

Bond Market Development and Infrastructure Development Index: An Analysis of African Countries with the Portfolio Investment Bonds

Tuhaise Betty Tumuhirwe¹, Eric Nzibonera², Jude Thadeo Mugarura³, Yusuf Kiwala⁴

¹Ph.D. Candidate and Assistant Lecturer, Department of Accounting and Finance, College of Business and Management science, School of Business, Makerere University, Kampala, Uganda.

²Main PhD Supervisor, Senior Lecturer, Head of Department of Accounting and Finance, College of Business and Management science, School of Business, Makerere University, Kampala, Uganda

³Ph.D supervisor, Senior Lecturer, Head Department of Marketing and Management, Makerere University, College of Business and Management science, School of Business, Makerere University, Kampala, Uganda.

⁴Ph.D supervisor, Lecturer, Department of Accounting and Finance, College of Business and Management science, School of Business, Makerere University, Kampala, Uganda.

ABSTRACT

This paper analyses the empirical relationship between portfolio investment bonds and Infrastructure development index in Africa. The study seeks to establish if there is a statistically significant relationship between the portfolio investment bonds and infrastructure development index in Africa. Panel data of 13 countries for the period of 9 years from 2013 to 2022 was adopted. The study is supported by positivism philosophical underpinnings, a quantitative approach, multiple case design. It is a triangulation of correlation, regression, and hypothesis -testing through the linear dynamic panel data Generalized method of Momentum (GMM) model. This model estimates the empirical relationship between the key variables under study. The results from the study indicate a significant positive relationship between the portfolio dollar amount logged twice from the world bank data indicators and the infrastructure index from the Africa Infrastructure development Indicator (AIDI) also logged twice based on the model requirements. Therefore, countries that receive higher portfolio dollar amounts realize more infrastructure development. It is therefore recommended for African countries to create a Political, Economic and Regulatory supportive policies for bond market development especially the portfolio investment bonds.

This paper ascertains a relationship between bond market development and Africa infrastructure development index. And develops policy discussions regarding infrastructure financing through a well-developed bond market with a variety of bond types.

Keywords: Bond market development, Infrastructure financialization, Infrastructure financing.

Introduction

1.1. Background and motivation of the study.

The world and various scholars recognize the role and need for infrastructure development as a major driver for political, economic and social development (Kodongo, Mukoki, and Ojah 2023). Much as expenditure on infrastructure investment is appreciated, it has been hindered by the constrained fiscal space, the reducing Official Development Assistance, Public corruption, stringent terms by lenders and general inefficiencies in financing public infrastructure (Fioravanti, Lembo, and Deep 2019; Mukoki 2022). As a result, habitable continents do not have enough resources to fund all their infrastructure needs evidenced through various infrastructure investment gaps (Mayer and Wargo 2023). Africa as a continent is considered to have a huge infrastructure financing investment gap of USD \$ 150 billion annually (Mukoki 2022). In addition, the majority of Africans access to vital infrastructure is limited. Africa as a continent is deemed to be lagging behind the other comparable peer continents in basic infrastructure that includes clean water and sanitation, energy generation, Transport and ICT coverage (Bagenda 2023).

Infrastructure financing has caused various interventions like the Integrated national financing frameworks, these were initiated by the United Nations in 2015 to support the Sustainable development goals financing (UNDP 2021). In addition, the Africa Infrastructure Country Diagnostic (AICD) is a comprehensive knowledge program commissioned by the Infrastructure Consortium for Africa (ICA) to improve understanding of Africa's infrastructure situation. The AICD assists policymakers in setting priorities for current infrastructure investments and provides a baseline for monitoring progress (Chuku, Simpasa, and Ekpo 2023; Omotor and Elu 2020). Furthermore, the Africa;50 fund, a financing vehicle for incorporating and expanding private sector participation in Infrastructure development (Kararach, 2017). Africa infrastructure development bank is a private sector based that makes the African Infrastructure development index, one of its role is to measure the status and development of infrastructure in Africa (AfDB 2018). Lastly but not least, is the Program for infrastructure development in Africa (PIDA), initiated to develop a vision and strategic framework for the development of regional and continental infrastructure (Energy, Transport, information and communication Technologies (ICT), and Trans-boundary water resources. All the efforts have been put in place due to the inadequate infrastructure amidst limited capacity to tap in to emerging financing options like bonds (Mawejje and Munyambonera 2017; Nuwagaba, Nyende, and Namanya 2021). Hence the need to study the study variables of Infrastructure development index and bond market development.

Infrastructure development index (AIDI), the dependent variable is represented by the Infra index, developed by the African Development Bank (AfDB, 2022; Kodongo & et al 2023). It is treated as a single infrastructure investment just like previous scholars did (Mukoki, 2023; Kodongo and et al 2023). The African infrastructure development index measures Infrastructure status and development using four sectors, namely: the water and sanitation infrastructure gap, the energy infrastructure gap, the Transport infrastructure gap and the Information and communication technology infrastructure gap (ICT). The above-mentioned sectors are measured using nine indicators (AfDB 2018).

The nine indicators measure both the quantity and the quality of infrastructure for the African continent. These indicators include improved sanitation facilities (percentage of population with access to clean water), as measures for water and sanitation. Electricity generation (kilowatt per hour (kWh) per inhabitant), as a measure for energy infrastructure status and development. The total paved roads (km per 10,000 inhabitants), the total road network in kilometers (per square km of exploitable land area), as

measures for road transport. Lastly yet not least, is the total Phone Subscription (per 100 inhabitants), and the number of Internet Users (per 100 inhabitants)(AfDB 2018).

