). Therefore, it has become common practice for governments and infrastructure developers with constrained internal financing capacity to turn to capital market borrowing (GIZ, 2017). For example, between 2007 and 2017, about a dozen countries in Sub-Saharan Africa issued sovereign bonds, raising commercial debt in excess of US$ 35 billion for infrastructure projects; however, due to apparent domestic debt market capacity constraints, most of these issues have been floated in international (Eurobond) debt markets (Juvonen, Kumar, Ayed and Marin, 2019). However, because of the relatively well-developed bond market in South Africa, state-owned enterprises such as Eskom (power utility), Transnet (railways), and Sanral (roads) have, in recent years, raised bridging capital by floating project/infrastructure bonds (Mezui, 2013; Raubenheimer, 2019).

Use of the debt market is not the preserve of governments and public utilities. The African Development Bank, which has raised more than US$1 billion since 2010 by issuing green bonds[[2]](#footnote-3) in foreign capital markets, is calling for the enhancement of capacity of African bond markets to issue local currency green bonds so as to attract private infrastructure capital from the growing institutional investor segment with a mandate to spend a portion of their resources in environment-friendly infrastructure projects (AfDB, 2016; Humphrey, 2018). Since 2012, twenty green bonds have been floated in Africa, raising a total of US$2.78 billion, suggesting great potential to expand this public bond market segment to bridge the infrastructure finance gap (AfDB, 2016; Caminha, 2020).[[3]](#footnote-4)

Given these developments, it is not surprising that studies have pointed to the essential role that domestic public debt markets could play in mobilizing resources from diverse savers (e.g., Collier & Cust, 2015). Yet, with the exception of South Africa, public debt markets in Sub-Saharan Africa (SSA) are largely at their infancy and are considered shallow and illiquid (Essers, Blommestein, Cassimon & Ibarlucea Flores, 2015; Machokoto, Areneke & Ibrahim, 2020). To illustrate, Mu et al. (2013) have shown that the region's government and corporate debt market capitalization amounted to only 14.8% and 1.8% of GDP, respectively. This is very low compared to other developing regions such as Asia, where Malaysia for example, has domestic public debt market capitalization of 57.3% and 57% of GDP for government and corporate bond markets, respectively. Whereas some national markets in Africa have shown good promise, they are invariably thinly traded and dominated by public sector issuances. For example, the gross amount of bonds issued between 2013 and 2018 in Morocco averaged 67 billion Moroccan Dirham (US$ 7.5 billion, approximately) per year with Treasury bills making up almost 75% of the total debt issued on the public capital market (Raubenheimer, 2019).

As such, it is interesting to address the question of whether the region’s public debt markets are well-equipped to mobilize a sufficient amount and type of capital to meet the huge infrastructure need: infrastructure projects often require lumpy capital characterised by long gestation and payback periods, as well as have high exposure to economic, political and financial risks (Ba, Gasmi & Um, 2017; Mustafa, 2015). Thus, this study seeks to address the question of whether Africa’s domestic public debt markets can play an effective role in plugging the region’s infrastructure financing gap. Specifically, we seek, first, to establish the nature of the relationship between the levels of development of Africa’s public debt markets and the infrastructure gap; and second, to ascertain the (threshold) level of development of Africa’s public debt markets that can mobilize sufficient capital to effectively attenuate the region's notorious infrastructure gap. In our robustness checks, we use the limited available data to test these same relationships with infrastructure financing gap. Because the results are similar, we argue that the infrastructure gap is a reasonable proxy for infrastructure financing gap, which allows us to make inferences about infrastructure financing.

These questions must be understood against the backdrop of the many studies that have given a prominent role to well-functioning domestic debt markets in the participation of the private sector in provisioning long-term financing for infrastructure investment (e.g., Ba & Gasmi, 2011; Hyun et al. (2019). In the case of Sub-Saharan Africa, some recent studies (e.g., Calderon et al., 2018; Foster & Briceño-Garmendia, 2010) have argued that although the private sector’s contribution towards infrastructure financing is low (at about US$ 9.4 billion or 1.5% of GDP), if effectively harnessed, private finance – by way of public debt markets – could help close about 40% of the SSA’s infrastructure financing gap – an equivalent of about 2% of GDP.

In the literature, whilst most studies have examined the link between financial development (FD)/public bond market development[[4]](#footnote-5) and economic growth (e.g., Islam, 2014; Kapingura & Makhetha-Kosi, 2014; Muharam, Ghozali & Arfinto, 2018; Pradhan et al., 2015; Pradhan, Arvin, Bennett, Nair & Hall, 2016a; Thumrongvit, Kim & Pyun, 2013), and between infrastructure and economic growth (e.g., ACBF, 2016; Calderón & Servén, 2014; Estache & Garsous, 2012; Kodongo & Ojah, 2016; Zhang & Ji, 2018), the impact of public bond market development on the infrastructure deficit (financing gap), has not received much attention. In other words, while both FD and infrastructure spending are known to impact economic growth, it remains unclear whether FD plays a role on infrastructure financing gap (IFG). Since both public bond market development (PBMD) and infrastructure spending are linked to economic growth, we hypothesise that PBMD is linked to the IFG.

Suppose that our conjecture is not refuted. In that case, the need to understand the precise level of development of the public debt markets that would have a meaningful effect on IFG in the region becomes critical. We argue that if the capacities of local public debt markets are bolstered, they will facilitate the extension of local currency (LCY) debt under competitive terms, which is crucial in fostering private-sector participation in infrastructure financing (Ba et al., 2017).[[5]](#footnote-6) Thus, we initially use a linear function to test for the existence of a relationship between debt markets development and infrastructure financing gap, and then employ a panel threshold regression model (PTR), proposed by Hansen (1999), to ascertain the exact nature of the relationship if one exists. To our knowledge, this is the first study to empirically investigate the functional form of the relationship between debt markets development and infrastructure financing gap in SSA. The key objective here is to assist SSA governments by providing data-guided, and hopefully more productive, infrastructure investment strategies and policies.

The main findings of this paper are as follows. First, provisioning of government and/or corporate public debt finance reduces the infrastructure financing gap (i.e., there is a significant negative association). Specifically, the results show that an increase of 10% in the size of *government* bond markets reduces IFG by between 0.16% and 0.54% of GDP, while the same change in the size of *corporate* bond markets has a larger effect on the infrastructure financing gap, reducing it by between 0.36% and 1.10%. This interesting finding is interpreted in light of the fact that the private sector contributes not only financial capital but also managerial expertise to infrastructure projects, which result in the delivery of low-cost and better quality of infrastructure services (Ba et al., 2017; Gassner, Popov & Pushak, 2009).

Our second major finding is that the relationships between both government public debt markets and corporate public debt markets, and the infrastructure financing gap, are nonlinear and largely indicating a single to triple thresholds values. The single threshold for public debt markets for SSA’s overall infrastructure gap is 80.71% of GDP (against current mean endowment of only 35.6% of GDP) while the double threshold capitalisation for corporate debt markets is 75.99% and 91.61% of GDP (against an observed mean of 15% of GDP). This means that the size debt markets should grow from the current average levels to at least these threshold levels for SSA economies to experience substantial reductions in infrastructure deficits.

The remainder of this paper is organised as follows. Section 2 presents stylized facts and further discusses the need for active public debt markets in Sub-Saharan Africa; Section 3 presents the data, model specification and econometric method deployed for data analysis; Section 4 discusses empirical results; Section 5 presents robustness checks; and Section 6 concludes.

# **Stylized facts: the need for active public debt markets in Sub-Saharan Africa**

Calderon et al. (2018), according to whom the SSA region has huge infrastructure development gaps compared to other regions at the same level of economic development, estimate that closing the gaps will increase the region’s per capita income growth by 1.2 percentage points per annum, the largest growth benefits accruing from electricity and road sectors. Undoubtedly, to provide adequate and sustainable quality infrastructure requires large capital resources. Studies and policymakers (e.g., AUC, 2014; Bond, 2016) cite funding constraints as the major obstacle impeding most SSA countries from providing adequate and quality infrastructure to meet the demands of increasing economic activity, rapid upward trends in youth demographics, and increasing incidences of urbanisation and climate change-based demands.

To close its infrastructure endowment gap requires countries to accelerate infrastructure investments (Ba et al., 2017). ACCA and CPA Canada (2019) estimates that the SSA region requires about US$ 177.7 billion (10% of GDP as of 2018) annually until 2040 to meet its infrastructure needs. Of this amount, only US$ 132.3 billion (8% of GDP) per annum can be raised from traditional sources (e.g., public sector, donors, and private sector) given existing capacity. This leaves a financing gap of about US$45.5 billion (or 2% of GDP) per annum. Given the public sector’s limited resources, the huge financing gap requires that the region employs innovative strategies to attract supplementary private investment from publicly accessible markets to bridge the gap (Calderon et al., 2018; Kodongo & Ojah, 2016).

Therefore, in light of evidence indicating that inadequate fiscal resources are a binding constraint to infrastructure financing, we take the view that governments in SSA must, among other interventions, encourage increased private sector participation in infrastructure financing through, for instance, Public-Private Partnerships (PPPs) procurement arrangements, which are now widely embraced by many governments around the world to reduce fiscal burdens and enhance risk-sharing (Babatunde & Perera, 2017; Li, Abraham & Cai, 2017). For example, Hyun, Park and Tian (2017) show that PPPs in conjunction with LCY bond markets are used widely in Malaysia, China, Japan, and other countries, as an alternative source for infrastructure financing. PPPs are generally regarded as proficient in mobilising private finance, especially from the perspective of long-term institutional investors (e.g., pension funds, insurance companies, etc.) and channelling them into infrastructure investments; in that way, they help to address the infrastructure investment gap (Berrone et al., 2018; Gerbert, 2013).

However, also notable is the fact that government bonds are dominant in some under-developed domestic debt markets in low-and middle-income countries (LMCs), particularly where the infrastructure financing is heavily dependent on government resources. While well-developed government bond markets provide conducive conditions for the development of corporate bond markets, dominance of the public debt market by government issuances may diminish the effective participation of the private sector in the financing of infrastructure projects. For example, while empirically examining the determinants of PPPs in infrastructure provisioning in twelve Asian LMCs over the period 1995–2015, Hyun, Park and Tian (2018) find a negative correlation between bond markets development and PPP investment. They attribute this finding to the crowding-out effect on corporate debt by the dominant government bond market.

Countries often finance infrastructure projects via the Eurobond markets whilst generating revenue in domestic currency, which exposes them to risks of exchange rate and interest rate volatilities (Ba et al., 2017; Turner, 2002). Therefore, well-developed LCY debt markets (“bond markets”) not only play a critical role in matching overall savings with long-term investment opportunities (Luüs, 2014), but also offer an alternative source of debt finance to both public and the private sectors. Furthermore, studies (e.g., Cassimon, Essers & Verbeke, 2016) argue that by developing LCY debt markets, emerging economies reduce dependency on foreign funds, and thereby reduce their vulnerability to international financial shocks that may inhibit cross-border capital flows. For these reasons, Sub-Saharan African countries are encouraged to accelerate the development of their public debt markets so that these markets could play the much-needed vital role in infrastructure financing, among other capital projects funding (Berensmann, Dafe, Lindenberg & Volz, 2015; Essers et al., 2015).

# **Data and Methodology**

## **3.1 Data and model specification**

We use annual data of four infrastructure types, namely, electricity, water and sanitation, transport, and information and communication technology (ICT), all of whose financing reflect some level of private sector participation (documented in World Bank’s Private Participation in Infrastructure, PPI database) for the period 2003–2018 for 40 SSA countries. The length of the study period and the countries selected are determined by availability of data for the relevant variables of the study. The list of countries sampled for the study is presented in Table A-1 of the Appendix. The table also shows the income groups in which the countries were classified, based on the 2009 World Bank Analytical Classifications. We start by specifying the following empirical model:

where infrastructure deficit/gap (the dependent variable) is represented by. We rely on the Africa Infrastructure Development Index (AIDI) developed by the African Development Bank (AfDB, 2013) to calculate the infrastructure gap, our proxy for the infrastructure deficit[[6]](#footnote-7). AIDI is used to estimate the infrastructure deficit/gap for both aggregate/overall infrastructure deficit index , and sub-indices of deficits in infrastructure types, namely, transport infrastructure deficit ), electricity infrastructure deficit ), information and communications technology (ICT) infrastructure deficit ), and water and sanitation (WSS) infrastructure deficit (), which alternately, serve as the dependent variables in our baseline regression.[[7]](#footnote-8)

We estimate the infrastructure gap/deficit as the difference between the optimal and the actual infrastructure endowment (Liberini, 2006). That is, we consider the existing infrastructure indices to represent the ‘actual infrastructure endowment’ at time . Since, according to AfDB (2013), the composite index for each component is normalised to take the values of between 0 and 100, the ‘optimal infrastructure endowment’ of each country is 100. Therefore, we estimate the infrastructure gap of country at time as 100 minus ‘actual infrastructure endowment’. Use of infrastructure indexes to proxy for infrastructure investment is not new in infrastructure literature, having featured in studies such as Calderón and Servén (2010), who use indicators of quantity and quality of infrastructure to examine the trends in financing of infrastructure investments in Latin America.

