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China's infrastructure investments in Africa: An imperative for attaining sustainable development goals or a debt-trap?

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ABSTRACT

In recent times, China, as part of its 'Going Global Strategy', has extended its developmental aids to countries in Africa. Being the largest country-to-country lender in the world, China has become the largest supplier of infrastructural finance and second largest source of foreign direct investments (FDI) to Africa. Some scholars have expressed concern that the engagement is a debt trap, a ruse towards modern neo-colonization and resource extinction in Africa. However, others have documented the significance of such investments in attaining SDGs. In this paper, we employ the Heckman two-stage model and logistic regression to predict the debt-trap crisis in Africa and the results establish no debt-trap for China's infrastructure investments in Africa. Contrary to the belief on resource-seeking motive, we find that commodity-based infrastructure loan reduces debt burden on African countries, albeit other inherent factors contribute to the upsurge of government debt. Furthermore, we test the impact of China's infrastructure investments on achieving the sustainable development goals (SDGs) in Africa, specifically SDG 3 (human development) and SDG 7 (environmental sustainability through access to modern energy). While our study reckons that China's infrastructure investment is beneficial for SDG attainment, we recommend that fiscal policy governing foreign financial flows should be periodically reviewed to avoid debt overhang.

1. Introduction

The African continent accounts for about 2% of global economic activities despite being the second-most populous and second-largest continent in the world (Kiran, 2021). A major contributor to Africa's low level of economic activities is the infrastructure investment gap which has exacerbated the cost of doing business relative to other continents (World Bank, 2017). Consequently, in recent years, infrastructure investment has become a policy priority for most African economies, as it serves as a catalyst for attaining sustainable development goals (SDGs). However, despite the efforts of governments to improve infrastructure, the rating of African countries on global infrastructure index still remains manifestly inadequate, as they are often placed towards the bottom of the rankings. Infrastructure gaps in Africa can be attributed to obstacles in accessing the finance needed for developmental projects such as roads, bridges, ports, technology, and railways. According to the World Bank (2017), Africa is likely to consistently achieve a growth rate of 1.7% per annum if the infrastructure gap is closed. Therefore, external finance is critical to accelerate growth and development in Africa.

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For decades, significant interventions to bridge the infrastructure gap have been made through the concerted efforts of traditional donors such as the World Bank, International Monetary Fund (IMF), United States of America, United Kingdom, Paris Club and European Union. Although most of the investments from these donors are through the lens of development aids, nonetheless, the problem of infrastructure gap persists on the continent. More so, the severe economic decline caused by the COVID-19 epidemic has greatly impacted numerous African countries, leading to significant fiscal distress, low revenues, high domestic spending, and escalating debt levels, thus posing a huge concern in their pursuit of attaining the SDG targets (Changwony & Paterson, 2019; Osakede & Adeleke, 2022).

Prior to the COVID-19 pandemic, the aggregate external debt of the African continent had grown from an estimated US$305 billion in 2010 to more than US$ 665 billion at the end of 2019 (more than a 218 percent increase) with an average of debt to Gross Domestic Product (GDP) ratio rising from 40% in 2010 to 59% in 2018 (World bank, 2019). According to IMF (2018), it was observed that many sub-Saharan African nations had exceeded the debt to GDP ratio benchmark of 60% established by the African Monetary Co-operation Program (AMCP) for economies in the developing stage. These circumstances have significantly curtailed the capacity of these nations to get funding for budgetary shortfalls and novel development initiatives. The potential for debt unsustainability is looming, if not already realized, thus raising serious concerns on multinational fronts.

In recent times, China, as part of its 'Going Global Strategy', has extended its development aids to countries in Africa. Being the largest country-to-country lender in the world, China has become the largest supplier of infrastructural finance and second largest source of foreign direct investments (FDI) to Africa (AidData, 2019; Brautigam & Hwang, 2016). These finance deals appear attractive that majority of the governments in Africa have engaged with the Chinese state-owned enterprises (SOEs) via infrastructure projects. A report by China-Africa Economic and Trade Relationship shows that China has successfully built a total of 25 economic and trade cooperation zones across 16 African nations, thus positioning China as the foremost trading partner for Africa. Furthermore, the report reveals that Chinese investors have allocated approximately USD 735 billion to various firms in Africa as of the year 2020, thus placing Africa as the second most significant beneficiary of Chinese outbound investments (also see Figs. 1 and 2 in the appendix for the distribution of China's outward investment). Anecdotal evidence reveals that China's foreign direct investment (FDI) to Africa had a remarkable increase of eighty-five times, rising from less than $0.5 billion in 2003 to $43 billion in 2017. Essentially, China's increasing economic footprint and political influence in Africa have garnered substantial attention from academic and global perspectives.

A strand of the literature has tagged China-Africa relationship a debt trap, a tool of modern neo-colonization and resource extinction (Babatunde, 2013; Cheung et al., 2012, pp. 419–444; Moody, 2011). Kiran (2021) reports that as of 2020, 45% of total government debts owed in Africa are obligations to China through the influx of China's infrastructure investment on the continent. These investments entail loans, FDI, grants, resource for infrastructure (R4I) among others, with loans constituting a major part (Pigato & Tang, 2015; Brautigam & Gallagher, 2014). While there are several existing studies on China-Africa engagement (see, for example, Carrai, 2021; Cheung et al., 2012, pp. 419–444; Donou-Adonsou & Lim, 2018), little empirical attention is given to the implications of such infrastructure investments on debt trap paradigm. A debt trap is a major fiscal circumstance in which countries are forced to look for further credit in order to pay off prior debts, leading to a vicious cycle of fiscal distress (Osakede & Adeleke, 2022; Ostadi & Ashja, 2014; Swamy, 2020). Such countries have more debt than they can afford to pay back, which creates a cycle of borrowing and can cause severe socio-economic and political implications.

Many African countries have become enmeshed in debt traps as a result of substantial borrowing, frequently for the purpose of infrastructure development. As a result, there has been a rise in reliance on foreign lenders and a decrease in the ability to allocate funds towards development projects. Most studies on China-Africa debt trap diplomacy are basically anecdotal, consulting reports, conceptual review, and media publication (for example: Brautigam, 2020; Addi et al., 2020; Were, 2018, pp. 1–13). As external borrowing levels continue to surge in Africa, there is need for empirical evidence to clear the controversy surrounding the China-Africa interaction and the implications for African government national debts. Furthermore, to the best of our knowledge, there is no study that has explored the link between China's infrastructure investment and SDG attainment in Africa. This is crucial given that the primacy of these infrastructure loans is predicated on improving the socio-economic wellbeing of the African continent. While previous

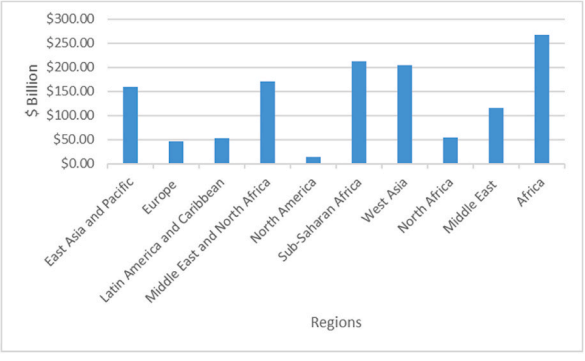


Fig. 1. Distribution of China's OII across regions of the World
Source: China Global Investment Tracker, 2021

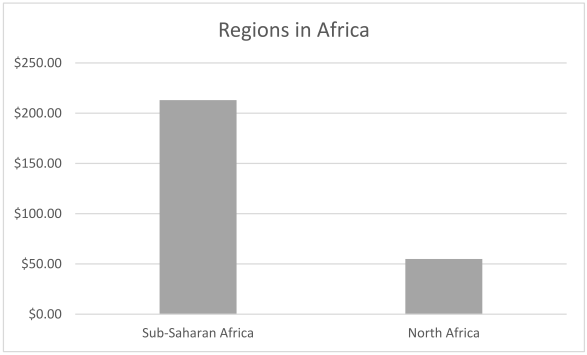


Fig. 2. Distribution of China's OII across regions and sectors in Africa.

studies have reported the effect of China's infrastructure investment on economic growth and poverty reduction (Amighini et al., 2013), our focus in this study is also to consider aspects of human development (SDG 3) and environmental sustainability through access to modern energy (SDG 7). By addressing these areas, we intend to illuminate the potentials of these infrastructure investments to significantly advance SDGs in Africa.