Whereas the independent/ exogenous variable of interest, bond market development has been measured by the lagged market value of outstanding bonds to the second differentiation. Various scholars have used the lagged outstanding amount to measure bond market development(Agliardi and Agliardi 2019; Kodongo et al. 2023; Mukoki 2022). The log for portfolio investment bonds (PIB), combines the public and publicly guaranteed bonds alongside the private non-guaranteed bonds measured by Net flows in (US\$) (Andersen and Kragh 2010).

Furthermore, the preferred habitat theory anchors this study. The preferred Habitat theory, interests itself in the behavior of bond buyers and sellers. It assumes that bond investors and bond issuers have habitats they prefer to operate in. It can be based on time horizon to maturity, the financing product issued, the sector of investment, the quality of governance or the desired impact or outcome for the financed project. But bond market participants are willing to shift to other maturities if compensated for, by the appropriate risk premium (Rattiner, 2009). This theory also states that investors prefer shorter-term bonds to longer-term bonds while issuers prefer long term bonds to short term bonds. Thus, the supply or demand imbalance for funds in a given maturity range will induce lenders and borrowers to shift from their preferred habitats (maturity ranges) to one that has the opposite imbalance given a compensating incentive. This study, to differ from others, will use the preferred habitats in a Duo perspective. The demand side that prefers one type of bond over another. Whereas on the supply side, the providers of capital, sometimes have a certain infrastructure they prefer to finance over the other motivated by the purpose for the resources.

To the best of the researchers' knowledge, no research has been done about bond market development and infrastructure development index; an analysis of countries with the Portfolio investment bonds. Creating a need for research about the existence of a relationship between bond market development and infrastructure development index. Thus, the broad research question for the study is; "Is there any relationship between infrastructure development index and bond market development in Africa? This will inform the various stakeholders and governments' financing policies. The financing policies that will be influenced by this study include the Integrated National financing frameworks and the various public financing management reforms in Africa. To shed more light, here is the statement of the problem.

1.2 Statement of the problem and justification of the study.

Infrastructure financing has attracted a lot of interest in both practice and academics. This is evidenced through various studies about public infrastructure financing options (Mayer and Wargo 2023).Albeit other studies close to this study considered infrastructure financialization which involves infrastructure financing through bond market development (Skclair and Gilbert 2022). And other scholars have gone ahead to ascertain the relationship between Bond market development and infrastructure investment gap (Kodongo et al. 2023; Mukoki 2022). As well as the required threshold for a statistically significant relationship between infrastructure investment gap and bond market development. The same scholars established a negative relationship between Bond market development and infrastructure investment gap for government bonds, which was attributed to African bond markets operating below the threshold. The same study confirmed a statistically significant positive relationship between bond market development and infrastructure development for corporate bonds (Kodongo et al. 2023). Amidst the immense academic debate about infrastructure and bond market development, there is very scanty literature about bond market development using Portfolio investment bonds and Infrastructure development in Africa. This

motivated this study. Moreover, the bond market development has been recommended as a viable infrastructure financing option for Africa by several authors (Mawejje and Munyambonera 2017; Oji 2015).

Methodologically; Studies for bond market development as a financing option for infrastructure investments have majorly used various economic models. Specifically the traditional dynamic panel system of generalized method of moments for linear relationships and PTR for non-linear relationships (Ojah et al 2016; Kodongo et al. 2023) or multiple qualitative methods only (Gorelick 2018, 2019). While (Mukoki 2022) used mixed methods that applied economic modelling, the pooled mean group estimator (PMG), interview guides and questionnaires. This study, to differ from the previous authors, adopted the Linear Dynamic Panel data Generalized method of moments (LDPD-GMM) econometric model by Arrelano, 2009) the linear dynamic panel, to estimate the linear relationship between the infrastructure development index and the bond market development.

Practically, Africa's limited infrastructure financing options amidst the huge infrastructure financing demands albeit minimal utilization of bonds which have been embraced globally for infrastructure financing, is the main cause for this study (Ahwireng-Obeng and Ahwireng-Obeng 2022; Gorelick 2019; sekitoleko 2018).

1.3 Main purpose, Objectives and hypothesis

The main purpose of this study is to explore how bond markets can be developed into viable financing options for infrastructure gaps in Africa. And the Specific objective is to examine the relationship between bond market development and the infrastructure status and development between 2012 to 2022. The hypothesis for the study is that there is no statistically significant relationship between Bond Market development and infrastructure status and development.

1.4. This study is justified because it focuses on bond market development and infrastructure development in Africa, using portfolio investment bonds instead of government, corporate, and environmental bonds. Previous studies have used the infrastructure investment gap, which assumes the best four African countries have optimal infrastructure. This does not take into account the actual desired infrastructure per country based on parameter differences like population, Fiscal space, Geographical space and various economic resources for that country. To differ from those studies, this study acknowledges the uniqueness of each country and uses the Africa Infrastructure Development Index to measure the status and development of infrastructure as established by the African development bank. This approach adds to existing literature on bond market development and Infrastructure status in Africa.

Infrastructure development index, the dependent variable is represented by the (Infra index) accessed through the African Development Bank. The African Development Bank uses the Infrastructure Development Index (IDI) to monitor infrastructure status and development among other uses. The index consists of four sectors: water and sanitation, energy, transport, and ICT. These indicators form nine indicators, forming the Aggregate/Overall Infrastructure index. The use of an infrastructure index as a proxy for investment is not new in infrastructure studies, as seen in Kodongo et al 2023 and Mukoki et al 2023. This study treats it as a single infrastructure investment just like previous scholars did. The same studies measured the exogenous variable of interest, bond market development using outstanding amount of bonds like government bonds and corporate bonds, but this study will use portfolio investment bonds to measure the same (Mukoki, 2023; Kodongo et al 2023).