The explanatory variable of interest, debt market size, represented by in Equation (1), is measured as the market value of outstanding domestic listed government debt securities ) and outstanding domestic listed corporate debt securities , each scaled by GDP. The two indicators of bond markets development are covered by Beck, Demirgüç-Kunt and Levine (2000) in their financial development database and have been used by Čihák, Demirgüç-Kunt, Feyen and Levine (2012) in benchmarking financial systems in 205 countries, as well as in many recent studies to measure debt market depth or size (e.g., Burger, Warnock & Warnock, 2015; Fabella & Madhur, 2003; Pradhan et al., 2016a). Theoretically, we expect domestic debt variables to be negatively correlated with aggregate infrastructure gap and with individual infrastructure type gaps , , , and , and therefore to yield negative coefficient estimates.

Next, represents the PPP infrastructure variables, namely, transport , electricity , ICT (), and water and sanitation (, all scaled by GDP. These variables represent some level of existing private sector investment in key infrastructure sectors as documented in World Bank’s Private Participation in Infrastructure (PPI). In the empirical analysis, we work with infrastructure investments as a single variable through a synthetic index , constructed using Principal Components Analysis (PCA). Further, because the infrastructure gap variables are highly correlated (see correlation matrix in Table A-2 of the Appendix), they are introduced in the model alternately. We postulated that the infrastructure gap and infrastructure investments are negatively related because higher investment in infrastructure should reduce IFG (Calderon et al., 2018).

We control for economic growth using annual growth rate in GDP per capita. Economic output growth may generate additional demand for supportive infrastructure to sustain the growth momentum (Kumo, 2012; Lee, Levendis & Gutierrez, 2012), thus expanding the infrastructure gap. Alternatively, an expansion in economic output (positive GDP growth) may create additional resources to invest in infrastructure, thereby reducing the infrastructure gap. Thus, depending on the relative strength of each of these two opposing effects, the coefficient sign might be negative or positive; the two effects may also cancel out each other, in which case the coefficient of GDP growth might be statistically zero.

Equation (1) also includes a vector of other controls (), which includes corporate governance, the exchange rate, foreign direct investment, public sector gross fixed capital formation, stock market capitalization and interest rates. Quality of governance is one of the key determinants of private sector participation in infrastructure investments (Ba et al., 2017; Noumba Um, Gasmi & Ba, 2010). The governance index variable is a synthetic indicator constructed from government efficiency, control of corruption, regulatory quality and political stability, obtained from the Worldwide Governance Indicators database (Kaufmann, Kraay & Mastruzzi, 2011). Each indicator of governance ranges from -2.5 to +2.5, with higher scores denoting higher perceptions of effective governance (Kaufmann et al., 2011). Studies suggests that good governance attracts infrastructure finance and facilitates the growth of debt markets (Misati & Nyamongo, 2011; Regan, 2017). The governance indicator is therefore expected to correlate negatively with the infrastructure gap/deficit.

According to Schwartz, Ruiz-Nuñez and Chelsky (2014), exchange rate volatility could affect the cost of imported infrastructure construction or operations input. For example, in a study to examine the determinants of private sector investments in energy infrastructure projects in 37 developing countries, using a 1990-2007 dataset, Noumba Um et al. (2010) find that currency risk negatively impacts energy infrastructure projects. Similarly, Frimpong and Marbuah (2010) find that depreciation of real exchange rate increases cost of imported capital goods, and may as a result negatively influence the level of private-sector investment in import-dependent infrastructure sectors. Depending on the dominant form of change in exchange rates (appreciation, or depreciation) in the sampled countries, the exchange rate coefficient may be negative or positive.

Foreign direct investment (FDI) scaled by GDP is included as a control variable in this study in order to capture the flow of foreign capital into the economy, which possibly injects additional capital into infrastructure investments and help to reduce the country’s infrastructure gap (Anaman, 2018; Ndikumana & Verick, 2008; Tsaurai & Ndou, 2019). To account for domestic investment in infrastructure development, we use the change of gross fixed capital formation (GFCF, public sector) to GDP (. We expect both domestic investments and FDI inflows to have a negative correlation with infrastructure deficit. The macroeconomic environment is also important for the development of infrastructure, hence in this study we use real interest rate as a measure of macroeconomic stability. High levels of real interest rate discourages infrastructure investments by increasing the cost of funds and affecting its availability (Schwartz et al., 2014). We therefore expect real interest to have a positive impact on infrastructure deficit.

We incorporate stock market capitalization as a percentage of GDP into the equation to capture the role of financial intermediation in promoting infrastructure financing. Stock markets, as a financial intermediary, can play both a substitution and complementary role alongside public bond markets in providing long-term finance to infrastructure projects (Brealey, Cooper & Habib, 1996; Gatti, 2013). Therefore, the influence of the stock market capitalization variable on infrastructure deficit can either be positive or negative. Lastly, we include human development index (HDI), a proxy for human capital development. Human capital fosters the availability of skilled and highly productive labour that contributes to efficient and/or effective delivery of infrastructure projects (ACBF, 2016; Han & Lee, 2020; Tsaurai & Ndou, 2019). The HDI is a component of three indices, namely the average and expected year of schooling index, life expectancy index and national income index.

Table 1 contains a summary description, notations, and source of the deployed data (variables).

*(Table 1 about here)*

Equation (1) assumes a linear relationship between the two key variables. However, we argue that low levels of debt markets development may not have a meaningful impact on the high infrastructure deficits observed in the SSA region and that larger debt markets may be necessary to enable a cumulation of such meaningful effects. Specifically, we believe that there is a requisite minimum cumulation of infrastructure investment (or endowment) reflected by a threshold level of debt markets development at which domestic debt financing begins to have an effect on the infrastructure deficit (and financing gap). To estimate the threshold effect, we employ the panel threshold regression model (Hansen, 1999):

where is the threshold variable, defined as the level of infrastructure financing gap;,, are the values of the threshold variable, and are estimated coefficients of the threshold variables; , , and are other coefficients to be estimated; and are the cross-sectional fixed effects to deal with unobserved country-level heterogeneity, and noise terms, respectively. We first estimate a single threshold model and test the significance of the single threshold: the null hypothesis of no threshold effect is tested against the alternative hypothesis of a single threshold. We subsequently test for the null hypothesis of a single threshold against the alternatives of two thresholds and three thresholds, and so on, as we seek to determine the number of thresholds in the model.

# **Descriptive statistics**

Table 2 shows the summary statistics of the variables used in this study.

*(Table 2 about here)*

The sample size in this balanced panel dataset is 640. The table shows that existing infrastructure investment in SSA countries is relatively low, with transport being the least, with an average investment of 0.98% of GDP, followed by water, ICT, and electricity with mean values of 1.92%, 2.86% and 5.66% of GDP, respectively. This is not surprising since private sector involvement in infrastructure in SSA is still minimal. For example, between 2014 and 2018, SSA received an average of US$4.3 billion annually in private infrastructure investment commitment, compared to an annual average of US$34 billion, US$28 billion and US$17 billion for Latin America and the Caribbean (LAC), East Asia Pacific (EAP) and Europe and Central Asia (ECA) regions respectively (World Bank, 2014, 2018). Thus, of the developing regions, SSA’s share of overall PPI investment commitmentsis on average only around 5% compared to 41%, 34% and 20% for LAC, EAP and ECA, respectively. The data also show that government debt market size (mean value, 35.63% of GDP) is high relative to corporate debt market size (15.06% of GDP).

The nexus between debt market size (market capitalisation), our target independent variable, and infrastructure gap is explored further in the scatter plots in Figure 1 and Figure 2. Figure 1 plots the 16-year averages (2003-2018) of countries’ infrastructure gap as a percent of GDP (y-axis) against domestic government debt markets as a percent of GDP (x-axis). As expected, the figure shows a negative relationship between debt market size and infrastructure gap. Countries such as Comoros, Liberia and Eritrea reporting very low levels of government debt market size and high levels of infrastructure gap, which is expected, while countries such as Mozambique, and Niger surprisingly report relatively high government debt markets and high infrastructure gaps. The surprising observation may be explained by a number of factors, such as size of the economy, and population size. Relatively large economies and high population density require effectively higher infrastructure endowments.

*(Figure 1 about here)*

*(Figure 2 about here)*

Similar to Figure 1, Figure 2 indicates that the relationship between debt market size and infrastructure gap is negative (expectedly more negative than in Figure 1). Closer examination shows that middle-income countries such as Botswana Cape Verde, and Namibia have relatively low infrastructure gap and relatively high corporate debt markets. Conversely, low-income countries, such as Comoros, Sao Tome and Principe, and Chad appear to dominate the segment with low debt markets development and high infrastructure deficit.

# **Preliminary tests**

Before running our main empirical tests, we perform some preliminary tests on the data. First, we test for cross-sectional dependence in the variables. Cross-sectional dependence occurs when the cross-section units are highly correlated, say due to the effect of unobserved common factors. The presence of cross-sectional dependence in a panel can create estimation problems if it is not accounted for. By way of mitigation, the unit root tests and the regression estimation methods should be adjusted to account for the cross-sectional dependence (Martı́nez-Zarzoso & Bengochea-Morancho, 2004). Table A-2 in the Appendix shows the null hypothesis of no cross-sectional dependence is rejected for all variables except trade balance. Thus, we control for cross-sectional dependence in our tests.

Next, we test for unit roots in our panel dataset. Given the presence of cross-sectional dependence reported in Table A-3, we thus deploy unit root tests of Im, Pesaran’s and Shin W-statistic, ADF - Fisher Chi-square and PP - Fisher Chi-square. These unit root tests assume cross-sectional independence, but allow for heterogeneity of the form of individual deterministic effects and heterogeneous serial correlation structure of the error terms (Gengenbach, Palm & Urbain, 2009). Table 3 shows the unit-root test outcomes with variables in first difference. The null hypothesis is of a unit root (non-stationary). The results shows that all the variables are stationary after differencing once.

*(Table 3 about here)*

# **4.0 Empirical Results**

## **4.1 Infrastructure gap and government bond markets development: linear analysis**

We use the pooled mean group (PMG) estimator (Pesaran, Shin and Smith, 1999) to explore the linear relationship between infrastructure gap and debt market variables. The PMG estimator has the advantage of being robust to outliers and lag orders. (In our robustness checks, we use the fixed effects estimator: results are qualitatively similar). Table 4 and Table 5 present the results of various linear models of infrastructure gap against government debt markets and corporate debt markets respectively. In Table 4, column 2, where we regress the overall infrastructure gap on government debt market , control variables and a constant, the results show that government debt market development is negatively and statistically significantly related to the overall infrastructure gap.

This result means that more developed government debt markets can facilitate the channelling of funds to infrastructure projects and help to reduce the overall infrastructure gap. Models 2 through 6 have the dependent variable as gaps in individual infrastructure types and also control for corporate governance , the annual growth rate of gross domestic product per capita , the exchange rate , foreign direct investment (), gross fixed capital formation of the public sector, stock market capitalisation and real investment interest rates . Several of these control variables are normalized by Gross Domestic Product (GDP). In addition to the listed control variables, the models also control for the current PPP infrastructure investment in the respective models.

*(Table 4 about here)*

In all the models, we observe that the coefficient for government debt markets is negative and statistically significant when using different infrastructure gap variables. We, therefore, conclude that there is a robust negative association between the infrastructure gap and size of the government debt markets, suggesting that the government debt market plays a vital role in reducing the infrastructure gap. Specifically, the coefficients for government debt markets range from -0.054 (-3.039) for transport to -0.016 (-2.944) for electricity, implying that an improvement in the development of government debt markets by, say 10%, would elicit a reduction in the average transport infrastructure gap by 0.16% to 0.54 % of GDP.

In models 2 and 3, we observe a statistically significant negative relationship between current PPP investment levels in individual infrastructure types and respective infrastructure gaps. Specifically, in model 2, a 10% increase in current transport investment elicits a 2.12% decline in the transport infrastructure gap. In model 3, a 10 % increase in current electricity investment is associated with a 0.99% reduction in the electricity infrastructure gap. These results are consistent with our expectations and with previous studies (e.g., Calderon et al. (2018).

In models 1 and 4, we have a contrary relationship where widening of the infrastructure gaps appear to be associated with an increase in the PPP investment level overall () and in the ICT infrastructure (). This relationship might be due to demand-driven type of investment where an additional investment of one infrastructure type should be accompanied by more investment in another infrastructure type, generating a complimentary type of investment which, if not done, may raise the infrastructure gap (Agénor, 2010; Rinaldi, Peerenboom & Kelly, 2001). According to Rinaldi et al. (2001), most infrastructure sectors are highly connected/networked and mutually dependent: for example, the addition of a new water supply facility or transportation infrastructure (e.g., railway system) may, in turn, require new and better energy infrastructure to support the initial infrastructure addition.