To achieve our objectives, we use a panel data of 54 African countries for the period 2005 to 2019. The results obtained from Heckman two-stage model ascertain no debt -trap paradigm for China-Africa infrastructure interactions. Moreover, when we classify debt into short and long terms, we also obtain evidence for no debt-trap between R4I and short-term debt sustainability. For the SDG variables, we find that there is a significant positive impact of China's infrastructure loans on human development and environmental sustainability. This may not be surprising given that these loans are deployed towards growth-promoting activities in Africa, including clean power generation and construction of educational facilities, thus creating jobs and enhancing human development. Given our results, we contribute to the literature in at least three ways. First, our results contribute to the literature on foreign investments and economic prosperity of the recipient country. Based on our results which indicate that China's infrastructure investment is beneficial in bridging the infrastructure gap on the African continent, we contend that such investments are essential to achieving the SDGs. Importantly, while existing studies on China-Africa partnership majorly focus on the economic values (Amighini et al., 2013), there is no evidence, to the best of our knowledge, on how Chinese investments in Africa impact the attainment of SDGs. Moreover, since a thread of research documents that Chinese investors prioritize the prosperity of African continent (Cheung et al., 2012, pp. 419–444; Hendrix, 2020), we anticipate that China's infrastructure investments would play a vital role in expediting the attainment of SDGs in Africa.

Second, in addition to the widely used proxy for infrastructure investments - the value of Chinese investments in a country -, we also adopt a new measure called *resource for infrastructure (R4I)*. R4I is a unique form of commodity-based investment which involves servicing the infrastructure loan with natural resources instead of actual money (Brautigam & Gallagher, 2014). China has provided funding for a variety of infrastructure projects in Africa through R4I. Notable examples include the Addis Ababa-Djibouti Railway, Lagos and Abuja Light rail projects in Nigeria and the Standard Gauge Railway in Kenya. Considering this form of infrastructure investments in our analysis provides fresh information to relevant stakeholders. Third, unlike existing studies, we offer new empirical evidence by employing logistic regression to predict debt-trap crisis of countries in Africa. This approach shows improved prediction accuracy over traditional models and provides empirical basis for future similar studies.

The rest of the paper continues as follows. The next section discusses the literature review, underlying theories and hypothesis development. This is followed by explanation of the data collection methods, estimation techniques and measurement of variables. Section 4 discusses the empirical results, and the paper is concluded in section 5.

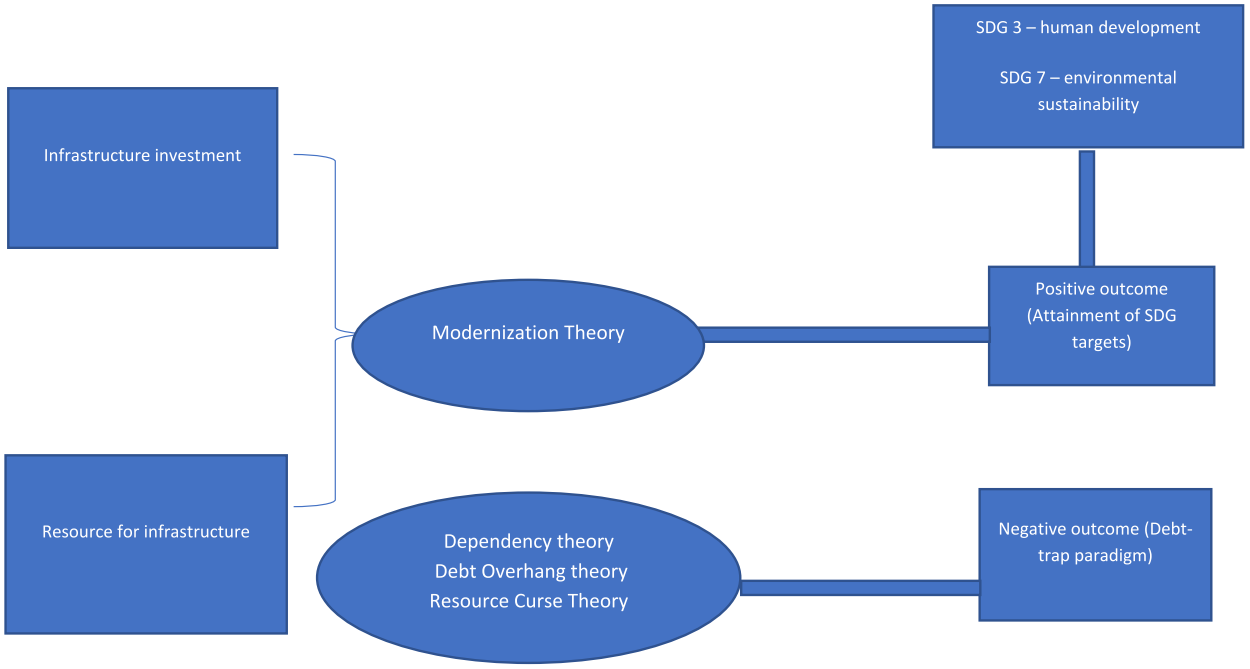
2. Related literature, underlying theories, and hypotheses development

A substantial body of research has focused on the relationships between foreign investment, trade patterns, and economic growth in developing countries. Studies broadly affirm that Foreign Direct Investment (FDI) can substantially benefit host economies, mainly when supported by adequate infrastructure, skilled human capital, strong institutions, and effective policies (Asiedu & Esfahani, 2001; Agrawal, 2005). However, the extent and nature of these impacts can differ significantly depending on the context, sector, and type of FDI (Bertrand et al., 2004). While existing literature has deepened our understanding of the link between FDI and economic forces, there remains a paucity of systematic evidence on the specific impacts of China's infrastructure investment, a notable category of foreign investment, on debt sustainability and the attainment of sustainable development goals.

China's infrastructure investment typically involves financial inflows into sectors such as transportation, energy, agriculture and utilities, often facilitated through bilateral agreements or by Chinese state-owned firms. These investments have garnered praise for their role in infrastructure development and criticism for potentially fostering economic dependencies (Brautigam & Gallagher, 2014). Critics argue that such dependencies can lead to unsustainable debt levels, potentially resulting in a "debt trap." The term "debt-trap diplomacy" describes a scenario where a creditor extends excessive credit with the ulterior motive of extracting economic or political concessions from a debtor country unable to fulfil its repayment obligations (Sun et al., 2017). The correlation between high debt-to-GDP ratios and susceptibility to debt traps highlights this concern (Zeng, 2019).

Many African countries now face significant debt obligations to China, which may restrict their economic policy freedom and exacerbate economic vulnerabilities. Anecdotal analysis by Sun et al. (2017) pointed out that while State-Owned Enterprises (SOEs) have supported job creation and infrastructure expansion, they frequently promote dependency as local firms struggle to compete against well-supported Chinese companies, creating an economic imbalance. Zeng (2019) further demonstrates this through case studies in Zambia and Ethiopia, where Chinese investments in major infrastructure projects have not only bolstered dependency but also typically imposed conditions that bind recipient countries to Chinese contractors and suppliers, thus limiting their economic sovereignty.

In this study, we aim to elucidate the relationship between China's infrastructure investment, debt sustainability and SDG attainment, employing theories of dependency, debt overhang, resource curse and modernization.



2.1. Dependence, debt overhang and resource curse theories

From a theoretical perspective, dependence and debt overhang theorists suggest that external finance may not always foster sustainable economic development. Dependence theory, introduced by Prebisch (1950), contends that the economic development of poorer nations is limited by their dependence on wealthier countries. This dependence extends beyond financial aspects to include technological and managerial reliance. This creates an imbalanced economic relationship where wealthier nations disproportionately benefit (Frank, 1967; Prebisch, 1950). For example, large-scale Chinese infrastructure investments in Africa, aimed at spurring development, might instead exacerbate economic dependency (Mthembu, 2020; Were, 2018, pp. 1–13). These investments address infrastructural deficits and promote growth, yet they tie the recipient countries to China's financial and technical resources.