1.5 Operationalization of variables and contextual definitions of concepts

Table A. Data, explanation, notation, and source

Item no	constructs	Construct explanation	Construct coding	Source of data
	DEPENDENT VARIABLES, ENDOGENOUS VARIABLES			
	Overall infrastructure	The overall infrastructure index	Overall Index	World development indicators
	EXPLANATORY (EXOGENOUS)VARIABLES,	CONSTRUCT EXPLANATION	CONSTRUCT CODING	
	PORTOFOLIO INVESTMENT BONDS	lnPIBS	PIBS	World bank development indicators and MUNDI INDEX

Conceptual framework

INDEPENDENT VARIABLES

DEPENDENT VARIABLE



2.0 RELATED LITERATURE REVIEW

In addition, the study by (Pozhidaev, 2021), entitled National Enablers for Infrastructure Investment and economic development in secondary cities in Ghana and Uganda; considered enabling conditions and six building blocks that are key for domestic bond market development and did not define it. These included the general macro-economic conditions, the financing needs of government, fiscal and debt position, structure of the economy, financial sector soundness, debt management capacity and operating procedures, monetary and exchange rate conditions, and the investor base. To differ from the above study, bond market development will be defined and its relationship to infrastructure status and development will be ascertained.

Bond market development is defined as the presence and significance of public sector, private sector and international bond issues (Pradhan et al,2016). This study has used the outstanding value of portfolio investment bonds to measure the bond market development. Portfolio investment bonds emerge as a potential solution to bridge the financing gap and accelerate infrastructure development. Given their ability

to draw in private capital and diversify funding sources. Portfolio investment bonds have a short definition of Public and publicly guaranteed debt as bonds that are either publicly issued or privately placed (World bank, 2013). A variety of financial instruments that are traded on capital markets are included in portfolio investment bonds, such as corporate, government, sukuk, and infrastructure bonds.

African nations like Nigeria, Egypt, and South Africa have been using portfolio investment bonds more frequently in recent years to raise money for infrastructure projects. In Africa, portfolio bonds such as sukuk, impact-based bonds, infrastructure bonds, and sovereign bonds have become increasingly popular in financing various infrastructure like transport, water and sanitation, energy, and Information, Communication and Technology (ICT). This offers investors opportunities for long-term returns while addressing critical infrastructure needs.

Lindner and Chung (2023) defined Infrastructure based on Jochimsen (1966), AS “the sum of all material, institutional and personal assets, facilities, and conditions available to an economy based on the division of labor and its individual economic units that contribute to realizing the assimilation of factor remuneration, given an expedient allocation of resources”. Despite the potential of portfolio investment bonds to mobilize capital for infrastructure projects, Africa continues to face significant challenges in achieving infrastructure development objectives. The continent lags behind other regions in key infrastructure indicators, including transportation networks, energy access, and digital connectivity. Limited access to financing, inadequate regulatory frameworks, and governance issues have hampered progress in infrastructure development across many African countries. In addition, COVID-19 pandemic exacerbated existing vulnerabilities, highlighting the urgent need for sustainable infrastructure investment to support economic recovery and resilience.

The study by (Kodongo et al. 2023), examined the relationship between bond market development and infrastructure gap reduction in sub-Saharan Africa. They discovered that there was a positive correlation between corporate bonds and infrastructure gap reduction, but a negative correlation between government bonds. They recommended more work to be done to expand the bond market and advance laws that support the corporate and sovereign bond markets. This study greatly informs our study by contributing the two concepts of bond market development and infrastructure investment gaps. To differ from it, the current study measured bond market development using portfolio investment bonds instead of corporate bonds and government bonds. Secondly, our study used infrastructure development index as a measure for infrastructure development in place of an infrastructure investment gap.

The study by Choo (2023) entitled Essays in international economics ascertained a positive correlation between the long run behavior of net international capital inflows, from both private and public sectors in emerging economies and economic growth. In addition, the same study ascertained a negative relationship between the net inflows of both public and private capital versus human capital development. This poses a threat of why Economic development without human capital development (soft infrastructure), could this be an effect of over dependence on external borrowing and concessional borrowings that do not favor the development of soft infrastructure (citizens of the nation) explaining the need for bond financing as well.

The study by (Musah, Badu-Acquah, and Adjei 2019) entitled Factors that influence bond markets development in Ghana, affirms that economic development, budget deficit, bank size, external debt, money supply and size of the economy are significant determinants of corporate bond market development in Ghana. However, bank size, money supply and external debt are seen to be the most important and significant drivers of total bond market size in Ghana,.. The study used the Vector Error Correction Model

(VECM) as technique of data analysis. The Augmented Dickey-Fuller (ADF) stationarity test, the Johansen Co-integration test and other tests were carried out to ensure the robustness of the results. Covering a period from 1980 to 2015. Our study appreciates the contribution of this study and differs in geographical context, by considering Africa and not one country, contextually by having another variable of infrastructure development in addition to bond market development, and by considering the relationship between the two variables and not what influences the bond market development.

The study by (Tian et al. 2020) entitled *Tokenization: A Blockchain Solution to Financing Infrastructure in Emerging Marketing and Developing Economies* through a mixed methods approach, a case study research design. Applied Asset tokenization and infrastructure financing for the independent variable and the dependent variable respectively. The findings of the study are; Infrastructure is essential to alleviate poverty and generate long-term growth in Emerging and Developing Economies. Furthermore, the Existing infrastructure financing models struggle with multiple issues such as: lack of transparency, insufficient efficiency, and limited liquidity and lastly yet not least is the Administrative and financial efficiencies such as automated auditing, enhanced project monitoring and lower financing costs can be improved through tokenization. This study contributes to the role of tokenization in Infrastructure financing but differs from our study, by the independent variable of bond market development.