A good example is the introduction of a Gautrain Rapid Rail Link[[8]](#footnote-9) in South Africa, which was an addition to transport infrastructure but required sufficient and reliable electricity supply to operate efficiently and sustainably (Xaba & Yusuff, 2018). The derived demand for complementary infrastructure may deepen the infrastructure gap if an appropriate injection of additional capital is not immediately available to meet the new demand. Another example is that a boom in mobile technology can create higher demand for complementary ICT infrastructure, such as secure servers, more efficient international Internet bandwidth, and faster Internet connectivity (ECA, 2019; Pradhan et al., 2017; Pradhan, Arvin & Hall, 2016b).

We also observe, in Model 2, a statistically significant negative relationship between the transport infrastructure gap and GDP growth rate per capita. That is, a 10% increase in GDP per capita growth would elicit a 0.40% reduction in the transportation infrastructure gap. This result can be explained by the fact that the growth in GDP per capita allows governments to mobilise resources from taxes and domestic savings to channel into transport infrastructure to facilitate population mobility and market access.

Except for the water infrastructure gap, the exchange rate has a positive and statistically significant relationship with all forms of infrastructure gaps. This finding is consistent with the literature (see, Frimpong & Marbuah, 2010; Noumba Um et al., 2010; Schwartz et al., 2014), which suggests that exchange rate volatility could reduce the size of private-sector spending in import-dependent infrastructure sectors, contributing to a rise in the infrastructure gap. Change in public sector GFCF has a negative and statistically significant relationship with gaps in all infrastructure types. This result implies that all infrastructure sectors benefit more from public sector investment in infrastructure (e.g., through fiscal budget appropriation). This finding is consistent with the many reports, which show that African governments are still the major financiers of African infrastructure (ICA 2015, 2016, 2017, 2018), contributing between 57%and 66% of infrastructure investments (ICA, 2015; Foster and Briceño-Garmendia (2010). Concerning model’s goodness of fit, the R-squared, Durbin-Watson statistic, and the many information criteria all largely suggest good fit.

## **4.2 Infrastructure gap and corporate bond markets development: linear analysis**

We now turn to corporate debt markets. Table 5 shows that, like government debt, corporate debt has a negative and statistically significant relationship with the infrastructure gap, as shown in row 4 of Table 5. In general, a 10% increase in corporate debt market size is associated with a 0.36% to 1.10% decline in the infrastructure gap. The magnitude of this relationship is stronger in models 1 (overall infrastructure gap) and 4 (ICT infrastructure gap). Our findings suggest that policymakers should be encouraged to mobilise private financing from public debt markets as a way of bridging the infrastructure financing gap (also see Collier & Cust, 2015; Hyun et al., 2019; Regan, 2017).

Comparing Tables 4 and 5, we observe that corporate debt is more effective than government debt in reducing the overall infrastructure gap, as well as transport, ICT and water infrastructure gaps. This result can be explained in many ways. Firstly, the private sector brings into PPP arrangements, financial resources, and managerial expertise and efficiency to the infrastructure projects (Ba et al., 2017; Hyun et al., 2019). It is assumed that the resulting private sector managerial expertise, technical and operational efficiency add to improved efficiency of spending and productivity; reduced corruption and red-tape; and sound procurement practices and revenue collection, among others, which result in the delivery of low cost and better quality of infrastructure services (Calderon et al., 2018).

Secondly, PPP infrastructure projects are also perceived to be efficient in controlling cost and time overruns relative to government-funded projects (Deep, Kim & Lee, 2019). For example, in a study of the outcome of large public construction projects in the United Kingdom between 1982 and 2001, MacDonald (2002) found that traditional public projects had cost overruns of 24%-66% and time overruns of 4%-39% during construction, whereas PPP projects were more effective in both. In the survey, the author found that 78% of PPP projects were within budgeted parameters, compared to 27% of government-funded projects.

Interestingly, models 3 in Table 4 and 5 show that the government debt market is more efficient in reducing the electricity infrastructure gap than the corporate debt market. Specifically, a 10% increase in government debt is associated with a 0.54% decline in the electricity infrastructure gap, compared to a 0.42% decline when using corporate debt. This finding is unsurprising if we consider that governments and state owned enterprises are the largest investors in SSA’s energy sector, with a contribution of around 81% (Foster & Briceño-Garmendia, 2010). Again, the model fitness tests show fairly well-fitted models.

*(Table 5 about here)*

## **4.3 Nonlinear analysis of bond markets development**

We now attempt to ascertain the true nature of the relationship between the infrastructure gap and government debt and corporate debt markets, respectively. In particular, we investigate possible nonlinearity in these relationships. Table 6 shows the results of the threshold regression analysis. The infrastructure variables, the dependent variables for the respective models, are depicted in the first row. Each infrastructure type has two threshold models, one each for government debt and corporate debt, presented side-by-side in row 2. Row 3 shows the threshold value(s) for each model while rows 4-7 report the beta coefficients for the respective threshold regimes. Row 8-19 show the coefficients of the controls and rows 20-27 report some diagnostic statistics. In our tests, only the debt market variable is considered regime dependent. Therefore, since we have already extensively discussed the effect of the other variables on the infrastructure gap in the previous section, we focus our discussion, in this section, only on the implications of debt markets.

*(Table 6 about here)*

Beginning with government debt markets under the overall infrastructure gap, for the entire sample of 40 countries, we find a single threshold value of 80.71% (government debt as a proportion of GDP). A single threshold value implies that we have two regimes, first, when the government debt as a per cent of GDP is below 80.71%, and the second when the government debt as a per cent of GDP exceeds 80.7%. The two regime betas are in rows 4 and 5. The beta for the first regime, -0.436, is not significant given the t-statistics of -1.158, which is below the acceptable rule of thumb[[9]](#footnote-10). The slope of the second regime, -0.560, is significant given the t-statistic value of -4.845. Thus, when the size of government debt exceeds 80.71% of GDP, we have a negative and significant relationship between the overall infrastructure gap and the government debt. This relationship is not available when the government debt is below the 80.71 value as a per cent of GDP value. This points to a nonlinear relationship between the overall infrastructure gap and government debt. The implication of this finding is that for a significant reduction of the overall infrastructure gap, SSA countries should more than double the size of their government debt market from the current mean of 35.63 (Table 2) to no less than 80.71% of GDP.

Judging by the betas of the corporate debt model under the overall infrastructure gap, we can see that more corporate debt than government debt is required for a significant reduction in the overall infrastructure gap. The corporate debt model has two threshold values (75.99, 91.61), thus creating three regimes. We can observe that the third regime is the only one that is producing a statistically significant relationship. This result means that to reduce the overall infrastructure gap significantly, the corporate debt market as a percent of GDP should grow by more than six times from the current average of 15.06 (Table 2) to 91.61 or higher. That is, a substantial critical level of corporate bond market development needs to be built beyond the threshold value of about 91.66 % of GDP to effectively reduce the infrastructure gap.

To get the infrastructure and debt market size relationships for the sub-categories, Table 6 also shows the threshold model for transport, electricity, ICT, and water infrastructure. Starting with the transport infrastructure gap, columns 4 and 5 show single threshold values of 97.97 and 93.44 as per cent of GDP for government debt and corporate debt, respectively. Thus, we have two regimes for both government debt and corporate debt, with only the second one being statistically significant (t-values of -3.330 and -5.552) for the beta coefficients. As before, the implications of these results are that both government and corporate debt markets need to grow to the at least the threshold levels to make an impact on infrastructure gaps.

Similar results obtain for electricity, water and sanitation, and ICT, each showing that substantial impacts on the infrastructure financing gap are possible with larger debt markets relative to GDP. However, corporate debt markets appear to start exerting substantial influence on ICT at relatively low levels of development, while for water and sanitation infrastructure, both corporate and government debt report substantial effects at lower levels of development. A possible interpretation of both findings is that water and sanitation, and ICT infrastructure tend to have high social returns to formerly excluded segments of society (Hagerman, 2012), the former in terms of health benefits and the latter in the form of financial inclusion, both of which quickly improve their quality of life. Thus, small increments in funding would incentivize their development and yield substantial improvements in their provisioning.

**4.4 Some robustness checks**

We run several tests to check the robustness of our findings. First, we re-estimate the models in Table 6 with different compositions of sampled countries in the first instance, excluding South Africa, and in the second case, grouping countries by income level. The purpose of excluding South Africa is that, as seen in Figures 1 and 2, the country is an outlier having more advanced capital markets and substantially above-zero infrastructure endowment. For this reason, one may argue that it has the capability to bias our results. Figures 1 and 2 also show that richer countries in the region (e.g., Mauritius and Seychelles) have relatively lower infrastructure deficits than their lower-income counterparts. For these reasons, it is interesting to establish whether our baseline results hold across income levels.

*(Table 7 about here)*

Table 7 above shows the summary of the robustness tests results. Except for the overall infrastructure gap under LICs-government debt which produces no threshold values, the tests yield threshold values for all models, which are generally consistent with the results in Table 6. We also have relatively high threshold values under all the models, with consistently low threshold values being reported for the water infrastructure gap. Our results are therefore robust to the composition of countries in the sample. In our second robustness tests, we estimate the models using fixed effects regression (FER). Tables A-4 and A-5 in the Appendix report the results of the linear model estimated through the FER procedure. Although the magnitudes of the regression coefficients are expectedly different, both the PMG and FEM shows a negative and significant relationship between the infrastructure gap and government (Table A-4) and corporate (Table A-5) debt markets.

In the third set of robustness checks, we use a measure of infrastructure financing gap (IFG) as the dependent variable.[[10]](#footnote-11) The IFG data, obtained from World Bank’s Africa Infrastructure Country Diagnostic (AICD) are available for only 24 countries. Using IFG as the dependent variable, we estimate the PMG in linear and non-linear forms. The results, reported in Tables A-6, through A-8 in the Appendix, are qualitatively similar to those using our construct of infrastructure gap, reported in Table 4, Table 5, and Table 6 respectively. The results indicate that increasing the size of debt markets in the region will help lower the infrastructure financing gap. In this regard, we can infer that the infrastructure gap developed and used in the baseline tests in this paper is a good proxy for infrastructure financing gap. Therefore, our results speak to the much-discussed infrastructure financing gap in Sub-Saharan Africa.

# **Conclusions**

In this paper, we use a panel of 40 SSA countries, for the period 2003–2016, to empirically examine the relationship between public debt markets development and the infrastructure financing gap, with the main aim of establishing the potential of debt markets to reduce Africa’s infrastructure financing gap. Firstly, we find that the relationship between the infrastructure financing gap and debt markets development in our sample of SSA countries is negative. Secondly, we find a nonlinear relationship between the infrastructure financing gap and local currency public debt markets development. Thirdly, our threshold analysis shows that the current average size of sovereign public debt markets needs to more than double while the corporate public debt markets should increase more than six-fold for SSA to realise a significant pace of reduction in its legendary colossal infrastructure financing gap.

Indeed, the empirical results strongly confirm that the public debt markets in many SSA countries are under-developed and cannot significantly plug the infrastructure financing gap in the region unless substantial capital (especially public debt) markets growth and/or development embarked upon. A valuable and clear policy implication emanating from our findings is that attention should be paid to designing policies and strategies that boost the level of government and corporate bond markets to facilitate the mobilization and channelling of substantial debt funds towards infrastructure investments. Such policy initiatives would reduce the current excessive reliance on tax revenues and official development assistance, the supplies of which have been dwindling.

# **References**

ACBF. (2016). Infrastructure Development and Financing in Sub-Saharan Africa: Towards a framework for capacity enhancement. *Occasional Paper No. 25*.

ACCA, & CPA Canada. (2019). *How accountants can bridge the global infrastructure gap: Improving outcomes across the entire project life cycle* Retrieved from <https://www.accaglobal.com/content/dam/ACCA_Global/professionalinsights/Infra-gap/pi-global-infrastructure-gap.pdf>:

Acemoglu, D., Johnson, S., & Robinson, J. A. (2005). Institutions as a fundamental cause of long-run growth. *Handbook of economic growth, 1*, 385-474.

ADB. (2017). *Good Practices in Developing Bond Market: with focus on government bond market*. Retrieved from <https://asianbondsonline.adb.org/documents/abmi_good_practices_developing_bond_market_draft.pdf>:

AfDB. (2013). *The Africa Infrastructure Development Index (AIDI)*. Retrieved from Tunis, Tunisia: [www.afdb.org](../../../../../../C:/Users/a0027395/Documents/PhD%20files%20from%20Desktop/_PhD%202016,%202017&%202018%20study%20docs/_Research%20Paper%201_Threshold/_Final%20_June%202021/www.afdb.org)

AfDB. (2016). Why Africa Needs Green Bonds. *Africa Economic Brief, 7*(2 (2016)).