Similarly, the debt overhang theory, formulated by Krugman (1988), posits that high debt levels can impede economic growth by discouraging new investment. In the African context, countries laden with significant debts may appear less attractive to other potential lenders, given that new loans might merely serve to pay off existing debts rather than foster growth (Panizza et al., 2009). The risk escalates if financed infrastructure projects fail to yield expected returns, thereby increasing debt burdens and perpetuating a cycle that discourages new loans and stifles economic growth, potentially leading to a debt crisis (Reinhart & Rogoff, 2010).

Empirical research further substantiates these theories. Krugman (1988) finds that an overhang effect is particularly pronounced in countries where public debt exceeds 60% of GDP, deterring investors who fear their returns might be diverted to debt servicing. Conversely, in their extensive analysis of data from over 44 countries, Reinhart and Rogoff (2010) reveal that debt-to-GDP ratios above 90% are associated with lower growth rates. Revisiting their earlier findings during the European sovereign debt crisis, Reinhart and Rogoff (2011) observed significant growth slowdowns in countries like Greece, Spain, and Portugal, where high debt levels deterred investment and necessitated severe austerity measures. Panizza and Presbitero (2013) similarly concluded that high public debt levels during the European debt crisis were linked to reduced economic growth. Eberhardt and Presbitero (2021) has also shown that high debt-to-GDP ratios in various African and Latin American countries correlate with lower growth rates and investment levels, reinforcing the debt overhang theory.

These high debt levels are often characterised by a significant dependence on external finance, increasing vulnerability to financial shocks and volatility (Smith, 2020). Different studies by Prebisch (1950) and Frank (1967) demonstrate how Latin American countries remain economically dependent on developed nations despite their natural resource wealth. This dependence, characterised by the export of raw materials and the import of manufactured goods, resulted in a persistent trade imbalance that hindered local industrial development. This trend, also observed in various African countries, shows how foreign direct investments often result in wealth extraction by multinational corporations, leaving little behind in terms of sustainable development (Dos Santos, 1970; Gallagher & Porzecanski, 2010). Reports by international bodies such as the IMF (2018) and the World Bank (2019) have echoed these concerns, indicating that while external financing, including Chinese loans, has enabled infrastructure development in low-income countries, it has also raised significant risks related to debt sustainability and economic stability. In the context of global interaction and government debt in African countries, Bataka (2019) used second-generation panel data tools to find that economic globalisation increases government debt in the short run but decreases it in the long run. Using Turkey as a case study, Barıs, 2019 adopted the KOF index to measure economic globalisation and showed that it exerts upward pressure on the external debt of developing countries. Similarly, Waheed (2017) investigated the determinants of external debt in oil and gas-oriented countries (importing and exporting) from 2004 to 2013. The author found mixed results, with FDI increasing government debt in oil and gas-importing countries but decreasing external debt in exporting countries. This body of evidence underscores the complex interplay between dependence and debt overhang in shaping economic outcomes. We can deduce that while infrastructure investments are intended to spur growth, the immediate effect of large-scale financing may increase national debt relative to GDP. Hence, we postulate our hypothesis as follows.

H1a. China's infrastructure investment is associated with an increase in the debt-to-GDP ratio of African countries, indicating a potential debt trap.

When analysing China-Africa relations, a careful assessment of the nature and implications of resource for infrastructure (R4I) model is necessary to ensure the sustainability of resources. The R4I model, as described by Dreher et al. (2021), is a type of financial arrangement that, while offering a solution to infrastructure financing, also carries significant risks. It involves a country, rich in natural resources, securing financing for infrastructure projects by leveraging its natural resource wealth. The borrowing country agrees to supply natural resources, such as oil, minerals, or gas, to the lending country or its companies in exchange for infrastructure development, such as roads, railways, hospitals, and schools (Menegazzi, 2018).

Brautigam and Gallagher (2014) assessed the infrastructure investments in Latin American and African countries during 2003–2011 and found that about 56% of infrastructure investments are R4I. Collier (2007) also highlights that such investments, while providing financial opportunities and infrastructure development, may also perpetuate a resource curse and hinder African nations' long-term economic diversification and stability. The resource curse theory posits that countries blessed with abundant natural resources, such as gas, crude oil, or minerals, often face adverse economic and political outcomes instead of reaping the benefits from their resource wealth (Auty, 1993). This phenomenon can result in corruption, economic mismanagement, and social inequality, hindering sustainable long-term development (Sachs & Warner, 2001).

Ideally, African governments might prefer the R4I model over non-R4I models because it is easier and less risky to repay loans with available natural resources than to source revenue for repayment or wait for the infrastructure to yield returns. However, the indebtedness would be severe if the motivation of China's infrastructure investment is to gain exclusive access to natural resources (Were, 2018, pp. 1–13). Ross (2012) supports this view, indicating that reliance on natural resources can trap countries in a cycle of economic volatility and governance challenges. Menegazzi (2018) has also highlighted instances where countries engaging in R4I agreements with China experienced significant increases in their debt burdens without corresponding economic growth, thus exacerbating the resource curse. Thus, we hypothesise that.

H1b. Resource-for-Infrastructure (R4I) model is associated with an increase in the debt-to-GDP ratio in African countries, thus suggesting a debt trap.

2.2. Modernization theory

Modernization theorist, Rostow (1960), contends that strategic investments can catalyse economic growth and modernization, thus presenting an alternative to dependence and debt overhang theories. Well-managed investments have the potential to foster economic development, achieve sustainable development goals and mitigate the risks associated with debt distress (Todaro & Smith, 2015). Rostow (1960) asserts that financial and technological inputs from developed nations are crucial for the economic upliftment of developing countries. Such investments are pivotal in constructing essential infrastructure that promotes economic growth and modernization (Calderon & Serven, 2010). This influx of capital, technology, and expertise from more advanced economies can expedite the development process in less-developed regions by establishing the foundations for industrialisation and broader economic expansion (Todaro & Smith, 2015).

In the context of African nations, investments in infrastructure by China are seen as beneficial drivers for growth. These investments could potentially address structural impediments and pave the way for consistent economic growth. For instance, upgrading transportation infrastructure can diminish logistics costs and broaden market access for local enterprises, while improving energy infrastructure can facilitate industrial activities, improve environmental sustainability and enhance human development (Lerner, 1968). The core assertion is that infrastructure investments enhance economic growth, which in turn bolsters debt sustainability through increased revenue generation (Hoselitz, 1960).

Extant studies support the positive impact of infrastructure investments on economic growth in African countries. For instance, a study by Dreher et al. (2021) found that Chinese infrastructure investments in Africa have led to significant improvements in transportation networks, reducing logistics costs and increasing market access. They also show that Chinese infrastructure projects in Africa are associated with significant economic growth in recipient countries, leading to improved public revenues. Similarly, Calderon and Serven (2010) highlight that infrastructure development significantly contribute to economic growth in Sub-Saharan Africa. A report by the World Bank (2019) further emphasises that improved infrastructure, particularly in the transportation and energy sectors, has increased productivity and economic activities in various African countries. Furthermore, a case study on Kenya by Muchira (2018) demonstrates that China's infrastructure projects, such as the Standard Gauge Railway, have reduced transportation costs and enhanced trade efficiency, boosting economic growth.

Studies on public finance have also highlighted the positive impact of investments in reducing government debt. For instance, Swamy (2015) found that foreign direct investment (FDI) negatively affects government debt in the sovereign countries studied. In addition, Pyeman et al. (2016) conducted an empirical analysis of the determinants of government external debt in Malaysia from 1972 to 2012, reporting that FDI was one of the factors exerting downward pressure on external debt. Furthermore, Sinha et al. (2011) classified countries into middle-income and high-income categories, discovering a negative relationship between global interaction (FDI) and external debt in middle-income countries, while no such relationship was found for high-income countries. Thus, investments in infrastructure contribute to economic growth and ensure the attainment of SDGs by boosting productivity, facilitating trade, and attracting further investments. This economic expansion can also augment government revenues, thereby enabling countries to manage their debt obligations and enhance debt sustainability.

Hence, we postulate our hypothesis as follows.

H2. Chinese infrastructure investment is associated with attainment of SDGs and improved debt sustainability in African countries, thus suggesting no debt trap.