The study by (Lindner and Chung 2023) entitled *Technology-enabled financing of sustainable infrastructure: A case for blockchains and decentralized oracle networks*, developed a new theory based on distinct disciplines, this was done through building and combining selected literature and sources of information. The research method was aligned with that of a conceptual research article, which Jaakkola (2020) characterizes as creating new theory by building on concepts and data tested through empirical research. The study developed a Model to justify and predict how blockchain technologies can leverage infrastructure data to close the finance gap by introducing new financing mechanisms. Blockchains provide trust and transparency in data and transactions. They utilize oracles to access off-chain information for on-chain decision-making. This study introduces infrastructure gap closing which is similar to our study but differs on the proposed solution of using smart contracts and decentralized oracle networks and performance benchmarks yet ours considers the role of bond market development in closing the same gap.

The study by (Wanta et al 2023) entitled Finance: Is this Supporting SDG 14 Financing Gap? used a qualitative desk review and interview method. Used financing and SDG 14 financing gap as an independent and dependent variable respectively. The study found out that though the process is ongoing, there are currently no figures available regarding the ideal financing needs to achieve SDG 14 in Indonesia until 2030. And there is an essential collaboration by the Government of Indonesia with all potential stakeholders to speed up the establishment of Blue Economy in Indonesia in order to achieve SDG 14 target. This study is similar to the current study by emphasizing the role of financing. However, it differs from our study in scope; It limits itself to the role of financing SDG14, the need to ascertain the Actual SDG14 financing gaps and Geographically to Indonesia. Our study is considering the viability of bond market development as an infrastructure financing option in Africa.

The study by (Alam et al. 2023) entitled *Motivation of Firms to Issue Sukuks* through a case study, with the independent variable being motivation and the dependent variable of Issuance of Sukuk. It established that the performance of companies issuing Sukuks resembles Conventional Bond issuers in financial performance. Also, Larger companies will enter the Sukuk market as an alternative to the Conventional Bond market when there is a higher demand for capital and Firms with higher financial performance may enter the Sukuk market as a premium where it may not be accessible in the Conventional Bond Market.

This study is similar to ours in the concept of bonds as a financing option, but is limited to only sukuk, which means an Islamic bond. In addition, it looks at larger firms' motivation for using Sukuk. It differs from our study variables of bond market development and infrastructure status and development.

The study by (Alam et al. 2023) entitled How Does Sukuk Investment Perform? A Literature Review used through PRISMA systems research design, to review 778 Journals using a Scopus database to form a 15 full text Journals for review. Used an inclusion criterion of sukuk performance. The study ascertained that sukuk performance had been analyzed using two major approaches; Descriptive analysis and thematic qualitative synthesis. The descriptive analysis indicated growth in the number of studies about sukuk performance until 2022 and the most cited articles in the same area. Analysis of sukuk performance found out that Sukuk performance studies have experienced a growth in the number of studies until 2022 and the social contributions, such as investment in the education sector are the main drivers and motivations for investors to invest. Furthermore, the thematic qualitative synthesis, summarizes the key topics using a Word Cloud and Tree Map analysis of the findings. Additionally, the measurements researchers used to gauge the performance of sukuk investments were identified and recorded in the study. This study brings in the concept of bond market development through measuring Sukuk performance. However, it differs from the current study in the study variables by using bond market development instead of sukuk performance and the intent of the scholars which aimed at examining the relationship between bond market development and infrastructure development index instead of sukuk performance. Additionally, the methods and the measurements used equally differ in the two studies.

The study by (Adelegan and Herrala 2023;2009) entitled What Determines Bond Market Development in sub-Saharan Africa? This study empirically examines the determinants of bond market development in 23 sub-Saharan African (SSA) countries between 1990 and 2008. It takes into account the bond market's size and development stage in addition to the historical, structural, institutional, and macroeconomic variables influencing the growth of the bond market in SSA. The study finds that the savings constraint is a key impediment to financial market deepening and development of the domestic bond market. The study further established that a confluence of many variables drives the level of development of the domestic bond market in Sub-Saharan Africa and there is no single class of variables that is wholly responsible for the underdevelopment of the domestic bond market. Similar to our study, the study considers bond market development in a part of Africa, it highlights critical bond market drivers like saving and the fact that it would take a congruence of factor for it to be realized. It differs from our study on geographical scope, that considers the African Continent instead of Sub Saharan Africa, as well as the second variable of infrastructure development index which was never part of their studies.

The study by (Guo and Zhou 2023) entitled The Evolution of Financial Market Infrastructure (FMI): From Digitalization to Tokenization. This study examines the historical development and cross-sectional heterogeneities of Financial Market Infrastructure (FMI) from an evolutionary perspective. The study reviewed and compared FMIs in the US, Europe, and China and found out that there is an emerging trend of transitioning from digitalization to tokenization. This addresses the principal agent problem of centralized systems, DLT, especially blockchain technology. This has provided a solution to restore trust among market participants by removing the need for a trusted authority or intermediary. Similar to the current study, the study looked at one of the stages of bond market development which is the evolution of financial market infrastructure, and its role to the bond market players trust in the bond market development. To differ from the current study, it didn't look at Africa at all, neither the bond market development as a whole nor the infrastructure development as a result of bond market development.