AfDB. (2018). *African Economic Outlook 2018*. Retrieved from <http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/2018AEO/African_Economic_Outlook_2018_-_EN_Chapter3.pdf>:

Agénor, P.-R. (2010). A theory of infrastructure-led development. *Journal of Economic Dynamics and Control, 34*(5), 932-950.

Anaman, G. (2018). *Investigating the Impact of Foreign Direct Investment on Domestic Investment in Sub-Saharan Africa: A Case Study of Kenya and South Africa.* (Master of Arts in Economics), Eastern Illinois University, <https://scholar.google.co.za/scholar?hl=en&as_sdt=0%2C5&q=Investigating+the+Impact+of+Foreign+Direct+on+domestic+investment+in+Sub-saharan+Africa&btnG>=.

AUC. (2014). *Programme for Infrastructure Development in Africa (PIDA): Addressing the infrastructure gap in Africa, to speed up regional integration.* Paper presented at the Seventh Conference of African Ministers in Charge of Integration: 14-18 July 2014, Mbabane, Swaziland.

Azolibe, C. B., Okonkwo, J. J., & Adigwe, P. K. (2020). Government Infrastructure Expenditure and Investment Drive in an Emerging Market Economy: Evidence from Nigeria. *Emerging Economy Studies, 6*(1), 61-85.

Ba, L., Gasmi, F., & Um, P. N. (2017). The Relationship between Financial Development and Private Investment Commitments in Energy Projects. *Journal of Economic Development, 42*(3), 17-40.

Babatunde, S. O., & Perera, S. (2017). Barriers to bond financing for public-private partnership infrastructure projects in emerging markets: A case of Nigeria. *Journal of Financial Management of Property and Construction, 22*(1), 2-19.

Banerjee, S. G., Oetzel, J. M., & Ranganathan, R. (2006). Private provision of infrastructure in emerging markets: do institutions matter? *Development Policy Review, 24*(2), 175-202.

Banga, J. (2019). The green bond market: a potential source of climate finance for developing countries. *Journal of Sustainable Finance & Investment, 9*(1), 17-32.

Barth, J., Lee, C., McCarthy, D., Phumiwasana, T., Sui, S. Z., & Yago, G. (2004). Capital Access Index 2004: Emerging Growth in Asian Bond Markets. *Milken Institute, April*.

Beck, T., Demirgüç-Kunt, A., & Levine, R. (2000). A new database on the structure and development of the financial sector. *the world bank economic review, 14*(3), 597-605.

Berensmann, K., Dafe, F., Lindenberg, N., & Volz, U. (2015). Financing global development: The role of local currency bond markets in Sub-Saharan Africa. *German Development Institute/Deutsches Institut für Entwicklungspolitik (DIE) Briefing Paper, 11*.

Berrone, P., Fageda, X., Llumà, C., Ricart, J. E., Rodríguez, M., Salvador, J., & Trillas, F. (2018). *Public-Private Partnership in Latin America: A Guide for Regional and Local Governments* (9804220962). Retrieved from [http://scioteca.caf.com/bitstream/handle/123456789/1220/PPP%20Ingles.pdf?sequence=1&isAllowed=y](http://scioteca.caf.com/bitstream/handle/123456789/1220/PPP Ingles.pdf?sequence=1&isAllowed=y):

Bond, J. (2016). Infrastructure in Africa. *Global Journal of Emerging Market Economies, 8*(3), 309-333.

Brealey, R. A., Cooper, I. A., & Habib, M. A. (1996). Using project finance to fund infrastructure investments. *Journal of applied corporate finance, 9*(3), 25-39.

Briceño-Garmendia, C., Smits, K., & Foster, V. (2008). Financing public infrastructure in sub-Saharan Africa: Patterns and emerging issues. *Background Paper, 15*.

Burger, J. D., Warnock, F. E., & Warnock, V. C. (2015). Bond Market Development in Developing Asia. *Asian Development Bank Economics Working Paper Series*(448).

Calderon, C., Cantu, C., & Chuhan-Pole, P. (2018). *Infrastructure development in Sub-Saharan Africa: a scorecard*: The World Bank.

Calderón, C., & Servén, L. (2010). *Infrastructure in Latin America*. Retrieved from <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/206841468263714529/infrastructure-in-latin-america-working-paper>:

Calderón, C., & Servén, L. (2014). *Infrastructure, Growth, and Inequality: An overview*. : The Word Bank.

Caminha, M. (2020). Climate Bonds Initiative and FSD Africa launch Africa Green Bonds Toolkit: a practical guide for African markets. *Climate Bonds Initiative*. Retrieved from <https://www.climatebonds.net/2020/09/climate-bonds-initiative-and-fsd-africa-launch-africa-green-bonds-toolkit-practical-guide> website:

Canning, D., & Pedroni, P. (2008). Infrastructure, long‐run economic growth and causality tests for cointegrated panels. *The Manchester School, 76*(5), 504-527.

Cassimon, D., Essers, D., & Verbeke, K. (2016). *The changing face of Rwanda’s public debt*: Belgian Policy Research Group on Financing for Development: Working Paper N° 14 November 2016.

Chakamera, C., & Alagidede, P. (2018). The nexus between infrastructure (quantity and quality) and economic growth in Sub Saharan Africa. *International Review of Applied Economics, 32*(5), 641-672.

Čihák, M., Demirgüç-Kunt, A., Feyen, E., & Levine, R. (2012). Benchmarking financial systems around the world. *World Bank policy research working paper, (6175).*

Collier, P., & Cust, J. (2015). Investing in Africa’s infrastructure: Financing and policy options. *The Annual Review of Resource Economics, 7*(1), 473-493.

Deep, A., Kim, J., & Lee, M. (2019). Realizing the Potential of Public–Private Partnerships to Advance Asia’s Infrastructure Development. In: Asian Development Bank.

Dominguez-Torres, C., & Foster, V. (2011). *AICD Report on Cameroon’s Infrastructure: A Continental Perspective*. Retrieved from World Bank website:

Domínguez, C., & Foster, V. (2011). The Central African Republic's Infrastructure: A Continental Perspective. *World Bank Policy Research Working Paper 5697*.

ECA. (2019). *Economic Report for Africa: Fiscal Policy For Financing Sustainable Development In Africa*. Retrieved from <http://repository.uneca.org/bitstream/handle/10855/41804/b11928190.pdf?sequence=1>:

Ehlers, T., & Packer, F. (2017). Green bond finance and certification. *BIS Quarterly Review of September*.

Endo, T. (2000). The development of corporate debt markets. *Financial Markets Advisory Department International Finance Corporation, The World Bank Group, www. worldbank. org*.

Engel, E., Fischer, R., & Galetovic, A. (2014). Finance and public-private partnerships. *Financial Flows Infrastructure Financing, 193*.

Essers, D., Blommestein, H. J., Cassimon, D., & Ibarlucea Flores, P. (2015). Local currency bond market development in Sub-Saharan Africa: A stock-taking exercise and analysis of key drivers. *Emerging Markets Finance and Trade*, 1-28.

Estache, A., & Garsous, G. (2012). *The impact of infrastructure on growth in developing countries*. Retrieved from Washington DC:

Estache, A., Speciale, B., & Veredas, D. (2005). How much does infrastructure matter to growth in Sub-Saharan Africa? *Unpublished, World Bank (June 2005)*.

Fabella, R., & Madhur, S. (2003). *Bond market development in East Asia: issues and challenges*: Asian Development Bank.

Faulkner, D., Loewald, C., & Makrelov, K. (2013). Achieving higher growth and employment: Policy options for South Africa. *South African Reserve Bank Working Paper, 13*(03), 1-34.

Fedderke, J., & Bogetić, Ž. (2009). Infrastructure and growth in South Africa: Direct and indirect productivity impacts of 19 infrastructure measures. *World development, 37*(9), 1522-1539.

Fedderke, J., & Garlick, R. (2008). Infrastructure development and economic growth in South Africa: A review of the accumulated evidence. *Policy school of economics, University of Cape-Town and Econ. Res. South Afr*, 12.

Fink, G., Haiss, P., & Hristoforova, S. (2003). Bond Markets and Economic Growth. *IEF Working Paper Nr.49*.

Fink, G., Haiss, P. R., Kirchner, H., & Thorwartl, U. (2005). Financing through bond issues and the nexus with economic growth. *Available at SSRN 1003352*.

Foster, V., & Briceño-Garmendia, C. (2010). Africa’s infrastructure. *A Time for Transformation. A co-publication of the Agence Française de Développement and the World Bank* [*http://webcache*](http://webcache/)*. googleusercontent. com/search*.

Frimpong, J. M., & Marbuah, G. (2010). The determinants of private sector investment in Ghana: An ARDL approach. *European Journal of Social Sciences, 15*(2), 250-261.

Gassner, K., Popov, A., & Pushak, N. (2009). Does Private Sector Participation Improve Performance in Electricity and Water Distribution? Washington, DC: World Bank. In.

Gatti, S. (2013). *Project finance in theory and practice: designing, structuring, and financing private and public projects*. In.

Gengenbach, C., Palm, F. C., & Urbain, J.-P. (2009). Panel unit root tests in the presence of cross-sectional dependencies: Comparison and implications for modelling. *Econometric Reviews, 29*(2), 111-145.

Gerbert, P. (2013). Partnerships help bridge the infrastructure gap. *Boston Consulting Group*.

GIZ. (2017). *Mobilization of Long-term Savings for Infrastructure Financing in Africa*. Retrieved from <https://www.bmz.de/en/zentrales_downloadarchiv/wege_und_akteure/170419_Study_Infrastructure_Finance_Africa_fin.pdf>:

Glenday, G., Bharali, I., & Wang, Z. (2019). *Enhancing Domestic Revenues: Constraints and Opportunities*. Retrieved from Center for Policy Impact in Global Health and the Duke Center for International Development, Duke University. : <http://centerforpolicyimpact.org/wp-content/uploads/sites/18/2019/04/CPIGH-Report_Tax-report_Enhancing-Domestic-Revenues__April-2019_FINAL.pdf>

Gutman, J., Sy, A., & Chattopadhyay, S. (2015). *Financing African infrastructure: Can the world deliver?* Retrieved from Global Economy Development at Brookings <https://www.brookings.edu/wp-content/uploads/2016/07/AGIFinancingAfricanInfrastructure_FinalWebv2.pdf>:

Hagerman, E. (2012). Challenges to Regional Infrastructure Development. *A Paper prepared for the Development Bank of Southern Africa. Available at:* [*http://www*](http://www/)*. tips. org. za/files/report\_on\_regional\_infrastructure\_development\_in\_africa\_tips\_-\_ellen\_hagerman. pdf (Accessed 1st April 2014)*.

Han, J.-S., & Lee, J.-W. (2020). Demographic change, human capital, and economic growth in Korea. *Japan and the World Economy, 53*, 100984.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of econometrics, 93*(2), 345-368.

Humphrey, C. (2018). Channelling private investment to infrastructure. *Overseas Development Institute, Working Paper 534*(April 2018).

Hyun, S., Park, D., & Tian, G. (2018). Determinants of Public–Private Partnerships in Infrastructure in Asia: Implications for Capital Market Development. *Asian Development Bank Economics Working Paper Series*(552).

Hyun, S., Park, D., & Tian, S. (2017). Infrastructure Bond Markets Development in Asia: Challenges and Solutions. *Global Economic Review, 46*(4), 351-371.

Hyun, S., Park, D., & Tian, S. (2019). *Mobilizing Finance For Public-Private Partnerships: Determinants of Public-Private Partnerships in Infrastructure in Emerging Economies*. Retrieved from <https://www.think-asia.org/bitstream/handle/11540/9448/potential-ppp-asia-infrastructure.pdf?sequence=1>:

ICA. (2015). *Infrastructure Financing Trend in Africa-2015*. Retrieved from Abidjan, Cote Ivoire: [www.icafrica.org](../../../../../../C:/Users/a0027395/Documents/PhD%20files%20from%20Desktop/_PhD%202016,%202017&%202018%20study%20docs/_Research%20Paper%201_Threshold/_Final%20_June%202021/www.icafrica.org)

ICA. (2016). *Infrastructure Financing Trend in Africa-2016*. Retrieved from Abidjan, Cote Ivoire: [www.icafrica.org](../../../../../../C:/Users/a0027395/Documents/PhD%20files%20from%20Desktop/_PhD%202016,%202017&%202018%20study%20docs/_Research%20Paper%201_Threshold/_Final%20_June%202021/www.icafrica.org)

ICA. (2017). *Infrastructure Financing Trends in Africa-2017*. Retrieved from Abidjan, Côte d'Ivoire: [www.icafrica.org](../../../../../../C:/Users/a0027395/Documents/PhD%20files%20from%20Desktop/_PhD%202016,%202017&%202018%20study%20docs/_Research%20Paper%201_Threshold/_Final%20_June%202021/www.icafrica.org)

ICA. (2018). *Infrastructure Financing Trends in Africa-2018*. Retrieved from Abidjan, Côte d'Ivoire: [www.icafrica.org](../../../../../../C:/Users/a0027395/Documents/PhD%20files%20from%20Desktop/_PhD%202016,%202017&%202018%20study%20docs/_Research%20Paper%201_Threshold/_Final%20_June%202021/www.icafrica.org)

Islam, M. (2014). *Growth and Development of Bond Market in Bangladesh-An Evaluative Study*.