3. Data and methodology

3.1. Description of data and sources

We obtain data for this study from China Global Investment Tracker (CGIT), China-Africa Research Initiative (CARI), and World Development Indicators (WDI) database. Although forty-six (46) African countries have received China's infrastructure investments, but for this study, all the fifty-four (54) countries in Africa are sampled over the period 2005 to 2019 based on data availability. Meanwhile, six countries (Libya, Mauritania, Equatorial Guinea, Namibia, Seychelles, and South Sudan) with missing government debt data are dropped from the analysis. Our variables in this study are described as follows.

i. Dependent variable

Government borrowing (*GB*): Our first dependent variable in our empirical model is the value of African government external borrowing scaled by GDP. The annual data on external debt (including short- and long-term debt) and GDP are sourced from the World Development Indicators (WDI) database of the World Bank.

Sustainable Development Goals (SDGs): Our next dependent variables are SDG 3 representing human development and SDG 7 which denotes environmental sustainability through access to modern energy. To proxy human development, we use the human development index (HDI) developed by the United Nations, sourced from the United Nations Development Programme (UNDP) database. The HDI of a country evaluates the standard of living and well-being of its populace and ranges between 0 and 1 (Etudaiye-Muhtar et al., 2024; Johan et al., 2023). For environmental sustainability, we use data for access to clean and affordable energy, sourced from World Development Indicators of the World Bank. This proxy specifically examines a country's performance in terms of universal energy efficiency, reliability, affordability, and sufficiency (Sakariyahu et al., 2024).

ii. Explanatory variables

Infrastructure investment: This is the main explanatory variable which is proxied by three indicators. (1) the total amount of infrastructure investment received by each African country from China, (2) a dummy variable which takes the value of one if a country in Africa received China's infrastructure investment, otherwise it is zero, (3) a dichotomous variable that takes value of 1 if a country received infrastructural loan for the R4I deal with the Chinese, otherwise zero. Data for the first two variables are sourced from the CGIT database while data for the third is obtained from China-Africa Research Initiative database.

iii. Control variables

Following the current body of literature on external financing, we adopt relevant control variables (Barıs, 2019; Bataka, 2019; Gargouri & Keantini, 2016; Swamy, 2015). These include GDP growth rate, domestic investment of the country, interest rate, inflation rate, exchange rate, institutional quality, existing infrastructure, trade openness, population growth, and legal origin. Gross domestic product growth rate (*GDP*) is a proxy for market seeking motive and measures the growth rate of the host country. The data for this variable is collected from the World Development Indicators (WDI) database. Institutional quality *(INQ)* is a measure of the quality of

governance. This is an arithmetic mean of six governance indicators namely, rule of law, control of corruption, voice and accountability, political stability, government effectiveness and absence of violence/terrorism. For each indicator, countries are allocated ranks between 2.5 and −2.5. Trade openness (*TO*) is measured as the ratio of trade (exports plus imports) to GDP. This shows the extent to which a country is open to external trade. Natural resources (*NR*) are measured as the total natural resources rent to GDP. It is a proxy for resource seeking motive. Exchange rate (*EXC*) is the real exchange rate of the host country. Existing Infrastructure (*INF*) shows the broadband subscriptions per 100 people. It indicates the presence of communication services and infrastructure in the host country, thus enhances flow of goods and information. Population growth is measured as the annual growth rate of the country's population. Legal origin *(LO)* is a dichotomous variable that takes the value of one if the African country is a country that practices British common law, otherwise it is zero for French civil law. The information on legal origin is sourced from the work of La-Porta et al., (1999). In line with law and finance theory, La-Porta et al., (1999) argues that British common law offers investors stronger protection than French civil law. Domestic investment (*DI*) is measured as the ratio of African countries' gross capital formation to GDP. Interest rate *(INR)* is the rate of return on investment of the host country. Inflation rate (*INFL*) is annual rate of change in consumer price index. The data is sourced from the CGIT database.

3.2. Model specification

We use Heckman two-stage model to assess the impact of China-Africa interaction via infrastructure projects on government borrowings in Africa. The econometric benefit of using Heckman is that it overcomes sample selection bias and by including exclusion restriction (ER) variables, it solves endogeneity issue. With a valid ER, Inverse Mill Ratio and Z, the vector in the selection equation will be less correlated. Supporting the assertion, Heckman and Vytlacil (2001) show that including at least one variable in selection equation which has little power to predict the outcome will reduce multicollinearity among the predictors as well as correlation between error terms.

We derive our probit model that allows *Probability* $(Recipient_{it} = 1)$ to depend on theoretically informed macro-economic variables such as the control variables stated above. We introduce belt and road initiative (BRI) as an exclusion restriction variable in the Heckman first stage model. Belt and road initiative (*BRI*) is a dichotomous variable that assesses the mode of entry surrounding China's infrastructure investment. It takes the value of one if a country in Africa received China's infrastructure investment tied with belt and road initiative, otherwise it is zero if it is greenfield and others. BRI sees infrastructure as crucial to economic development. It includes investment in transport connectivity, nuclear power and tourism. External debt is taken in form of natural logarithm to reduce the possibility of heteroscedasticity. The specification of the probit model for the countries is as follows:

3.2.1. First stage estimation

$$\begin{aligned} Probability\ (Recipient_{it} = 1) = {} & \beta_0 + \beta_1 GDP_{it} + \beta_2 NR_{it} + \beta_3 INQ_{it} + \beta_4 TO_{it} + \beta_5 LO_{it} + \beta_6\ INF_{it} + \beta_7 ADV_{it} + \beta_8 INFL_{it} + \beta_9 ED_{it} \\ & + \beta_{10} EXC_{it} + \beta_{11} INR_{it} + \beta_{12} BRI_{it}\ \ \mu_i + \varepsilon_{it} \end{aligned} \tag{1}$$

Where the dependent variable is a dummy variable ($Recipient_{it}$), which takes the value of 1 if a country in Africa received infrastructure investment from China, and otherwise 0. Also, the exclusion research instrument are natural resources and belt and road initiative. According to Amighini et al. (2013) and Cheung et al. (2012, pp. 419–444), motive and mode of entry are germane for China-Africa interaction and can influence the decision of Chinese investors. Hence, these variables do not have direct influence on government borrowing. μ_i is the individual specific error component and ε_{it} is the basic error component.

3.2.2. Second stage estimation

In the second stage model, we introduce the dependent variables individually while infrastructure investment is the main explanatory variable. Then, we control for the standard determinants of government debt relevant to the study and include the Inverse Mills Ratio (IMR) generated from the first stage (model 1). Thus, we obtain the following empirical model:

$$\begin{aligned} DV_{it} = {} & \beta_0 + \beta_1 Investment_{it} + \beta_1 GDP_{it} + \beta_2 INQ_{it} + \beta_3 TO_{it} + \beta_4 LO_{it} + \beta_5\ INF_{it} + \beta_6 ADV_{it} + \beta_7 INFL_{it} + \beta_8 ED_{it} + \beta_9 EXC_{it} + \beta_{10} INR_{it} \\ & + \beta_{11} IMR + \mu_i + \varepsilon_{it} \end{aligned} \tag{2}$$

Where $Investment_{it}$ is proxied by two variables: infrastructure investment and resource-for-infrastructure. DV are the three dependent variables which are (i) the external debt to GDP ratio (in terms of debt sustainability), (ii) SDG 3 – HDI - and (iii) SDG 7 - environmental sustainability through access to modern energy -. *GDP* is the GDP growth rate, *INQ* is the institutional quality, *EXC* is the real effective exchange rate, *POPU* represents the population growth. *TO* is the trade openness, *DI* is the domestic investment, *LO* is the legal origin, *INR* is the interest rate, *INFL* represents the inflation rate, μ_i is the individual specific error component and ε_{it} is the basic error component. The explanations of the variables are in appendix 1. Additionally, we treat the country component as homogeneous individual and assume that some country characteristics remain constant across country and overtime.