Kalu Ojah (2016), the study entitled: Does Infrastructure really explain economic growth in Sub Saharan Africa? Applied System GMM to estimate economic growth in 45 Sub-Saharan African countries from 2000-2011. It finds that infrastructure spending and access to it influence economic growth and development, particularly in less developed economies. Infrastructure access and quality also indirectly relate to economic growth through export diversification and cross-border capital flows. The findings suggest that efforts to reverse Africa's infrastructure deficit must be carefully nuanced. This study is similar to ours through the use of infrastructure as a study variable but differs from ours through the scope, period, and the second study variable. Our study covers Africa as a continent and while this one covered Sub-Saharan Africa (SSA). It covered a period of 2000-2011 and ours is covering 2012- 2022. Context wise, our study looks at the relationship between infrastructure and Bond market development while the current study looked at infrastructure and economic growth.

Theoretically, we expect the coefficient of bond market development (BMD) to positively correlate with the aggregate infrastructure status and development variable (*infra index*). These variables represent some level of existing private sector investment in key infrastructure sectors as documented in the World Bank's Private Participation in Infrastructure (PPI) and in the *mundi Index*

3.0 METHODOLOGY

The study used a positivist paradigm in which the researcher remains detached from the information collected (Baškarada and Koronios 2018). The African Development Bank's credible and moral institutional websites provide the data for the composite infrastructure index, which displays the status and development of infrastructure throughout the continent (AfDB 2018). The African Development Bank produced the Africa Infrastructure Development Index (AIDI), a dependent variable that offers yearly information on the state and progress of infrastructure in 13 African nations.

Bond market development on the other hand, is taken from world bank indicators as the independent variable. It refers to the Net flows from international public and publicly guaranteed bond issuance as well as private nonguaranteed bond issues measured in current U.S. dollars (Choo, 2023). Based on "debt instruments issued by public and publicly guaranteed or private debtors with durations of one year or longer," The researcher obtained the bond data for Portfolio investment bonds (PIB) from world development indicators between 2013 and 2022 (world bank; 2018).

The investigator generated duplicate Excel sheets within the identical data sheet, then replicated and appended the primary copy to an additional sheet. This was followed by the cleaning of the data, which involved reading, analyzing and synthesizing the downloaded data. There were 217 valid countries per year and 49 regional associations that the raw data identified as countries. The authors deleted every set of the 49 regional associations from 2013 to 2022 by scrolling down and removing all the regional associations. This followed by the deleting of countries that did not have portfolio investment bonds for the period between 2013 to 2022. A sample of 13 countries for a period of nine years remained, based on the availability of the raw study variables of interest (Portfolio Investment bonds and infrastructure index). That was the panel data development process. It was majorly anchored on data availability for the pertinent variables under study, to determine the duration of the study, and the countries chosen. A large range of data was captured both geographically and contextually. That an African continent-wide application of the findings is possible. This study aims to extend the academic literature to portfolio investment bonds, which have received very little attention. It also makes a methodological contribution by confirming the

models and theories that have been developed by earlier researchers who employed interpretivism paradigms to produce models and theories that are derivatives and need to be verified.

The research involved desk-top triangulation, correlation, regression, and hypothesis testing. We aim to examine the empirical relationships between the dollar amounts of portfolio investment bonds (PIB) and the infrastructure development index (INFRA) for the period of 2013 to 2022 logged twice. African countries that employ Portfolio investment bonds as a source of funding are the units of analysis. The World Bank's annual reports on development indicators from 2013 to 2022 and the composite infrastructure index from Africa infrastructure development Bank website served as the investigation's units of inquiry. Secondary and quantitative data sources constituted the study's data sources. The authors started with 54 African countries. E-swartini was deleted, leaving 53 countries that had corresponding composite infrastructure index. However, in the process of panel development, it was only 13 African countries that had data about portfolio investment bonds. Hence the study population and sample size were purposefully chosen to include all the countries that use portfolio investment bonds as a financing option and yet have data for infrastructure index. This is in order to get the most comprehensive comparative analysis of the key research variables for the years 2013 to 2022.

This is further supported by the use of the most relevant kinds of empirical data analysis, that were methodically, expertly, meticulously, diligently, and ethically compiled and validated by the Data Resources and Statistics division of the African Infrastructure Development Bank and the World Bank. The two reliable and morally-respected organizations availed the data used in this study. Using the Excel spreadsheet and Stata 13 software, panel data were analyzed primarily using econometric estimation modeling to produce descriptive and inferential statistics.

Model estimation

The econometric activity aims to establish structural or causal relationships which are very vital for policy evaluation and theory testing. We explore the relationships of interest in the first instance by estimating the following linear empirical model specification, adapted from the study by Kodongo et al 2023.

$$\text{Infra Index}_{it} = \beta_0 + \beta_1 \text{Infra index}_{it-1} + \beta_2 \text{debt}_{it} + \beta_3 X_{it} + \varepsilon_{it} \text{----- (1)}$$

Where Infra Index, the dependent variable, is the log change in the infrastructure indices which represents the infrastructure status and development at time t. Where i denotes a unit of observation which is a country, and t denotes a time period. Thus, infra index_{it} , stands for a country specific infrastructure at time t. The explanatory variable of interest, bond market development has been proxied by debt in equation 1. Meaning the debt_{it} symbolizes the presence of bond market development biased towards portfolio investment bonds. The equation also contains a vector of controls (X), which includes change in the exchange rate, human development index and the fiscal balance. Control variables are factors that indirectly affect the variables of interest. Much as they might not be examined in the equation. β is the autoregressive coefficients of the regressors and ε_{it} indicates the errors that exist due to the period under review or white noise.