Johnson, O., Muhoza, C., Osano, P., Senyagwa, J., & Kartha, S. (2017). Catalysing investment in sustainable energy infrastructure in Africa: Overcoming financial and non-financial constraints.

Juvonen, K., Kumar, A., Ayed, H. B., & Marin, A. O. (2019). Unleashing the potential of institutional investors in Africa. *African Development Bank Group Working, Paper Series No. 325*.

Kapingura, F., & Makhetha-Kosi, P. (2014). The Causal Relationship between the Bond Market Development and Economic Growth in Africa: Case Study of South Africa. *Mediterranean Journal of Social Sciences, 5*(3), 126.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: methodology and analytical issues. *Hague Journal on the Rule of Law, 3*(2), 220-246.

Kodongo, O. (2013). Infrastructure financing in sub-Saharan Africa: options and issues. *AfricaGrowth Agenda*, 12-15.

Kodongo, O., & Ojah, K. (2016). Does infrastructure really explain economic growth in Sub-Saharan Africa? *Review of Development Finance (2016)*, 21.

Kumo, W. L. (2012). Infrastructure Investment and Economic Growth in South Africa: A Granger Causality Analysis. *African Development Bank Group Working Paper Series*(160).

Lee, S. H., Levendis, J., & Gutierrez, L. (2012). Telecommunications and economic growth: An empirical analysis of sub-Saharan Africa. *Applied Economics, 44*(4), 461-469.

Li, S., Abraham, D., & Cai, H. (2017). Infrastructure financing with project bond and credit default swap under public-private partnerships. *International Journal of Project Management, 35*(3), 406-419.

Liberini, F. (2006). Economic growth and infrastructure gap in Latin America. *Rivista di Politica Economica, 96*(11/12), 145.

Luüs, C. (2014). The role of capital markets in supplying long-term finance for economic development. Retrieved from <http://financialmarketsjournal.co.za/role-of-capital-markets/>

MacDonald, M. (2002). *Review of large public procurement in the UK*. <https://www.parliament.vic.gov.au/images/stories/committees/paec/2010-11_Budget_Estimates/Extra_bits/Mott_McDonald_Flyvberg_Blake_Dawson_Waldron_studies.pdf>: HM Treasury, London.

Machokoto, M., Areneke, G., & Ibrahim, B. M. (2020). Rising corporate debt and value relevance of supply-side factors in South Africa. *Journal of Business Research, 109*, 26-37.

Marin, P. (2009). *Public-private partnerships for urban water utilities: a review of experiences in developing countries*: The World Bank.

Martı́nez-Zarzoso, I., & Bengochea-Morancho, A. (2004). Pooled mean group estimation of an environmental Kuznets curve for CO2. *Economics Letters, 82*(1), 121-126.

Mathews, J. A., & Kidney, S. (2012). Financing climate-friendly energy development through bonds. *Development Southern Africa, 29*(2), 337-349.

Mbulawa, S. (2017). The impact of economic infrastructure on long term economic growth in Botswana.

Meyer, D. F., & Sanusi, K. A. (2019). A Causality Analysis of the Relationships Between Gross Fixed Capital Formation, Economic Growth and Employment in South Africa. *Studia Universitatis Babes-Bolyai Oeconomica, 64*(1), 33-44.

Mezui, C. A. M. (2013). Unlocking Infrastructure Development in Africa through Infrastructure Bonds. *GREAT Insights, 2*(4). Retrieved from <https://ecdpm.org/great-insights/financing-infrastructure/unlocking-infrastructure-development-africa-infrastructure-bonds-2/> website: <https://ecdpm.org/>

Mezui, C. A. M., & Hundal, B. (2013). Structured finance: Conditions for infrastructure project bonds in African markets. *Tunis: African Development Bank*.

Misati, R. N., & Nyamongo, E. M. (2011). Financial development and private investment in Sub-Saharan Africa. *Journal of Economics and Business, 63*(2), 139-151.

Mu, Y., Phelps, P., & Stotsky, J. G. (2013). Bond markets in Africa. *Review of Development Finance, 3*(3), 121-135.

Muharam, H., Ghozali, I., & Arfinto, E. D. (2018). Bond Market Development, Economic Growth, and the Role of Foreign Investment. *KnE Social Sciences, 3*(10).

Mustafa, A. (2015). Public–Private Partnerships in Sub-Saharan Africa: Challenges and Opportunities. *The Journal of Structured Finance, 21*(2), 55-59.

Ndikumana, L., & Verick, S. (2008). The linkages between FDI and domestic investment: Unravelling the developmental impact of foreign investment in Sub‐Saharan Africa. *Development Policy Review, 26*(6), 713-726.

Noumba Um, P., Gasmi, F., & Ba, L. (2010). *Is the level of financial sector development a key determinant of private investment in the power sector?* : The World Bank.

Olaniyan, R. O. (2002). *Official development assistance and sustainable development in Africa: Towards a new strategy*. Retrieved from Department of Economic and Social Affairs, Division of Sustainable Development, United Nations.: [http://ces.iisc.ac.in/hpg/envis/sdev/nairobi\_meeting.pdf#page=93](http://ces.iisc.ac.in/hpg/envis/sdev/nairobi_meeting.pdf" \l "page=93)

Oxford Economics, & Global Infrastructure Hub. (2017). *Global Infrastructure Outlook: Infrastructure investment needs for 50 countries, 7 sectors to 2040*. Retrieved from Oxford, England:

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American statistical Association, 94*(446), 621-634.

Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of econometrics, 68*(1), 79-113.

Pradhan, R., Zaki, D., Maradana, R., Dash, S., Jayakumar, M., & Chatterjee, D. (2015). Bond market development and economic growth: The G-20 experience. *Tékhne, 13*(1), 51-65.

Pradhan, R. P., Arvin, M., Nair, M., Bennett, S., & Bahmani, S. (2017). ICT-finance-growth nexus: Empirical evidence from the Next-11 countries. *Cuadernos de Economía, 40*(113), 115-134.

Pradhan, R. P., Arvin, M. B., Bennett, S. E., Nair, M., & Hall, J. H. (2016a). Bond Market Development, Economic Growth and Other Macroeconomic Determinants: Panel VAR Evidence. *Asia-Pacific Financial Markets, 23*(2), 175-201.

Pradhan, R. P., Arvin, M. B., & Hall, J. H. (2016b). Economic growth, development of telecommunications infrastructure, and financial development in Asia, 1991–2012. *The Quarterly Review of Economics and Finance, 59*, 25-38.

Ranganathan, R., & Foster, V. (2011a). East Africa’s Infrastructure: A Continental Perspective. *World Bank Policy Research Working Paper, 5844*.

Ranganathan, R., & Foster, V. (2011b). ECOWAS's infrastructure: a regional perspective. *World Bank Policy Research Working Paper, 5899*.

Ranganathan, R., & Foster, V. (2011c). The SADC's infrastructure: A regional perspective. *World Bank Policy Research Working Paper, 5898*.

Raubenheimer, H. (2019). *African Capital Markets: Challenges and Opportunities*. Retrieved from <https://www.cfainstitute.org/-/media/documents/article/rf-brief/rf-african-capital-markets.ashx>:

Regan, M. (2017). Capital markets, infrastructure investment and growth in the Asia Pacific region. *International Journal of Financial Studies, 5*(1), 5.

Rinaldi, S. M., Peerenboom, J. P., & Kelly, T. K. (2001). Identifying, understanding, and analyzing critical infrastructure interdependencies. *Control Systems, IEEE, 21*(6), 11-25.

Sahoo, P., Dash, R. K., & Nataraj, G. (2010). Infrastructure development and economic growth in China.

Schwartz, J. Z., Ruiz-Nuñez, F., & Chelsky, J. (2014). Closing the infrastructure finance gap: Addressing risk. *Financial Flows Infrastructure Financing, 141*.

Thumrongvit, P., Kim, Y., & Pyun, C. S. (2013). Linking the missing market: The effect of bond markets on economic growth. *International Review of Economics & Finance, 27*, 529-541.

Tobin, J. (1965). Money and economic growth. *Econometrica: Journal of the Econometric Society*, 671-684.

Tsaurai, K., & Ndou, A. (2019). Infrastructure, human capital development and economic growth in transitional countries. *Comparative Economic Research, 22*(1), 33-52.

Turner, P. (2002). Bond markets in emerging economies: an overview of policy issues. *BIS papers, 11*, 1-12.

Tyson, J. E. (2018). Private infrastructure financing in developing countries.

World Bank. (2014). *2014 Global PPI Update*. Retrieved from <https://ppi.worldbank.org/~/media/GIAWB/PPI/Documents/Global-Notes/Global2014-PPI-Update.pdf>:

World Bank. (2018). *Private Participation in Infrastructure (PPI) Annual Report*. Retrieved from <https://ppi.worldbank.org/~/media/GIAWB/PPI/Documents/Global-Notes/PPI_2018_AnnualReport>:

World Bank, & PPIAF. (2014). *Public-Private Partnerships Reference Guide Version 2.0*. Retrieved from <http://documents.worldbank.org/curated/en/600511468336720455/pdf/903840PPP0Refe0Box385311B000PUBLIC0.pdf>:

Xaba, P., & Yusuff, A. (2018). *Powering Gautrain Stations and Depot Buildings Based on Renewable Energy Resource.* Paper presented at the 2018 IEEE PES/IAS PowerAfrica.

Zhang, Y.-F., & Ji, S. (2018). Does infrastructure have a transitory or longer-term impact? Evidence from China. *Economic Modelling, 73*, 195-207.

**Table *1*: Data description, notation, and source**

| Variables | Notation | Data source |
| --- | --- | --- |
| Dependent variables | | |
| Overall infrastructure index |  | African Development Bank’s Africa Infrastructure Development Index (AIDI) Database |
| Aggregate/overall infrastructure gap index |  | Authors’ calculations using data from African Development Bank’s Africa Infrastructure Development Index (AIDI) Database |
| Infrastructure gap for the transport sector |  |
| Infrastructure index gap for the electricity sector |  |
| Infrastructure index gap for the information and communications technology (ICT) sector |  |
| Infrastructure index gap for water and sanitation sector |  |
| Independent variables | | |
| Government public debt market capitalisation–GDP ratio |  | African Development Bank |
| Corporate public debt market capitalisation-GDP ratio |  | World Bank, Financial Development Indicators (FDI), and Authors’ calculations using data from DataStream, World Federation of Exchanges (WFE), African Security Exchanges Association (ASEA). |
| Public-Private Partnerships (PPP) investment in Aggregate/overall infrastructure |  | Authors’ calculations using data from World Bank’s Private Participation in Infrastructure (PPI) Database |
| PPP investment in transport sector-GDP ratio |  | World Bank’s PPI Database |
| PPP investment in the electricity sector- GDP ratio |  | World Bank’s PPI Database |
| PPP investment in ICT sector-GDP ratio |  | World Bank’s PPI Database |
| PPP investment in water and sanitation (WSS) sector- GDP ratio |  | World Bank, World Development Indicator (WDI) Database |
| Annual growth rate of GDP per capita |  | World Bank, World Development Indicator (WDI) Database |
| Control variables | | |
| Stock market capitalisation–GDP ratio |  | World Bank, Financial Development Indicators (FDI), and Authors’ calculations using data from DataStream, World Federation of Exchanges (WFE), African Security Exchanges Association (ASEA). |
| Human development index |  | World Bank, WDI Database |
| Exchange rate |  | The Global Economy.com |
| Real interest rate (per cent) |  | International Monetary Fund, International Financial Statistics and data files using World Bank data on the GDP deflator. |
| Change in Gross capital formation-GDP ratio |  | World Bank, WDI Database |
| Foreign direct investment-GDP ratio |  | World Bank, WDI Database |
| Governance indicators |  | World Bank, Worldwide Governance Indicators (WGI) produced by Daniel Kaufmann (Natural Resource Governance Institute and Brookings Institution) and Aart Kraay (World Bank Development Research Group) |

**Fig 1:** **Infrastructure deficit/gap and domestic government debt market in SSA**



Data source: African Development Bank Group

**Fig 2** **Infrastructure gap and corporate debt market as a share of GDP in SSA**Data source: African Development Bank Group