3.3. Preliminary findings

Table 1 presents the summary statistics of the variables used in the empirical analysis. Overall, the mean value of external debt to GDP ratio is 0.38 with short-term and long-term debt sustainability of 0.06 and 0.30, respectively. However, these are aggregate values

of all the countries under study, the maximum values of these variables (in Table 1) show the unsustainable effects. The average value of China's infrastructure investment received by the continent is $459.35 million. Of this figure, Chinese project loans amount to $196.4 million, indicating that loans constitute major part of the total infrastructure investments into Africa (which is almost half of the total Chinese infrastructure investment). Moreover, the average value of Chinese infrastructure investment received by the sampled countries is $0.39 million. Conversely, about $0.05 million in commodity-based payment loan are received by countries in Africa. Furthermore, the average value of the economic size of the continent is 4.16%. Institutional quality has a negative mean of −0.69 which is an indicator of poor goverance in Africa. The sampled countries have an average of 66.75 for trade openness to GDP which implies that the African economy is open to the world for economic activities. The mean value of domestic investment is 21.53 which implies low level of acitivities. The output also shows mean value of population growth of 2.44%. Table 2 presents the correlation matrix of the variables under study. The Variance Inflation Factor (VIF) (see appendix 2) also shows that the values of the variables are below the benchmark of 10. Thus, both the correlation matrix and VIF provide support that multicollinearity is not a serious problem in this study.

4. Empirical results

4.1. The first stage estimation: examining factors that increase the probability of an African country being a recipient of China's infrastructure investments

Table 3 shows the results of first-stage Heckman selection model. It explains the probability that an African country is a recipient of China infrastructure investment (*Recipient)*. We find that GDP growth rate and natural resources are positively related with the probability that an African country is a recipient of China infrastructure investment (significant at 1%). This implies that African countries that have natural resource endowment and have large market size are more likely to receive China's infrastructure investment. These confirm the resource-seeking and market-seeking notions of China infrastructure investments in Africa. This corroborates with the assertion of Cheung et al. (2012, pp. 419–444) and Amighini et al. (2013). The estimated coefficient for external debt and trade openness are negative at 10% significance level. This shows that the more indebted a country is, the less likely that it would receive China infrastructure investment. With respect to trade openness, level of trade liberalization of an African country matters when it comes to China infrastructure investment. The estimated coefficient of existing infrastructure is positively significant at 1%. This means that countries with more infrastructural needs are more likely to be a recipient of China infrastructure investment in Africa. Estimated coefficient of legal origin is positively associated with China infrastructure investment at 5% level of significance. This implies that African countries that practice British common law are more likely to receive China infrastructure investment because of the level of their financial development, reinforcing the position of La-Porta (1999) The coefficient of belt and road initiative is positive and significant at 1%. It can be deduced that an African country that incorporates BRI in its policy is more likely to receive infrastructure investment from the Chinese.

Overall, the model performance is acceptable as shown by the Wald Chi-square test. The Wald test of the Probit model is highly significant which shows that coefficients of explanatory variables contribute significantly to the model (Heckman, 1979). Likewise, the reported McFadden pseudo-R-square is 0.3970 which indicates a reasonably good model fit. McFadden (1977) asserts that the rule of thumb for a good McFadden's pseudo-R-squared is usually set between 0.2 and 0.4.

Table 1
Summary statistics.

Variable	Obs.	Mean	SD	Min	Max
External debt to GDP	720	0.38	0.37	0.00	4.16
Short term debt to GDP	720	0.06	0.16	0.00	2.55
Long term debt to GDP	720	0.30	0.27	0.00	2.32
Recipient	720	0.39	0.49	0.00	1.00
Infrastructure Investment ($'million)	720	459.35	1023.14	0.00	8940.00
Resource for Infrastructure	720	0.05	0.22	0.00	1.00
Project Loan (($'million)	720	196.41	847.07	0.00	18817.00
GDP growth rate	720	4.16	4.10	−36.39	20.72
Domestic investment	720	21.53	11.89	−0.10	77.89
Interest rate	720	5.03	9.64	−78.52	52.44
Inflation rate	720	6.81	11.64	−8.97	255.30
Exchange rate ($)	720	38.53	48.51	0.00	142.60
Institutional quality	720	−0.69	0.61	−2.45	0.85
Existing infrastructure	720	0.80	2.24	0.00	24.20
Population growth	720	2.44	0.90	0.00	6.03
Trade openness	720	66.75	40.96	0.00	348.00
Natural resource	720	11.57	11.09	0.00	59.60
Legal origin	720	0.38	0.48	0.00	1.00
Belt and Road Initiative	720	0.18	0.38	0.00	1.00

Note: See Appendix 1 for definition and measurement of variables.

Table 2
Correlation matrix.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00														
2	−0.15[a]	1.00													
3	−0.16[a]	0.97[a]	1.00												
4	−0.04	0.27[a]	0.29[a]	1.00											
5	−0.09[a]	0.42[a]	0.45[a]	0.37[a]	1.00										
6	−0.05	0.08[a]	0.08[a]	0.11[a]	0.12[a]	1.00									
7	−0.05	0.20[a]	0.21[a]	0.10[a]	0.14[a]	0.07	1.00								
8	0.04	−0.01	−0.02	0.02	−0.09[a]	0.08[a]	0.02	1.00							
9	0.08[a]	0.11[a]	0.11[a]	0.06	0.09[a]	−0.06	−0.10[a]	−0.25[a]	1.00						
10	−0.15[a]	0.05	0.06	−0.02	0.03	−0.02	0.05	0.03	−0.03	1.00					
11	0.06	−0.03	−0.05	−0.18[a]	−0.05	0.13[a]	0.31[a]	0.13[a]	−0.05	0.03	1.00				
12	0.19[a]	0.02	0.01	−0.07[a]	−0.04	−0.06	0.28[a]	−0.04	−0.06	−0.01	0.38[a]	1.00			
13	−0.09[a]	0.09[a]	0.09[a]	0.17[a]	0.13[a]	0.19[a]	0.06	0.12[a]	0.03	0.07	−0.21[a]	−0.46[a]	1.00		
14	0.28[a]	−0.04	−0.05	0.09[a]	0.00	0.08[a]	0.39[a]	−0.02	−0.12[a]	0.00	0.16[a]	0.17[a]	−0.02	1.00	
15	−0.05	0.07	0.06	−0.09[a]	0.02	0.01	−0.12[a]	0.04	0.16[a]	0.25[a]	0.06	−0.17[a]	0.07	0.06	1.00

See Appendix 1 for definition and measurement of variables.
1- External debt to GDP.
2- Recipient.
3.-Infrastructure investment.
4- Resource for infrastructure.
5-Project loan.
6-GDP growth rate.
7- Exchange rate.
8- Domestic investment.
9- Interest rate.
10- Inflation rate.
11- Natural resources Institutional quality.
12- Existing infrastructure.
13- Population growth.
14- Trade openness.
15- Legal origin.
[a] Shows significance at 0.05 level.

Table 3
The first stage estimation: Examining factors that increase the probability of an African country being a recipient of China's infrastructure investments.

	Dependent variable
VARIABLES	Prob (Recipient = 1)
GDP growth rate	0.0498***
	(0.0160)
External debt	−0.0715*
	(0.0415)
Domestic investment	0.0019
	(0.0077)
Trade openness	−0.0049*
	(0.0027)
Natural resources	0.0375***
	(0.0073)
Legal origin	0.3614**
	(0.1441)
Institutional quality	−0.0094
	(0.1392)
Exchange rate	−0.0292
	(0.0662)
Existing infrastructure	0.0953***
	(0.0299)
Interest rate	0.0035
	(0.0062)
Inflation rate	0.0127
	(0.0091)
BRI	2.8340***
	(0.2216)
Constant	−1.9445***
	(0.2538)
Pseudo R^2	0.3970
Wald X^2	223.03***
Observations	720

Notes: This table reports the Probit estimation result in which the dependent variable is a dummy variable which show whether an African country is a recipient of China's infrastructure investment or not. Year and country dummies are included. Robust standard errors are in parentheses. Wald test Chi-squared and pseudo-R-squared represent the overall performance of the model. See Appendix 1 for definition and measurement of variables. ***, ** and * denote the statistical significance level at 1%, 5% and 10%, respectively.

4.2. Impact of infrastructure investment on total government borrowing of African countries

Table 4 shows the second-stage results of Heckman model with inclusion of inverse mills ratio (Lambda). Here, the dependent variable is the ratio of external debt to GDP. Under column one, the estimated coefficient of infrastructure investment is negative and significant at 5% level with external debt ratio. Invariably, hypothesis one is rejected which implies that Chinese infrastructure investments do not contribute to the incessant increase in government borrowing in Africa, indeed no-debt-trap paradigm in Africa. This opposes the assertions of debt overhang, dependence and resource curse. Moreover, it is consistent with the findings of Pyeman (2016) and Swamy (2015) but against the work of Bataka (2019). Specifically, in column two, we introduce another infrastructure investment variable "Resource for infrastructure (R4I)" to capture the theoretical effect of resource-seeking motive surrounding China's infrastructure investment. The estimated coefficient of resource-oriented investment is not significantly related to external debt ratio. It can be deduced that R4I does not exert downward nor upward pressure on government borrowing in Africa.