It can also be represented in the first-differenced GMM estimation, we transform the original equation by taking first differences, which helps in addressing endogeneity concerns and controlling for unobserved individual-specific effects. The first-differenced equation can be represented as:

$\Delta y_{it} = \Delta x_{it} \beta + \Delta z_{it} \gamma + \Delta \varepsilon_{it}$, where Δ denotes the first difference operator. The study variables characteristics, based on available data. Had to be differentiated the second time and the best suitable model to handle in that regard was the Linear dynamic panel data, Generalized method of moment. LDPD-GMM specified to estimate two lag model applied by Sennanda et al (2023), Mukiki et al (2023) and Kodongo (2023).

$$\ln INFRA_{it} = \beta_1 + \delta \ln INFRA_{i,t-2} + \ln BD_{it} \beta_2 + \mu_i + \varepsilon_{it} \dots \dots \dots$$

This study used panel GMM estimation because, based on the literature assessment, most studies have adopted panel regression models, such as Panel GMM and Panel regression (fixed-effects). The aim of this is to utilize panel data to manage unobserved time-invariant heterogeneity in cross-sectional models. Additionally, panel data can be utilized to separate variables and calculate transition probabilities, as well as more broadly to examine the dynamics of cross-sectional populations with lagged endogenous regressors. This includes addressing missing data, which is present in the datasets of infrastructure development and bond market development (Younas and et al 2022).

The specific LDPD-GMM econometric models specified to estimate each of the hypotheses as in the one lag model applied by Ledhem and Mekidiche (2021); Mukoki et al (2023) the two lag model Sennanda et al (2023) are;

$$\ln INF_{it} = \beta_1 + \delta \ln INF_{i,t-2} + \ln BD_{it} \beta_2 + \mu_i + \varepsilon_{it} \dots \dots \dots$$

Where infrastructure level at a specific time t is indicated by $\ln INF_{it}$, it is equated to the constant β_1 , this represents the infrastructure that would be available even without bonds intervention.

While the $\delta \ln INF_{i,t-2}$ represents the infrastructure development that existed in the previous two years and how it interferes with the current infrastructure status and development.

While $\ln BD_{it} \beta_2$, is the proposed intervention of bond market development and how it would contribute to the infrastructure status and development.

In addition, μ_i , represents the control variables which affect the relationship between the infrastructure level and the bond market development, but may not all be exhaustively represented in this paper. Whereas E, the errors that exist due to the period under review.

3.2 Econometric methodology

Estimation problems due to unobserved individual effects, endogeneity, and correlation between regressors and lagged variables can lead to biased results (Senanda 2023). Arellano&Bond,(2009: 1991) developed a specific model to remove these effects, using lagged values of dependent and exogenous variables. Later they developed a new method called the GMM system estimator that included lagged stages and lagged differences as instruments. This model is effective for empirical investigations. specified GMM as a system estimation that can resolve the problems correlated to endogeneity, unseen heterogeneity and autocorrelation. For this study, the system GMM estimator was applied to conduct the empirical investigation to address endogeneity, unseen heterogeneity, and autocorrelation issues.

4.0. PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

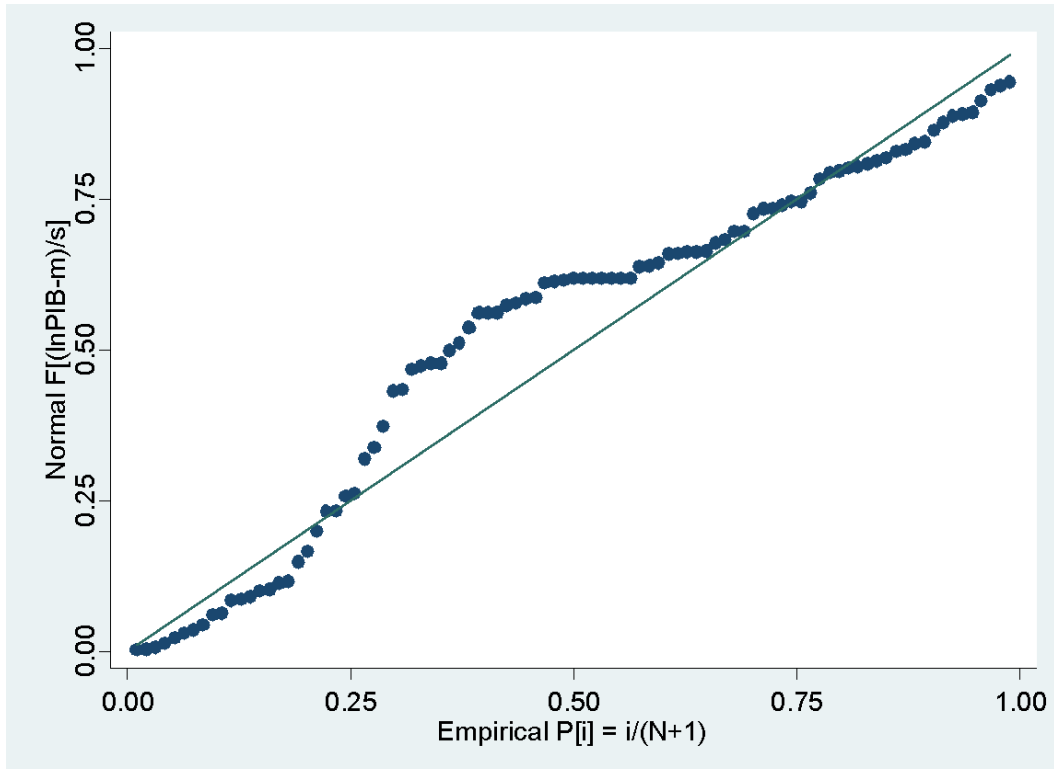
In order to create a sufficiently symmetric distribution that would serve as a solid foundation for additional statistical procedures, we transformed the data for this study to natural logarithms to base e (Ofoeda et al 2022) It is not necessary for the transformed distribution to be perfectly normal, but if it is, statistical modeling may be made easier and tests based on fewer samples would be more confident. Natural logarithms can be used to base e, and common logarithms to base 10.