**Table 2: Summary statistics**

| Variable | | | Mean | | Standard deviation | | Minimum | | Maximum | | Observations | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Income groups | | | 1.625 | | 0.828 | | 1 | | 4 | | N = 640 | |
|  | | | 17.863 | | 15.944 | | 0.369 | | 94.324 | | N = 640 | |
|  | | | 82.137 | | 15.944 | | 5.676 | | 99.631 | | N = 640 | |
|  |  | 5.658 | | 14.373 | | 0.001 | | 88.430 | | N = 640 | |  |
|  |  | 92.887 | | 15.043 | | 17.624 | | 100 | | N = 640 | |  |
|  | | | 1.921 | | 3.185 | | 0.015 | | 19.155 | | N = 640 | |
|  | | | 47.304 | | 20.104 | | 0.212 | | 99.109 | | N = 640 | |
|  | | | 0.983 | | 2.457 | | 0.00009 | | 14.906 | | N = 640 | |
|  | | | 90.594 | | 10.251 | | 46.691 | | 99.446 | | N = 640 | |
|  | | | 2.856 | | 7.274 | | 0.0002 | | 70.985 | | N = 640 | |
|  | | | 95.263 | | 8.773 | | 36.556 | | 100 | | N = 640 | |
|  | | | 2.004 | | 4.584 | | -36.557 | | 32.169 | | N = 640 | |
|  | | | 35.634 | | 17.442 | | 4.1 | | 98.487 | | N = 640 | |
|  | | | 15.055 | | 10.642 | | 0.738 | | 62.599 | | N = 640 | |
|  | | | 10.280 | | 36.044 | | 0.724 | | 328.361 | | N = 640 | |
|  | | | 0.484 | | 0.107 | | 0.263 | | 0.797 | | N = 640 | |
|  | | | 652.283 | | 1260.562 | | 0.867 | | 9088.32 | | N = 640 | |
|  | | | 6.157 | | 9.083 | | -34.210 | | 52.437 | | N = 640 | |
|  | | | 0.204 | | 4.091 | | -40.015 | | 31.981 | | N = 640 | |
|  | | | 4.983 | | 9.321 | | -6.369 | | 103.337 | | N = 640 | |
|  | | | -1.45e-10 | | 0.984 | | -1.778 | | 2.688 | | N = 640 | |
|  | | | 9.75e-11 | | 0.909 | | -0.470 | | 4.486 | | N = 640 | |

**Table 3: Unit root test**

| Variable |  | Im, Pesaran’s and Shin W | ADF - Fisher Chi-square | PP - Fisher Chi-square |
| --- | --- | --- | --- | --- |
|  | Statistic | -4.37(0.000) | 142.17(0.000) | 221.71(0.0000) |
|  | Statistic | -8.18 (0.000) | 226.89(0.000) | 478.53(0.000) |
|  | Statistic | -12.03(0.000) | 231.45(0.000) | 425.39(0.000) |
|  | Statistic | -0.83(0.000) | 94.92(0.000) | 245.46(0.000) |
|  | Statistic | 3.75(0.000) | 38.20(0.000) | 90.16(0.000) |
|  | Statistic | -10.39(0.000) | 257.59(0.000) | 755.24(0.000) |
|  | Statistic | -13.22(0.000) | 322.95(0.000) | 552.24(0.000) |
|  | Statistic | -16.75(0.000) | 404.83(0.000) | 755.24(0.000) |
|  | Statistic | -12.34(0.000) | 302.45(0.000) | 526.04(0.000) |
|  | Statistic | -6.32(0.000) | 168.71(0.000) | 331.41(0.000) |
|  | Statistic | -5.37(0.000) | 147.80(0.000) | 346.57(0.000) |
|  | Statistic | -13.05(0.000) | 318.91(0.000) | 507.90(0.000) |
|  | Statistic | -9.91(0.000) | 246.61(0.000) | 952.05(0.000) |
|  | Statistic | -18.25(0.000) | 438.97(0.000) | 755.25(0.000) |
|  | Statistic | -22.77(0.000) | 538.31(0.000) | 1111.88(0.000) |
|  | Statistic | -4.247(0.000) | 107.2315(0.000) | 195.749(0.000) |
|  | Statistic | -3.646(0.000) | 55.34(0.000) | 82.146(0.000) |
|  | Statistic | -6.87(0.000) | 179.05(0.000) | 353.77(0.000) |
|  | Statistic | -6.32(0.000) | 168.71(0.000) | 331.41(0.000) |

Notes:

1. The unit root tests are based on variables in the first difference.
2. Numbers in parentheses are p-values

**Table 4: Pooled mean group regression output (Government debt markets)**

| 1 |  | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| --- | --- | --- | --- | --- | --- | --- |
| 2 | Variable | Overall Infrastructure Gap | Transport Gap | Electricity Gap | ICT Gap | WSS Gap |
| 3 | Constant | 8.425  (2.404) | 9.363  (2.295) | 5.270  (2.450) | 1.894  (2.535) | 1.279  (3.494) |
| 4 |  | -0.018  (-2.283) | -0.016  (-2.944) | -0.054  (-3.039) | -0.042  (-1.560) | -0.041  (-3.351) |
| 5 |  | 1.915  (1.751) |  |  |  |  |
| 6 |  |  | -0.212  (-1.799) |  |  |  |
| 7 |  |  |  | -0.099  (-2.138) |  |  |
| 8 |  |  |  |  | 0.181  (3.950) |  |
| 9 |  |  |  |  |  | 0.118  (0.469) |
| 10 |  | -0.115  (-0.168) | 0.327  (1.045) | -0.971  (-1.737) | -0.353  (-0.359) | 1.289  (2.198) |
| 11 |  | -0.002  (-0.051) | -0.040  (-2.569) | 0.044  (1.592) | -0.005  (-0.104) | 0.006  (0.212) |
| 12 |  | 0.001  (3.755) | 0.0003  (2.254) | 0.001  (2.917) | 0.002  (4.575) | -0.002  (-5.309) |
| 13 |  | -0.004  (-0.978) | -0.008  (-0.890) | 0.008  (0.466) | 0.001  (0.051) | -0.017  (-0.998) |
| 14 |  | -0,074  (-2.061) | -0,012  (-2.840) | -0,017  (-1.933) | -0,0135  (-3.281) | -0,031  (-1.861) |
| 15 |  | -0.014  (-1.202) | 0.026  (4.868) | -0.013  (-1.381) | 0.003  (0.184) | -0.002  (-0.208) |
| 16 |  | -0.020  (-0.831) | -0.005  (-0.437) | -0.036  (-1.883) | 0.007  (0.204) | -0.015  (-0.736) |
| 17 | R squared | 0.536 | 0.554 | 0.473 | 0.488 | 0.491 |
| 18 | Durbin-Watson stat | 1.984 | 2.055 | 1.972 | 1.414 | 1.094 |
| 19 | Akaike info criterion | 5.47 | 3.91 | 5.053 | 6.21 | 5.18 |
| 20 | Schwarz criterion | 5.92 | 4.37 | 5.506 | 6.66 | 5.63 |
| 21 | Hannan-Quinn criterion. | 5.64 | 4.09 | 5.229 | 6.39 | 5.36 |

This table reports coefficient estimates (t-statistics in parentheses) for the linear regression. The dependent variables are the infrastructure gaps of overall/aggregate infrastructure, transport, electricity, information, and communications technology (ICT) and water and sanitation infrastructure types.

**Table 5: Pooled mean group regression output (Corporate debt markets)**

| 1 |  | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| --- | --- | --- | --- | --- | --- | --- |
| 2 | Variable | Overall Infrastructure Gap | Transport Gap | Electricity Gap | ICT Gap | WSS Gap |
| 3 | Constant | 8.795  (2.821) | 91.530  (2.654) | 5.288  (2.863) | 1.395  (2.872) | 0.245  (3.281) |
| 4 |  | -0.088  (-3.121) | -0.036  (-2.041) | -0.042  (-3.529) | -0.110  (-2.790) | -0.046  (-1.901) |
| 5 |  | 2.233  (2.076) |  |  |  |  |
| 6 |  |  | -0.210  (-1.793) |  |  |  |
| 7 |  |  |  | -0.126  (-2.690) |  |  |
| 8 |  |  |  |  | 0.182  (4.001) |  |
| 9 |  |  |  |  |  | 0.137  (0.539) |
| 10 |  | -0.368  (-0.539) | 0.386  (1.233) | -0.906  (-1.623) | -0.581  (-0.590) | 1.282  (2.159) |
| 11 |  | -0.0004  (-0.013) | -0.040  (-2.552) | 0.046  (1.643) | -0.007  (-0.151) | 0.009  (0.334) |
| 12 |  | 0.001  (3.797) | 0.0004  (2.352) | 0.0009  (3.242) | 0.002  (4.475) | -0.001  (-5.014) |
| 13 |  | -0.007  (-0.358) | -0.007  (-0.736) | 0.014  (0.861) | -0.005  (-0.179) | -0.012  (-0.707) |
| 14 |  | -0.002  (-3.705) | -0.040  (-2.214) | -0.244  (-2.117) | -0.105  (-1.875) | -0.206  (-2.309) |
| 15 |  | -0.012  (-1.018) | 0.026  (4.721) | -0.016  (-1.685) | 0.007  (0.399) | -0.004  (-0.403) |
| 16 |  | -0.019  (-0.828) | -0.005  (-0.473) | -0.039  (-2.018) | 0.009  (0.261) | -0.017  (-0.835) |
| 17 | R squared | 0.534 | 0.540 | 0.679 | 0.486 | 0.429 |
| 18 | D-W statistic | 2.14 | 2.55 | 1.853 | 1591 | 1.089 |
| 19 | Akaike | 5.45 | 3.91 | 5.05 | 6.20 | 5.19 |
| 20 | Schwarz | 5.90 | 4.36 | 5.50 | 6.65 | 5.65 |
| 21 | Hannan-Quinn | 5.63 | 4.08 | 5.22 | 6.38 | 5.37 |

Notes:

1. The dependent variables are the infrastructure gaps of overall/aggregate infrastructure, transport, electricity, information, and communications technology (ICT) and water and sanitation infrastructure types.
2. Numbers in parentheses are t-statistics.

**Table 6: Threshold regression results- full sample**

| 1 |  | Infrastructure Gap (Index) | | Transport Gap | | Electricity Gap | | ICT Gap | | WSS Gap | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | Debt market | Government | Corporate | Government | Corporate | Government | Corporate | Government | Corporate | Government | Corporate |
| 3 | Est. threshold value (% of GDP) | 80.71 | 75.99, 91.61 | 97.97 | 93.44 | 90.58, 96.19 | 90.44 | 97.23 | 91.28, 97.96, 99.98 | 30.65, 53.18, 65.45 | 25.21, 45.38, 63.59 |
| 4 | Beta for regime #1 | -0.436  (-1.158) | -1.207  (-1.014) | -0.529  (-0.706) | -1.538  (-0.547) | 0.224  (0.953) | -1.038  (-2.554) | -1.895  (-5.458) | -1.119  (-3.333) | 0.085  (0.404) | -0.512  (-2.177) |
| 5 | Beta for regime #2 | -0.560  (-4.845) | -1.379  (-1.042) | -1.058  (-3.330) | -2.112  (-5.552) | -0.744  (-2.235) | -1.958  (-6.867) | -0.577  (-4.715) | -1.700  (-4.032) | -0.408  (-3.362) | -0.849  (-3.464) |
| 6 | Beta for regime #3 |  | -3.161  (-7.317) |  |  | -0.750  (-5.669) |  |  | -2.486  (-2.308) | -0.335  (-2.441) | -1.206  (-4.369) |
| 7 | Beta for regime #4 |  |  |  |  |  |  |  | -1.632  (-1.777) | -0.302  (-2.398) | -1.079  (-3.117) |
| 8 |  | 0.489  (0.382) | -0.005  (-0.004) |  |  |  |  |  |  |  |  |
| 9 |  |  |  | 1.296  (2.891) | 1.675  (3.370) |  |  |  |  |  |  |
| 10 |  |  |  |  |  | 0.387  (4.577) | 0.118  (1.178) |  |  |  |  |
| 11 |  |  |  |  |  |  |  | 0.589  (3.779) | 0.975  (5.536) |  |  |
| 12 |  |  |  |  |  |  |  |  |  | 0.365  (1.453) | 1.097  (4.247) |
| 13 |  | -7.047  (-5.253) | -12.361  (-8.978) | -8.249  (-6.473) | -16.177  (-11.41) | -5.829  (-4.435) | -16.56  (-11.359) | -7.060  (-5.693) | -18.638  (-12.53) | -6.125  (-7.299) | 0.436  (5.045) |
| 14 |  | 0.989  (4.102) | 0.667  (6.817) | 0.873  (3.611) | 0.899  (3.338) | 1.057  (4.315) | 1.052  (3.711) | 0.881  (3.571) | 1.212  (4.283) | 0.769  (4.862) | 0.697  (4.083) |
| 15 |  | 0.002  (2.223) | 0.006  (4.435) | 0.004  (3.930) | 0.007  (6.926) | 0.001  (1.564) | 0.006  (6.286) | 0.002  (2.609) | 0.007  (7.247) | 0.002  (2.814) | 0.176  (1.977) |
| 16 |  | 0.357  (2.972) | 0.845  (6.786) | 0.387  (3.195) | 0.698  (5.155) | 0.387  (3.078) | 0.843  (5.891) | 0.429  (3.498) | 0.849  (5.946) | 0.210  (2.608) | -0.041  (-1.36) |
| 17 |  | 1.004  (-2.96) | 3.77  (-2.04) | 0.77  (-1.93) | 3.66  (-2.82) | 1.51  (-2.33) | 3.86  (-2.75) | 1.86  (-3,07) | 4.76  (-2,39) | 0.67  (-1.76) | -1.56  (-2.21) |
| 18 |  | -0.119  (-3.636) | -0.209  (-5.296) | -0.002  (-0.077) | -0.109  (-2.749) | -0.169  (-4.983) | -0.243  (-5.081) | -0.046  (-1.378) | -0.214  (-4.835) | -0.022  (-0.997) | -0.041  (-1.36) |
| 19 |  | 0.796  (6.565) | 0.817  (6.627) | 0.902  (7.386) | 0.938  (6.974) | 0.954  (7.695) | 1.135  (8.148) | 0.842  (6.672) | 0.928  (6.538) | 0.486  (5.975) | -10.556  (-12.21) |
| 20 | Number of countries | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| 21 | R-squared | 0.621 | 0.531 | 0.470 | 0.443 | 0.425 | 0.361 | 0.376 | 0.582 | 0.307 | 0.651 |
| 22 | Durbin-Watson statistic | 2.239 | 2.370 | 0.237 | 1.983 | 0.335 | 2.365 | 2.283 | 1.851 | 1.592 | 2.069 |
| 23 | Akaike info criterion | 9.48 | 9.718 | 9.49 | 9.856 | 9.53 | 9.79 | 9.52 | 9.79 | 8.64 | 8.789 |
| 24 | Schwarz criterion | 9.67 | 10.043 | 9.69 | 10.181 | 9.80 | 9.98 | 9.72 | 10.13 | 8.98 | 9.114 |
| 25 | Hannan-Quinn criterion. | 9.55 | 9.844 | 9.57 | 9.983 | 9.64 | 9.86 | 9.60 | 9.92 | 8.77 | 8.915 |