Regarding the control variables, the results in columns one and two are in tandem. The estimated coefficients of GDP growth rate are negative and significantly associated with government debt at 1% level. This shows that the growth in economies implies additional revenues for the government, as such no need to resort to external debt to bridge the infrastructure gap. Consequently, this exerts downward pressure on government borrowing in Africa. The coefficients of domestic investments are negatively and significantly related to government borrowing in Africa. Invariably, additional revenues are generated from the private investments which are useful for infrastructure development and debt services. Consequently, it reduces government indebtedness in Africa. The coefficients of interest rate are positive and significantly related to government borrowing in Africa. This suggests that interest rate exerts upward on the external debt. Basically, the increase in interest rate is supposed to attract investments for the government. An exception to this is if the loan investments are classified as China infrastructure loans and commodity-based payment loan. In this case, it would increase

Table 4
Impact of infrastructure investment on total government borrowing.

	(1)	(2)
Infrastructure investment	−0.0252**	
	(0.0109)	
Resource for infrastructure		−0.0494
		(0.0487)
GDP growth rate	−0.0100***	−0.0096***
	(0.0036)	(0.0037)
Domestic investment	−0.0063***	−0.0063***
	(0.0016)	(0.0017)
Interest rate	0.0035**	0.0036**
	(0.0015)	(0.0015)
Inflation rate	0.0043***	0.0044***
	(0.0012)	(0.0012)
Real Exchange rate	−0.0425***	−0.0429***
	(0.0124)	(0.0124)
Institutional quality	−0.0258	−0.0274
	(0.0266)	(0.0272)
Existing infrastructure	0.0507***	0.0515***
	(0.0074)	(0.0074)
Population growth	−0.0082	−0.0046
	(0.0157)	(0.0157)
Trade openness	0.0013***	0.0014***
	(0.0004)	(0.0005)
Legal origin	−0.0623**	−0.0634**
	(0.0301)	(0.0301)
Inverse mill ratio	−0.0115	0.0208
	(0.0287)	(0.0236)
Constant	0.3996***	0.3228***
	(0.0987)	(0.0933)
Observations	720	720
R-squared	0.233	0.229

Notes: This table reports the Heckman second stage regression results in which the dependent variable is external debt ratio. Infrastructure investment and real exchange rate are logged. Inverse Mills Ratio computed from the Probit regression is added. Year and country dummies are added. Robust standard errors are in parentheses. See Appendix 1 for definition and measurement of variables. ***, ** and * denote the statistical significance level at 1%, 5%, and 10%, respectively.

the debt burden of the government. As expected, the coefficients of inflation rate are positive and significant at 5% level. The increase in the general price level will lead to accumulation of interest rates and thus drive African governments to resort to external borrowing.

The coefficients of exchange rate are negative and significant at 1% level. This shows that the appreciation of the national currency against other currencies exerts downward pressure on government borrowing in Africa. This is because external debt is denominated in foreign currency and such appreciation will reduce the debt burden and debt servicing. The coefficients of existing infrastructure are positive and significant. This suggests that state of infrastructural development in Africa increases external borrowing. Invariably, government would resort to external debt if its sources of revenue are not enough to meet its infrastructure needs. The estimated coefficients of trade openness are positive and significant and therefore exert upward pressure on government borrowing in Africa. Under trade liberalization, trade deficit (where imports are greater than exports) would cause government to resort to external borrowing. Coefficients of legal origins are negative and significantly related to government borrowing. This can be argued that financial development enjoyed by those countries that practice common law is likely to reduce external debt. As seen from Table 4, inverse mills ratio (lambda) coefficients are not significant, indicating no serious bias in the sample selection.

4.3. Impact of infrastructure investment on short-term and long-term government borrowing in Africa

To best capture the specific reaction of the explained variable, we divide external borrowings into short- and long-term borrowings. Table 5 shows the second stage results of Heckman model with inclusion of inverse mills ratio for government's short-term borrowing. Overall, the estimated coefficient of the amount of investment is insignificant while R4I is negative and significant. Invariably, R4I exerts downward pressure on short term debt ratio. This is contrary to the negative outcome beliefs, thus conforming with the modernization theory. From the angle of long-term external debt, in Table 6, the signs and significant levels of the interaction variables (infrastructure investment and R4I) and the control variables are in tandem with the results obtained for total external debt ratio in Table 4. Hence, infrastructure investment decreases long-term external debt in Africa. This further strengthens the modernization theory.

Regarding the institutional quality and legal origin coefficients, we note that a law-abiding institution would allow for efficient use of resources and accountability in revenues generated to meet its need and thus reduce reliance on the short-term debt. Other control

Table 5
Impact of infrastructure investment on short-term government borrowing.

	(1)	(2)
Infrastructure Investment	−0.0003	
	(0.0040)	
Resource for infrastructure		−0.0481**
		(0.0192)
GDP growth rate	−0.0001	0.00096
	(0.0010)	(0.00097)
Domestic investment	−0.0028***	−0.0028***
	(0.0009)	(0.0009)
Interest rate	0.0005	0.0006
	(0.0008)	(0.0008)
Inflation rate	0.0009*	0.0010*
	(0.0005)	(0.0005)
Exchange rate	−0.0229***	−0.0230***
	(0.0067)	(0.0067)
Institutional quality	−0.0296***	−0.0338***
	(0.0086)	(0.0090)
Existing infrastructure	0.0195***	0.0198***
	(0.0022)	(0.0023)
Population growth	0.0126	0.0138
	(0.0088)	(0.0091)
Trade openness	0.00167**	0.0017**
	(0.00066)	(0.0008)
Legal origin	0.0768***	0.0738***
	(0.0169)	(0.0162)
Inverse mill ratio	−0.0035	−0.0047
	(0.0100)	(0.0083)
Constant	0.0234	0.0182
	(0.0496)	(0.0460)
Observations	720	720
R-squared	0.270	0.274

Notes: This table reports the Heckman second stage regression results in which the dependent variable is short term debt ratio. Infrastructure investment and real exchange rate are logged. Inverse Mills Ratio computed from the Probit regression is added. Year and country dummies are added. Robust standard errors are in parentheses. See Appendix 1 for definition and measurement of variables. ***, ** and * denote the statistical significance level at 1%, 5%, and 10%, respectively.

variables in Table 4 are in line with long-term debt results in Table 6. Thus, GDP growth rate, domestic investment, inflation rate, existing infrastructure, exchange rate and trade openness are determinants of external borrowing in Africa.

4.4. Robustness tests

To check the robustness of our results, we conduct a check on our baseline result in Table 4, we use another variable "Project Loans" as the main explanatory variable. Project loan, which is also known as Debt to China, is a type of financial assistance representing the infrastructure project debt owed by countries to China. This is sourced from the China-Africa Research Initiative database. The model is specified as follows:

$$GB_{it} = \beta_0 + \beta_1 Project\ loans_{it} + \beta_2 GDP_{it} + \beta_3 INQ_{it} + \beta_4 TO_{it} + \beta_5 LO_{it} + \beta_6\ INF_{it} + \beta_7 ADV_{it} + \beta_8 INFL_{it} + \beta_9 POP_{it} + \beta_{10} EXC_{it} + \beta_{11} INR_{it} + \beta_{12} IMR + \mu_i + \varepsilon_{it} \quad (3)$$

The result is in line with the baseline model that China-Africa interaction is negatively related to government borrowing in Africa. Invariably, debt to China in Table 7 also exerts downward pressure on external debt ratio. This implies that whether China's international capital flow is tied towards infrastructure investment or loans, the motive behind China's interaction with Africa significantly matters. The aim of the interaction is therefore to fill the infrastructure-gap for Africa and if efficiently utilized, revenue generated among other things would reduce the reliance on external debt. Consequently, it is a win for the African continent.