4.1 Summary for descriptive statistics data by Stata 13 for lnINFRA, lnPIB .

```
. xtset C YEAR, yearly
      panel variable: C (strongly balanced)
      time variable: YEAR, 2013 to 2022
      delta: 1 year
```

Normality tests;

Normality tests are statistical procedures used to assess whether a dataset follows a normal distribution, and the data for lnPIB shows a normal distribution as per the diagram below.



DYNAMIC PANEL DATA ESTIMATION

```
. xtddp lnINFRA lnPIB, twostep dgmiv(lnINFRA, lagrange(1)) artests(1)

Dynamic panel-data estimation          Number of obs      =          93
Group variable: C                     Number of groups   =          28
Time variable: YEAR

Obs per group:  min =          1
                  avg =    3.321429
                  max =          8

Number of instruments =          31      Wald chi2(1)       =    3.66e+06
                                          Prob > chi2        =    0.0000

Two-step results
```

lnINFRA	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
lnPIB	.0071309	3.73e-06	1913.52	0.000	.0071236 .0071382
_cons	3.184827	.0318781	99.91	0.000	3.122347 3.247306

Warning: gmm two-step standard errors are biased; robust standard errors are recommended.
 Instruments for differenced equation
 GMM-type: L(1/.)lnINFRA
 Instruments for level equation
 Standard: _cons

SARGAN TEST

The Sargan test measures validity of the instruments used.

```
. estat sargan
Sargan test of overidentifying restrictions
H0: overidentifying restrictions are valid
```

```
chi2(29) = 15.96292
Prob > chi2 = 0.9760
```

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	z	Prob > z
1	.02845	0.9773

H0: no autocorrelation

The Sargan test measures the validity of the instruments used in the analysis. In this case, where there is no autocorrelation, it means the data is valid.

SUPPORT FOR THE FINDINGS

There is a positive relationship between the Portfolio investment bonds (InPIBs) and infrastructure development index. For every 0.007-unit dollar of PIB, there is a corresponding infrastructure of 3.184. Similar to other previous studies, by Kodongo and et al (2023), Mukoki and et al (2023), and Ojah and et al (2022), They indicated a positive relationship between corporate bonds and infrastructure investment gap. The same studies ascertained a negative relationship between government bonds and infrastructure investment gap.

CONCLUSION

our study suggests that there is a statically significant relationship between each portfolio investment dollars in infrastructure by realizing the full potential of portfolio investment bonds in driving infrastructure development requires addressing a myriad of challenges and capitalizing on emerging opportunities. Emphasis on savings increment, financial market infrastructure reforms, Regulatory reforms, transparency enhancement, trust among the bond market players, investor protection, and risk mitigation frameworks are essential to attract private capital and foster infrastructure financialization in Africa.

5. Areas for Future research.

This study limited itself to African countries issuing Portfolio investment bonds and the composite infrastructure index. This was the best suited study at the time due to the researcher's data accessibility, knowledge and time. Other studies can extend to other continents, or specific infrastructure types like the energy sector.

Funding

The research is financed by the Government of Uganda through Makerere University.

Institutional Review Board Statement.

This study does not involve human beings or animals, thus no need for an institutional review board statement.

Informed Consent Statement

The study does not involve human resource participation, hence no need for informed consent.

Data availability statement.

The data used are available from the corresponding author upon request.

Conflicts of interest

The authors declare no conflict of interest.

References:

1. Adelegan, Olatundun, and Risto Herrala. 2023. *Debt in Developing Countries Debt in Developing Countries Expert Views from Sub-Saharan Africa*.
2. AfDB. 2018. "The Africa Infrastructure Development Index." *European University Institute* 2–5.
3. Agliardi, Elettra, and Rossella Agliardi. 2019. "Financing Environmentally-Sustainable Projects with Green Bonds." *Environment and Development Economics* 24(6):608–23. doi: 10.1017/S1355770X19000020.
4. Ahwireng-Obeng, Asabea Shirley, and Frederick Ahwireng-Obeng. 2022. "Corporate Bond Issuance Behaviour in African Emerging Markets." *Journal of African Business* 23(1):126–45. doi: 10.1080/15228916.2020.1826853.
5. Alam, Azhar., Ririn Tri. Ratnasari, Wiwin. Sawinda, and Muhammad Hanif AlHakim. 2023. "HOW DOES SUKUK INVESTMENT PERFORM? A LITERATURE REVIEW Article History : Keywords : Investment ; Sukuk Performance ; Systematic Review ; Islamic Finance ; Alam , A ., Ratnasari , R . T ., Sawinda , W ., Hakim , M . H . A . (2023) How Does Sukuk Investm." *International Journal of Professional Business Review* 8(April):1–21.
6. Andersen, Poul Houman, and Hanne Kragh. 2010. "Sense and Sensibility: Two Approaches for Using Existing Theory in Theory-Building Qualitative Research." *Industrial Marketing Management* 39(1):49–55. doi: 10.1016/j.indmarman.2009.02.008.
7. Anon. 2023a. "DEVELOPMENT OF A RISK MANAGEMENT MODEL FOR PUBLIC- PRIVATE PARTNERSHIPS IN UGANDA . by Bonny Bagenda Student Number : 24105953 Dissertation Presented in Fulfilment of the Requirements for the Degree of Doctor of Philosophy in Public and Development Manage." (March).
8. Anon. 2023b. "No 主観的健康感を中心とした在宅高齢者における 健康関連指標に関する共分散構造分析Title." 1–14.
9. Baškarada, Saša, and Andy Koronios. 2018. "A Philosophical Discussion of Qualitative, Quantitative, and Mixed Methods Research in Social Science." *Qualitative Research Journal* 18(1):2–21. doi: 10.1108/QRJ-D-17-00042.
10. Cevik, Serhan, and João Tovar Jalles. 2020. "This Changes Everything: Climate Shocks and Sovereign Bonds." *IMF Working Papers* 20(79). doi: 10.5089/9781513546216.001.
11. Chuku, Chuku, Anthony Simpasa, and Akpan Ekpo. 2023. "Catalysing Regional Integration in Africa: The Role of Infrastructure." *World Economy* 46(2):472–95. doi: 10.1111/twec.13364.
12. Enablers, National. n.d. "National Enablers for Infrastructure INVESTMENT AND ECONOMIC DEVELOPMENT IN SECONDARY CITIES IN GHANA AND UGANDA."
13. Fioravanti, Reinaldo, Carolina Lembo, and Akash Deep. 2019. "Filling the Infrastructure Investment Gap . The Role of Project Preparation Facilities : An Overview of MDBs and the Inter-American Development Bank Approach V Ice Pre s Idency for Countrie S."