In the table, we report the coefficient estimates from the threshold regression (t-statistics in parentheses)

**Table7: Threshold regression model summaries**

| Dependent variable | Debt market | Full sample | Without SA | Low income | Lower and Upper middle-income |
| --- | --- | --- | --- | --- | --- |
| Overall Infrastructure gap | Government  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***80.71***  -0.436 (-1.158)  -0.560 (-4.845) | ***73.61***  0.298 (0.984)  -0.69 (-5.381) | - | ***63.39***  -0.206 (-0.866)  -0.465 (-3.299) |
| Corporate  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***75.99, 91.61***  -1.207 (-1.0140)  -1.379 (-1.042)  -3.161 (-7.317) | ***75.99, 89.79***  -1.011 (-2.604)  -1.614 (-4.658)  -1.592 (-3.714)  -2.349 (2.422)) | **82.93, 92.39**  -1.127 (-1.675)  -1.787(-4.185)  -3.221(-5.504) | ***63.39, 79.55, 86.29***  0.190 (0.649)  -0.637 (-1.784)  0.499 (0.675)  -3.299 (-2.597) |
| Transport gap | Government  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***97.97***  -0.529 (-0.706)  -1.058 (-3.330) | ***82.71, 98.01***  0.258 (0.973)  -0.564(-4.494)  -1.185 (-3.905) | ***97.21, 98.09***  -0.737 (-4.338)  -0.71 6(-3.011)  -0.844 (-2.583) | ***73.59, 91.47, 97.36***  0.077 (0.320)  -0.489 (-2.068)  -0.853 (-3.442)  0.396 (1.441) |
| Corporate  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***93.44***  -1.538 (-0.547)  -2.112 (-5.552) | ***82.71, 93.48, 98.01***  -1.087 (-2.739)  -1.532 (-3.933)  -1.062 (-2.412)  -3.681(-3.950)) | ***94.45, 98.27***  0.046 (0.328)  -0.037 (-0.511)  -1.846 (-1.895) | ***90.76***  -0.779 (2.950)  -1.513 (-3.529) |
| Electricity gap | Government  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***90.58, 96.19***  0.224 (0.953)  -0.744 (-2.235)  -0.750 (-5.669) | ***90.69***  0.191(0.777)  -0.698 (-5.673) | ***97.09, 98.81***  -0.201 (-3.581)  -0.004 (-0.108)  0.023 (0.916) | ***65.64, 93.12, 95.54***  -0.313 (-0.638)  0.189 (0.813)  -0.619 (1.920)  -0.744 (-3.320) |
| Corporate  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***90.44***  -1.038 (-2.554)  -1.958 (-6.867) | ***93.13, 98.70***  -0.585 (-1.538)  -1.616 (-4.280)  -1.812 (-2.573) | ***96.85, 99.59***  0.043 (0.852)  0.031 (0.317)  -0.395 (-2.300) | ***90.76***  -0.779 (-2.950)  -1.513(3.529) |
| ICT gap | Government  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***97.23***  -1.895 (-5.458)  -0.577 (-4.715) | ***98.77***  -1.656 (-5.285)  -0.502 (-3.899) | ***94.82, 98.06***  -0.366 (-1.706)  0.019 (0.273)  0.004 (0.068) | ***83.68, 93.09, 99.99***  -1.879 (-1.556)  -1.781(-3.239)  -1.009 (-3.429)  -0.589 (-2.620) |
| Corporate  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | **91.28, 97.96, 99.98**  -1.119 (-3.333)  -1.700 (-4.032)  -2.486 (-2.308)  -1.632 (-1.777) | ***91.25, 99.98***  -1.129 (-3.069)  -1.905 (-4.755)  -2.202 (-3.067) | ***91.52, 96.99***  -0.283 (-4.222)  -0.238 (-1.829)  0.105 (0.482) | ***83.68, 99.92***  -1.372 (-2.562)  0.305 (0.622)  -1.563 (-4.242) |
| WSS gap | Government  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***30.65, 53.18, 65.45***  0.085(0.404)  -0.408 (-3.362)  -0.335 (-2.441)  -0.302 (-2.398) | ***30.65, 53.18***  0.032 (0.138)  -0.403 (-3.228)  -0.312 (-3.269) | ***39.97, 52.24***  -0.673 (-0.914)  -0.003 (-0.022)  -0.330 (-2.573) | ***22.40, 39.19***  -0.074(-0.465)  -0.431(-2.324)  -0.322 (-3.715) |
| Corporate  Beta for regime #1  Beta for regime #2  Beta for regime #3  Beta for regime #4 | ***25.21, 45.38, 63.59***  -0.512 (-2.177)  -0.849 (-3.464)  -1.206 (-4.369)  -1.079 (-3.117) | ***31.47, 51.44, 65.74***  0.398 (1.313)  -0.924 (-3.774)  -0.415 (-1.369)  -1.318 (-3.531) | ***42.70, 51.32, 69.06***  -1.753 (-3.312)  -0.204 (-1.533)  -0.831(-3.062)  1.007 (0.828) | ***12.07, 32.18, 43.84***  -0.377(-1.164)  -0.447(-1.798)  -0.351(-1.624)  -1.614 (-8.194) |
| Number of countries |  | 40 | 39 | 23 | 17 |

This table reports the threshold regression model outputs (t-statistics in parentheses) for various SSA country groupings. The numbers in bold and italics are the threshold values of debt markets as a per cent of GDP.

**APPENDICES**

**Table A-1: List of countries sampled**

|  | **Country** | **Income group** |
| --- | --- | --- |
| 1 | Burkina Faso | Low Income |
| 2 | Burundi | Low Income |
| 3 | Central African Republic | Low Income |
| 4 | Chad | Low Income |
| 5 | Comoros | Low Income |
| 6 | Congo, Dem, Rep, | Low Income |
| 7 | Eritrea | Low Income |
| 8 | Ethiopia | Low Income |
| 9 | Gambia | Low Income |
| 10 | Ghana | Low Income |
| 11 | Guinea | Low Income |
| 12 | Kenya | Low Income |
| 13 | Liberia | Low Income |
| 14 | Madagascar | Low Income |
| 15 | Malawi | Low Income |
| 16 | Mali | Low Income |
| 17 | Mozambique | Low Income |
| 18 | Niger | Low Income |
| 19 | Sierra Leone | Low Income |
| 20 | Tanzania | Low Income |
| 21 | Togo | Low Income |
| 22 | Uganda | Low Income |
| 23 | Zambia | Low Income |
| 24 | Angola | Lower middle income |
| 25 | Cameroon | Lower middle income |
| 26 | Cape Verde | Lower middle income |
| 27 | Congo, Rep, | Lower-middle-income |
| 28 | Cote d'Ivoire | Lower-middle-income |
| 29 | Nigeria | Lower middle income |
| 30 | Sao Tome and Principe | Lower middle income |
| 31 | Senegal | Lower middle income |
| 32 | Sudan | Lower middle income |
| 33 | Swaziland | Lower middle income |
| 34 | Benin | Upper-middle-income |
| 35 | Botswana | Upper middle income |
| 36 | Mauritius | Upper middle income |
| 37 | Namibia | Upper middle income |
| 38 | Seychelles | Upper middle income |
| 39 | South Africa | Upper middle income |
| 40 | Equatorial Guinea | High income |

**Table A-2: Correlation matrix**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variable |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| code | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) | (21) |
| (2) | -1.00 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (3) | -0.04 | 0.04 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (4) | -0.85 | 0.85 | 0.08 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (5) | 0.21 | -0.21 | 0.19 | -0.01 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (6) | -0.82 | 0.82 | 0.06 | 0.55 | -0.27 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (7) | 0.01 | -0.01 | 0.65 | 0.10 | 0.61 | -0.01 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (8) | -0.83 | 0.83 | -0.03 | 0.59 | -0.32 | 0.72 | -0.12 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| (9) | 0.20 | -0.20 | 0.25 | -0.03 | 0.53 | -0.21 | 0.51 | -0.30 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |  |
| (10) | -0.73 | 0.73 | 0.03 | 0.57 | -0.01 | 0.52 | 0.04 | 0.42 | -0.07 | 1.00 |  |  |  |  |  |  |  |  |  |  |  |
| (11) | -0.04 | 0.04 | -0.04 | 0.01 | -0.07 | 0.10 | -0.00 | -0.03 | 0.03 | 0.08 | 1.00 |  |  |  |  |  |  |  |  |  |  |
| (12) | 0.27 | -0.27 | 0.03 | -0.27 | -0.23 | -0.15 | -0.10 | -0.11 | -0.03 | -0.37 | -0.00 | 1.00 |  |  |  |  |  |  |  |  |  |
| (13) | 0.45 | -0.45 | 0.16 | -0.51 | -0.16 | -0.40 | 0.02 | -0.24 | -0.06 | -0.37 | -0.03 | 0.43 | 1.00 |  |  |  |  |  |  |  |  |
| (14) | 0.50 | -0.50 | -0.09 | -0.74 | -0.13 | -0.34 | -0.10 | -0.18 | -0.06 | -0.32 | -0.02 | 0.18 | 0.51 | 1.00 |  |  |  |  |  |  |  |
| (15) | 0.81 | -0.81 | -0.01 | -0.63 | 0.07 | -0.73 | 0.06 | -0.75 | 0.23 | -0.57 | -0.01 | 0.23 | 0.36 | 0.34 | 1.00 |  |  |  |  |  |  |
| (16) | -0.21 | 0.21 | -0.12 | 0.19 | -0.10 | 0.19 | -0.07 | 0.18 | -0.08 | 0.08 | -0.00 | 0.03 | -0.20 | -0.12 | -0.22 | 1.00 |  |  |  |  |  |
| (17) | 0.01 | -0.01 | -0.01 | 0.02 | 0.17 | 0.04 | 0.09 | -0.00 | 0.15 | -0.01 | 0.00 | -0.04 | -0.05 | -0.04 | 0.09 | 0.11 | 1.00 |  |  |  |  |
| (18) | 0.13 | -0.13 | 0.02 | -0.12 | -0.31 | -0.04 | -0.21 | -0.13 | -0.15 | -0.15 | 0.07 | 0.32 | 0.11 | -0.01 | 0.19 | 0.07 | -0.05 | 1.00 |  |  |  |
| (19) | 0.01 | -0.01 | 0.24 | -0.02 | 0.19 | 0.02 | 0.10 | -0.07 | 0.11 | 0.06 | 0.03 | -0.09 | -0.11 | -0.08 | -0.02 | -0.03 | 0.07 | 0.08 | 1.00 |  |  |
| (20) | 0.52 | -0.52 | 0.03 | -0.44 | 0.08 | -0.42 | 0.06 | -0.51 | 0.15 | -0.30 | 0.13 | 0.26 | 0.51 | 0.29 | 0.47 | -0.19 | 0.06 | 0.20 | 0.02 | 1.00 |  |
| (21) | 0.08 | -0.08 | 0.64 | 0.07 | 0.74 | -0.10 | 0.97 | -0.21 | 0.66 | 0.01 | -0.02 | -0.12 | -0.01 | -0.12 | 0.09 | -0.10 | 0.12 | -0.23 | 0.16 | 0.09 | 1.00 |