Next, we conduct a logistic regression (LR) estimation for our baseline model in Table 4. LR is a specialized machine learning algorithm used for classification study (Brownlee, 2016). Goto et al. (2018) and Barboza et al. (2017) assert that LR is good for classification of an explained variable and provides better prediction accuracy. This is conducted to test the validity of Heckman two-stage model. Here, our explained variable (external debt to GDP ratio) is classified into binary variables; $P(y = 1)$ represents debt trap paradigm (if the external debt ratio is equal or greater than 60% debt threshold), otherwise $P(y = 0)$ which is labelled as no debt-trap. The 60% used is in accordance with the threshold set by the AMCP for developing countries' debt sustainability. The model is specified as follows:

Table 6
Impact of infrastructure investment on long-term government borrowing.

	(1)	(2)
Infrastructure investment	−0.0141**	
	(0.0068)	
Resource for infrastructure		−0.0405
		(0.0343)
GDP growth rate	−0.0059**	−0.0056**
	(0.0025)	(0.0025)
Domestic investment	−0.0022*	−0.0022*
	(0.0011)	(0.0011)
Interest rate	0.0033***	0.0034***
	(0.0011)	(0.0011)
Inflation rate	0.0027*	0.0028*
	(0.0015)	(0.0015)
Exchange rate	−0.0307***	−0.0310***
	(0.0108)	(0.0109)
Institutional quality	0.0023	0.0002
	(0.0227)	(0.0230)
Existing infrastructure	0.0208***	0.0216***
	(0.0037)	(0.0037)
Population growth	−0.0139	−0.0122
	(0.0102)	(0.0103)
Trade openness	0.0008***	0.0008***
	(0.0003)	(0.0003)
Legal origin	−0.0899***	−0.0903***
	(0.0216)	(0.0219)
Inverse mill ratio	0.0025	0.0204
	(0.0176)	(0.0149)
Constant	0.5052***	0.4649***
	(0.0859)	(0.0830)
Observations	720	720
R-squared	0.210	0.208

Notes: This table reports the Heckman second stage regression results in which the dependent variable is long term debt ratio. Infrastructure investment and real exchange rate are logged. Inverse Mills Ratio computed from the Probit regression is added. Year and country dummies are added. Robust standard errors are in parentheses. See Appendix 1 for definition and measurement of variables. ***, ** and * denote the statistical significance level at 1%, 5%, and 10%, respectively.

$$\ln P(y=1) \,/\, P(y=0)_{it} = \beta_0 + \beta_1 Interaction_{it} + \beta_2 GDP_{it} + \beta_3 INQ_{it} + \beta_4 TO_{it} + \beta_5 LO_{it} + \beta_6 INF_{it} + \beta_7 ADV_{it} + \beta_8 INFL_{it} + \beta_9 POP_{it} + \beta_{10} EXC_{it} + \beta_{11} INR_{it} + \beta_{12} IMR + \mu_i + \varepsilon_{it} \quad (4)$$

The estimated coefficients of interaction variables in Table 8 (infrastructure investment, R4I and project loan) are negative and significant. Accordingly, their odd ratios: 0.706, 0.219 and 0.770 respectively (which are less than one) imply that the probability of China-Africa interaction causing debt trap crisis in Africa is minimal. Interestingly, the estimated value and odd ratio of the R4I interaction shows that R4I affects total government borrowing and not only short-term borrowing in Africa. This confirms the superior accuracy of the prediction result of using the algorithm. Hence, the negative signs of interaction coefficients in both Heckman Two-stage model and logistic regression portray that China-Africa interaction via infrastructure projects exerts downward pressure on government borrowing in Africa. The results of the control variables are in tandem with the results obtained in the Heckman two-stage model. Furthermore, these imply that the estimations in Tables 4 and 8 are valid. Overall, the model performance is acceptable as shown by the Wald Chi-square test. The Wald test of the model is highly significant which shows that coefficients of explanatory variables contribute significantly to the model. Likewise, the reported McFadden pseudo-R-square obtained is between 0.2 and 0.4, indicating reasonably good model fit.

4.5. Does China's infrastructure investment in Africa have any impact on the attainment of sustainable development goals?

Table 9 shows the results of Heckman model with inclusion of inverse mills ratio (Lambda). Here, the dependent variables are the proxies of sustainable development goals: SDG 3 (human development index (HDI)) and SDG 7 (environmental sustainability). Columns 1 and 2 show the results for HDI while columns 3 and 4 show the results for environmental sustainability. In both situations, infrastructure investment and resource for infrastructure are separately used as the main explanatory variables. Under columns one and two, the estimated coefficient of infrastructure investment is positive and significant at 5% level of significance. This implies that China's infrastructure investments contribute significantly to improvement in human development and environmental sustainability. This supports the modernization theory on positive outcome arising from global interaction and is in tune with previous positions of Lerner (1968) and Todaro and Smith (2015). Similarly, in columns three and four where we introduce another infrastructure

Table 7
Robustness test: Impact of Project Loan on government borrowing of countries in Africa.

	(1)
Project loan	−0.0219**
	(0.0106)
GDP growth rate	−0.0148***
	(0.0041)
Domestic investment	−0.0084***
	(0.0018)
Interest rate	0.0047***
	(0.0015)
Inflation rate	0.0031**
	(0.0012)
Exchange rate	−0.0585***
	(0.0152)
Institutional quality	−0.0063
	(0.0316)
Existing infrastructure	0.0552***
	(0.0087)
Population growth	−0.0262
	(0.0166)
Trade openness	0.0014***
	(0.0005)
Legal origin	−0.0451
	(0.0319)
Inverse mill ratio	−0.2311***
	(0.0680)
Constant	0.8677***
	(0.1481)
Observations	720
R-squared	0.271

Notes: This table reports the Heckman second stage regression results in which the dependent variable is external debt ratio. Project loan and real exchange rate are logged. Inverse Mills Ratio computed from the Probit regression is added. Year and country dummies are added. Robust standard errors are in parentheses. See Appendix 1 for definition and measurement of variables. ***, ** and * denote the statistical significance level at 1%, 5%, and 10%, respectively.

investment variable "Resource for infrastructure (R4I)" to capture the theoretical effect of resource-seeking motive surrounding China's infrastructure investment, we also find that the estimated coefficients are positive and significant, implying that R4I contributes towards human development and environmental sustainability in Africa. The outcomes are not unexpected, considering that these infrastructure loans are used for activities that promote growth in Africa, such as the development of clean power generation and the construction of educational facilities. This, in turn, leads to job creation and improvements in human development.

With regards to the control variables, our results reveal that the estimated coefficients of GDP growth rate, domestic investments, institutional quality, existing infrastructure, trade openness, and legal origin are all positive and significantly related to human development and environmental sustainability. Conversely, the coefficients of interest rate, inflation rate, real exchange rate and population growth are significantly negative. This suggests that an increase in any of these variables would worsen the human development index of the country and limit access to clean and affordable energy by the residents of the country. The results of the inverse mills ratio (lambda) coefficients are not significant, indicating no serious bias in the sample selection.

5. Further discussions and conclusion

5.1. Further discussions

Due to the consistent rise in government spending over time, several African nations have turned to obtaining loans from international lenders. In this paper, we examine the influence of China's infrastructure investments on the attainment of the sustainable development goal (SDG) targets in Africa. We also assess the extent to which these infrastructure loans contribute to the problem of debt trap in African nations.

In dealing with the infrastructure deficits on the continent, African countries have had to engage Chinese state-owned enterprises for infrastructure loans. Dreher et al. (2021) justify that utilising such loans assists in achieving economic growth. Our data shows that sustainable development goals can also be achieved through the use of such loans, notably SDGs 3 (human development) and 7 (environmental sustainability through access to modern energy). As previously noted, due to shortage of funds, countries were falling

Table 8
Robustness test: Impact of Infrastructure investment on government borrowing of countries in Africa using logistic regression.