14. Gorelick, Jeremy. 2018. "Supporting the Future of Municipal Bonds in Sub-Saharan Africa: The Centrality of Enabling Environments and Regulatory Frameworks." *Environment and Urbanization* 30(1):103–22. doi: 10.1177/0956247817741853.
15. Gorelick, Jeremy. 2019. "Municipal Bonds in Sub-Saharan Africa: The Checkered Past of Debt Instruments in an Era of Incomplete Decentralization."
16. Guo, Dong, and Peng Zhou. 2023. "The Evolution of Financial Market Infrastructure: From Digitalization to Tokenization." *International Journal of Innovation and Entrepreneurship* 2(1):1. doi: 10.56502/ijie2010002.
17. Kodongo, Odongo, Paul Mukoki, and Kalu Ojah. 2023. "Bond Market Development and Infrastructure-Gap Reduction: The Case of Sub-Saharan Africa." *Economic Modelling* 121(November 2021):106230. doi: 10.1016/j.econmod.2023.106230.
18. Ledhem, Mohammed Ayoub, and Mohammed Mekidiche. 2021. "Islamic Finance and Economic Growth Nexus: An Empirical Evidence from Southeast Asia Using Dynamic Panel One-Step System GMM Analysis." *Journal of Islamic Accounting and Business Research* 12(8):1165–80. doi: 10.1108/JIABR-03-2021-0107.
19. Lindner, Peter, and Kay Chung. 2023. "Sovereign ESG Bond Issuance."
20. Mawejje, Joseph, and Ezra Munyambonera. 2017. "Financing Infrastructure Development in Uganda." *Economic Research Centre* (130):36.
21. Mayer, Martin, and Lauren Wargo. 2023. *Book Review: Innovative Infrastructure Finance: A Guide for State and Local Governments*. Vol. 28.
22. Mukoki, Paul Shepherd. 2022. "INFRASTRUCTURE FINANCING AND BOND MARKETS DEVELOPMENT IN SUB-SAHARAN AFRICA By." (October).
23. Musah, Alhassan, Bernard Badu-Acquah, and Eunice Adjei. 2019. "Factors That Influence Bond Markets Development in Ghana." *Jurnal Perspektif Pembiayaan Dan Pembangunan Daerah* 6(4):461–76. doi: 10.22437/ppd.v6i4.6075.
24. Nuwagaba, Geoffrey, Festo Nyende, and David Namanya. 2021. "Financing Options and Sustainable Small Business Growth in Uganda: An Optimal Model." *International Business Research* 14(10):85. doi: 10.5539/ibr.v14n10p85.
25. Oji, Chijioke Kennedy. 2015. "Bonds: A Viable Alternative for Financing Africa's Development." *Occasional Paper 211 - Economic Diplomacy Programme* March:1–24.
26. Omotor, Douglason, and Juliet Elu. 2020. *Financing Africa 's Development Paths to Sustainable Economic Growth*.
27. sekitoleko, Isaac. 2018. "Leveraging Regional Capital Markets to Finance Uganda's Infrastructure Projects." *SSRN Electronic Journal* (August). doi: 10.2139/ssrn.3182243.
28. Sklair, Jessica, and Paul Gilbert. 2022. "Giving as 'De-Risking': Philanthropy, Impact Investment and the Pandemic Response." *Public Anthropologist* 4(1):51–77. doi: 10.1163/25891715-bja10033.
29. Tian, Yifeng, Zheng Lu, Peter Adriaens, R. Edward Minchin, Alastair Caithness, and Junghoon Woo. 2020. "Finance Infrastructure through Blockchain-Based Tokenization." *Frontiers of Engineering Management* 7(4):485–99. doi: 10.1007/s42524-020-0140-2.
30. UNDP. 2021. "Integrated National Financing Frameworks Stocktake." (87):1–4.
31. Wanta, Derry, Khomsiyah Khomsiyah, and Juniati Gunawan. 2023. "Blue Finance: Is This Supporting SDG 14 Financing Gap." *International Journal of Social and Management Studies (Ijosmas)* 4(1):93–105.

32. World Bank. (2020). World Development Report 2021: Data for Better Lives. Retrieved from www.worldbank.org/en/publication/wdr2021
33. World Health Organization (WHO) and UNICEF. (2021). Progress on Household Drinking Water, Sanitation and Hygiene 2000-2020: Five Years into the SDGs. Retrieved from washdata.org/sites/default/files/documents/reports/2021-06/JMP-2021-wash-households.pdf
34. World Bank. (2018). Africa's Pulse, No. 18, April 2018: Infrastructure Finance Trends in Africa. Retrieved from documents.worldbank.org/curated/en/999041524204948745/pdf/126565-REVISED-PUBLIC-Africas-Pulse-April-2018.pdf