**Table A-3: Cross-sectional dependence test**

| Variable | Breusch-Pagan LM | Pesaran scaled LM | Bias-corrected scaled LM | Pesaran’s CD |
| --- | --- | --- | --- | --- |
|  | 12257.49 (0.00) | 282.43 (0.00) | 281.06 (0.00) | 110.58 (0.00) |
|  | 4379.06 (0.00) | 87.88 (0.00) | 86.52 (0.00) | 41.46 (0.00) |
|  | 4583.13 (0.00) | 92.92 (0.00) | 91.56 (0.00) | 8.71 (0.00) |
|  | 13011.71 (0.00) | 301.05 (0.00) | 299.69 (0.00) | 103.00 (0.00) |
|  | 12515.03 (0.00) | 288.789 (0.00) | 287.42 (0.00) | 111.83 (0.00) |
|  | 3559.58 (0.00) | 67.65 (0.00) | 66.28 (0.00) | 16.34 (0.00) |
|  | 8902.68 (0.00) | 199.59 (0.00) | 198.22 (0.00) | 84.02 (0.00) |
|  | 4153.94 (0.00) | 82.33 (0.00) | 80.96 (0.00) | 2.30 (0.00) |
|  | 7660.25 (0.00) | 168.91 (0.00) | 167.54 (0.00) | 67.57 (0.00) |
|  | 5460.19 (0.00) | 114.58 (0.00) | 113.21 (0.00) | 55.85 (0.00) |
|  | 4456.63 (0.00) | 89.80 (0.00) | 88.43 (0.00) | 29.86 (0.00) |
|  | 1220.15 (0.00) | 9.88 (0.00) | 8.51 (0.00) | 6.82 (0.00) |
|  | 2613.29 (0.00) | 44.28 (0.00) | 42.82 (0.00) | 10.21 (0.00) |
|  | 2715.11 (0.00) | 46.80 (0.00) | 45.43 (0.00) | 13.10 (0.00) |
|  | 6259.25 (0.00) | 134.31 (0.00) | 132.95 (0.00) | 57.65 (0.00) |
|  | 65,47 (0.00) | 1,45 (0.00) | 1,39 (0.00) | 0,89 (0.00) |
|  | 29.63 (0.00) | 30.95 (0.00) | 32.64 (0.00) | 35.16 (0.00) |
|  | 62.91 (0.00) | 65.92(0.00) | 69.60 (0.00) | 75.16 (0.00) |

This table reports cross-sectional dependence test statistics (p-values in parentheses)

**Table A-4: Robustness checks: Fixed Effects regression output (Government debt markets)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Variable | Infrastructure Gap | Transport Gap | Electricity Gap | ICT Gap | WSS Gap |
| Constant | 38.29 (5.60) | 44.12 (6.88) | 43.12 (5.11) | 42.38 (5.61) | 49.92 (5.53) |
| Government debt | -0.033 (-2.05) | -0.052 (-3.06) | -0.079 (-3.06) | -0.081 (-5.06) | -0.000 (-4.06) |
| Control variables | Yes | Yes | Yes | Yes | Yes |
| Fixed effects | Yes | Yes | Yes | Yes | Yes |
| R squared | 0.434 | 0.480 | 0.469 | 0.466 | 0.429 |
| Durbin-Watson | 5.894 | 12.35 | 7.873 | 8.631 | 9.314 |
| Akaike | 10.93 | 9.476 | 9.425 | 11.364 | 11.536 |
| Schwarz | 15.07 | 12.650 | 9.475 | 10.320 | 9.146 |
| Hannan-Quinn | 10.624 | 11.409 | 10.039 | 11.716 | 11.094 |
| This table reports FEM regression for the linear model in Eq. (1). The dependent variables are the infrastructure gaps of overall/aggregate infrastructure, transport, electricity, information, and communications technology (ICT) and water and sanitation infrastructure types. T-statistics are in parentheses. | | | | | |

**Table A-5: Robustness checks: Fixed Effects regression output (Corporate debt markets)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Variable | Infrastructure Gap | Transport Gap | Electricity Gap | ICT Gap | WSS Gap |
| Constant | 38.57 (5.25) | 35.62 (4.92) | 42.47 (5.56) | 49.93 (5.28) | 45.12 (5.21) |
| Corporate debt | -0.307 (-4.70) | -0.212 (-4.97) | -0.214 (-5.96) | -5.331 (-4.38) | -5.428 (-3.30) |
| Control variables | Yes | Yes | Yes | Yes | Yes |
| Fixed effects | Yes | Yes | Yes | Yes | Yes |
| R squared | 0.434 | 0.480 | 0.469 | 0.466 | 0.429 |
| Durbin-Watson | 5.894 | 12.35 | 7.873 | 8.631 | 9.314 |
| Akaike | 10.93 | 9.476 | 9.425 | 11.364 | 11.536 |
| Schwarz | 15.07 | 12.650 | 9.475 | 10.320 | 9.146 |
| Hannan-Quinn | 10.624 | 11.409 | 10.039 | 11.716 | 11.094 |
| This table reports FEM regression for the linear model in Eq. (1). The dependent variables are the infrastructure gaps of overall/aggregate infrastructure, transport, electricity, information, and communications technology (ICT) and water and sanitation infrastructure types. T-statistics are in parentheses. | | | | | |

**Table A-6: Robustness check: PMG regression output using IFG data (Government debt markets)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Variable | Infrastructure Gap | Transport Gap | Electricity Gap | ICT Gap | WSS Gap |
| Constant | -6.09 (-0.05) | -4.99(-0.20) | -4.46(-0.41) | -2.52 (-1.07) | -2.52(-1.07) |
| Government debt | -8.56(-1.84) | -6.15(-1.25) | -1.35 (-0.10) | -2.27(-0.6) | -2.28 (-0.08) |
| Control variables | Yes | Yes | Yes | Yes | Yes |
| Fixed effects | Yes | Yes | Yes | Yes | Yes |
| R squared | 0.02 | 0.38 | 0.51 | 0.51 | 0.51 |
| Durbin-Watson | 3.98 | 4.06 | 3.07 | 3.40 | 3.94 |
| Akaike | 8.47 | 5.91 | 7.25 | 9.32 | 7.22 |
| Schwarz | 6.39 | 5.14 | 5.54 | 8.03` | 9.16 |
| Hannan-Quinn | 10.64 | 14.21 | 12.26 | 8.24 | 13.44 |
| This table reports FEM regression for the linear model in Eq. (1). The dependent variables are the infrastructure gaps of overall/aggregate infrastructure, transport, electricity, information, and communications technology (ICT) and water and sanitation infrastructure types. Standard errors are in parentheses. | | | | | |

**Table A-7: Robustness check: PMG regression output using IFG data (Corporate debt markets)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Variable | Infrastructure Gap | Transport Gap | Electricity Gap | ICT Gap | WSS Gap |
| Constant | 6.30 (0.07) | 5.35(0.21) | 5.11(0.41) | 4.11(0.73) | 4.11(0.73) |
| Corporate debt | -0.02 (0.01) | -0.01 (0.01) | -0.03 (0.014) | -0.03 (0.02) | -0.04 (0.02) |
| Control variables | Yes | Yes | Yes | Yes | Yes |
| Fixed effects | Yes | Yes | Yes | Yes | Yes |
| R squared | 0.43 | 0.47 | 0.44 | 0.43 | 0.43 |
| Durbin-Watson | 17.26 | 7.21 | 6.98 | 9.87 | 7.51 |
| Akaike | 5.51 | 7.45 | 8.49 | 5.62 | 7.04 |
| Schwarz | 6.58 | 10.18 | 9.48 | 8.86 | 10.01 |
| Hannan-Quinn | 12.20 | 9.49 | 9.58 | 5.58 | 12.12 |
| This table reports FEM regression for the linear model in Eq. (1). The dependent variables are the infrastructure gaps of overall/aggregate infrastructure, transport, electricity, information, and communications technology (ICT) and water and sanitation infrastructure types. Standard errors are in parentheses. | | | | | |

**Table A-8: Robustness check: Threshold regression output using IFG data – full sample**

| 1 |  | Infrastructure financing gap (IFG) | |
| --- | --- | --- | --- |
| 2 | Debt market | Government | Corporate |
| 3 | Est. threshold value (% of GDP) | 29.31, 45.38 | 75.99, 82.30 |
| 4 | Beta for regime #1 | -1.763 (-0.693) | -4.565 (-0.854) |
| 5 | Beta for regime #2 | -0.308 (-0.108) | -01.072 (-0.563) |
| 6 | Beta for regime #3 | 6.586 (0.604) | 0.892 (0.827) |
| 7 | Control variables | Yes | Yes |
| 8 | Number of countries | 42 | 42 |
| 9 | R-squared | 0.4991 | 0.4975 |
| 10 | Durbin-Watson statistic | 4.972 | 4.973 |
| 11 | Akaike info criterion | 2.527 | 4.859 |
| 12 | Schwarz criterion | 4.124 | 8.369 |
| 11 | Hannan-Quinn criterion. | 7.907 | 3.413 |

The dependent variable is the infrastructure financing gap (IFG) scaled by GDP. Standard errors are in parentheses.

1. Infrastructure financing gap is defined as “the difference between the infrastructure investment needs and the total amount of financial commitments by all financiers of infrastructure development” (AfDB, 2018). [↑](#footnote-ref-2)
2. According to Ehlers and Packer (2017, p. 1), “green bonds are fixed income securities which finance investments with environmental and climate-related benefits.” The bonds can be packaged as corporate bonds, project bonds or asset-backed security (ABS) bonds and used to finance climate-resilient projects through the capital market. [↑](#footnote-ref-3)
3. To ease the utilization of this market, Financial Sector Deepening (FSD) Africa, in partnership with Climate Bonds Initiative, has launched an Africa Green Bonds Toolkit to guide African capital markets on the mechanics of issuing green bonds in line with international standards (Caminha, 2020). [↑](#footnote-ref-4)
4. We use the terms ‘financial development’ and ‘public bond market development’ interchangeably. [↑](#footnote-ref-5)
5. Local currency debt is important in the mobilization of resources for infrastructure investment because proceeds from utilization of the financed asset (e.g., user charges on a toll road) are denominated in the same currency as liabilities (e.g., interest on debt), making planning less complicated by eliminating currency risk for the borrower. [↑](#footnote-ref-6)
6. Empirical literature suggest that infrastructure spending has a positive effect on long-term economic growth. For example, in a study of a panel of 45 SSA countries over the period 2000-2011, Kodongo and Ojah (2016) find that a 1% spending on infrastructure and incremental access to infrastructure influence economic growth by 0.127% and that infrastructure spending is more beneficial less developed economies than the relatively more advanced economies. Studies also point out that the current SSA infrastructure deficits play a role in hindering SSA's economic growth (e.g., Calderon et al., 2018). Consequently, infrastructure deficits, in one way or another, reflects the existence and/or extent of infrastructure financing gaps (IFG). [↑](#footnote-ref-7)
7. The four sub-indices are disaggregated into nine indicators that measure specific dimensions of infrastructure. The nine indicators aggregated into AIDI are, total paved roads (km per 10,000 inhabitants), total road network in kilometres (per square km of exploitable land area), electricity generation (kWh per inhabitant), total phone subscriptions (per 100 inhabitants), number of internet users (per 100 inhabitants), fixed (wired) broadband internet subscribers (per 100 inhabitants), international internet bandwidth (Mbps), improved water source (% of population with access) and improved sanitation facilities (% of population with access). AIDI, therefore, is a composite index of four infrastructure types: transport, electricity, information, communication and technology, and water and sanitation (AfDB, 2013). [↑](#footnote-ref-8)
8. The Gautrain Rapid Rail Link is an urban passenger railway transit system implemented in South Africa in 2010 to connect the Gauteng Province’s economic nodes of Johannesburg and Pretoria metropolis and the Oliver Tambo International Airport. [↑](#footnote-ref-9)
9. The rule of thumb is that a coefficient should have a t-statistic value of at least 2 to be statistically significant. [↑](#footnote-ref-10)
10. We use the IFG data, prepared by World Bank’s Africa Infrastructure Country Diagnostic (AICD) and many researchers (e.g., Briceño-Garmendia, Smits & Foster, 2008; Dominguez-Torres & Foster, 2011; Domínguez & Foster, 2011; Ranganathan & Foster, 2011a, 2011b; Ranganathan & Foster, 2011c) to test the robustness of our baseline results. The data are available for 24 SSA countries and only for a limited period. [↑](#footnote-ref-11)