	(1)	(2)	(3)
Infrastructure investment	−0.3485***		
	(0.1155)		
Resource for infrastructure		−1.5146*	
		(0.8705)	
Project loans			−0.2595**
			(0.1226)
GDP growth rate	−0.0928**	−0.0968**	−0.0993**
	(0.0416)	(0.0411)	(0.0418)
Domestic investment	−0.0520***	−0.0536***	−0.0534***
	(0.0160)	(0.0160)	(0.0158)
Interest rate	0.0313***	0.0329***	0.0285**
	(0.0120)	(0.0119)	(0.0117)
Inflation rate	0.0842***	0.0858***	0.0827***
	(0.0177)	(0.0192)	(0.0189)
Exchange rate	−0.3391**	−0.3393**	−0.3170**
	(0.1470)	(0.1491)	(0.1462)
Institutional quality	−0.5337**	−0.5266**	−0.4460*
	(0.2444)	(0.2562)	(0.2392)
Existing infrastructure	0.9739***	0.8983***	0.8810***
	(0.1588)	(0.1538)	(0.1528)
Population growth	0.0453	0.0097	−0.0144
	(0.1360)	(0.1448)	(0.1399)
Trade openness	0.0067**	0.0083***	0.0082***
	(0.0027)	(0.0028)	(0.0030)
Legal origin	−0.7033**	−0.8857**	−0.8248**
	(0.3251)	(0.3525)	(0.3492)
Constant	−0.3226	−0.3678	−0.1353
	(0.6626)	(0.7235)	(0.6639)
Pseudo R^2	0.322	0.315	0.313
Wald X^2	123.46***	135.87***	121.68***
Observations	720	720	720

Notes: This table reports the Logit model estimation result in which the dependent variable is classified into binary form, 1 stand for debt trap and 0 stands for no-debt- trap. Infrastructure investment, project loans and real exchange rate are logged. Year and country dummies are included. Robust standard errors are in parentheses. Wald test Chi-squared and pseudo-R-squared represent the overall performance of the model. See Appendix 1 for definition and measurement of variables. ***, ** and * denote the statistical significance level at 1%, 5% and 10%, respectively.

back on their reserves; this meant they had to increase their borrowings to meet revenue shortfalls. Dreher et al. (2021) confirm that countries were forced to embrace Chinese resource for infrastructure loans to finance their budgetary activities. While some scholars have expressed concern that the engagement is a debt trap, others have documented the significance of such loans in meeting operational needs of government. In this paper, we establish no debt-trap paradigm for China-Africa infrastructure investments and government borrowing in Africa, thus opposing the debt overhang theory and dependence theory. Contrary to the belief on resource-seeking motive, we find that commodity-based infrastructure loan reduces debt burden on African countries, albeit other inherent factors contribute to the upsurge of government debt. This finding also negates the proposition of resource curse theory.

This research enriches the foreign direct investment literature by shedding light on the hitherto underexplored China-Africa debt trap diplomacy. The China-Africa investment literature has predominantly focused on the effect of such investments on economic growth (Calderon & Serven, 2010; Dreher et al., 2021). Dreher et al. (2021) discuss the economic impacts of these loans, highlighting that their impacts go beyond local and national borders. Nevertheless, our study enhances the discussion by highlighting the pivotal significance of these loans as a factor influencing human development. We uncover infrastructure investments through resource for infrastructure loan employed by African governments over the years. Our data further attests to the effectiveness and impact of such loans on environmental sustainability, thus reinforcing the modernization theory.

5.2. Conclusion

We empirically assess how China-Africa partnerships, via infrastructure projects, influence the attainment of SDGs and upsurge of government debts in Africa. Our empirical results reveal that the interactions are significant towards achieving SDG targets and do not cause debt trap for Africa. This conforms with the positive outcome assertions of the modernization theory. Furthermore, when we disaggregate the government debt and apply both Heckman and logistic regression models, contrary to negative outcome beliefs, R4I decreases not only short-term debt but the total government borrowing in Africa. Therefore, hypotheses one is rejected while hypothesis two is accepted. Also, while we establish no-debt trap paradigm for long-term debts in Africa, our study corroborates previous findings in the literature and has great implications on the design and implementation of fiscal policies in Africa. We also report that GDP growth rate, domestic investment, inflation rate, interest rate, exchange rate, institutional quality, trade openness and legal origin

Table 9
Impact of infrastructure investment on sustainable development goals (SDGs 3 and 7).

	(1)	(2)	(3)	(4)
Infrastructure investment	0.1005*		0.1032**	
	(0.0011)		(0.0029)	
Resource for infrastructure		0.3144*		0.2035*
		(0.0122)		(0.0318)
GDP growth rate	0.4139**	0.2034*	0.3300*	0.1506**
	(0.0151)	(0.0239)	(0.0064)	(0.0211)
Domestic investment	0.2163**	0.3303*	0.2654**	0.3361
	(0.0901)	(0.0105)	(0.0126)	(0.0204)
Interest rate	−0.4021*	−0.3406*	−0.3901	−0.3622**
	(0.0913)	(0.0202)	(0.0400)	(0.0031)
Inflation rate	−0.2100**	−0.3142*	−0.5173	0.3504*
	(0.0191)	(0.0222)	(0.0390)	(0.0134)
Exchange rate	−0.0953*	−0.1425**	−0.0935*	−0.0552
	(0.0322)	(0.0451)	(0.0324)	(0.0372)
Institutional quality	0.4065	−0.3207	0.1082*	0.3346
	(0.0159)	(0.0072)	(0.0091)	(0.0163)
Existing infrastructure	0.3352**	0.2753*	0.3762	0.3094*
	(0.0129)	(0.0163)	(0.0137)	(0.0217)
Population growth	−0.1082*	−0.1065	−0.1280*	−0.1356
	(0.0332)	(0.0039)	(0.0042)	(0.0327)
Trade openness	0.2123*	0.3521	0.3435*	0.2154*
	(0.0901)	(0.0520)	(0.0694)	(0.0425)
Legal origin	0.0367*	0.0755	0.0349*	−0.0395
	(0.0214)	(0.0116)	(0.0033)	(0.0120)
Inverse mill ratio	0.3526	0.1015	0.1024	0.1028
	(0.0169)	(0.0119)	(0.0027)	(0.0200)
Constant	0.2135*	0.2248**	0.2361	0.2538*
	(0.0137)	(0.0145)	(0.0114)	(0.0203)
Observations	720	720	720	720
R-squared	0.317	0.312	0.341	0.306

Notes: This table reports the Heckman second stage regression results in which the dependent variables are SDGs 3 and 7. Columns 1 and 2 report the results for SDG 3 (HDI) while columns 3 and 4 show the output for SDG 7 (environmental sustainability through access to modern energy). Infrastructure investment and real exchange rate are logged. Inverse Mills Ratio computed from the Probit regression is added. Year and country dummies are added. Robust standard errors are in parentheses. See Appendix 1 for definition and measurement of variables. ***, ** and * denote the statistical significance level at 1%, 5%, and 10%, respectively.

are mediating variables that influence China-Africa interactions. Overall, Chinese infrastructure investment in Africa puts downward pressure on government borrowing. Invariably, Chinese infrastructure investment generates positive outcome which is an engine towards achieving sustainable economic development in Africa.

In policy terms, although our results yield positive outcomes, nevertheless, we opine that fiscal policies governing foreign financial flows measure should be reviewed. Designing a program for future financial assistance to be in the form of grants or concessions would require a major policy change from African governments. Furthermore, policy makers in Africa need to re-evaluate inherent factors (such as interest rate, inflation rate among others) that contribute to debt overhang whilst maintaining the dynamics of those factors that reduce the burden. For example, encouraging private and public savings through fiscal retrenchment would reduce government deficit budget and consequently reduce debt burden. Moreover, for commodity-based loans, evidence shows that R4I exerts downward pressure on government debt, and this is against the argument of most critics that the influx of the investments in Africa might increase debt and lead to resource curse - a situation where Chinese state-owned enterprises create export markets in Africa by taking advantage of host country's factor endowments. Hence, caution must be taken by policy makers in Africa when designing policies that would attract China's infrastructure investments, in order to prevent natural resource exploitation. Gaining a comprehensive understanding of the intricate mechanisms of debt traps is of utmost importance for policymakers in order to successfully handle national debt and guarantee sustainable economic well-being in the long run. Having considered national debts in this study, future research can replicate our study and also explore how China-Africa relationship affects corporate debts.

Declaration of competing interest

The authors declare that there is no conflict of interest.

Data availability

Data will be made available on request.

Appendix 1. Description of variables and data sources

Denotation	Variable	Measurement of variables	Data source
GB	Government borrowing	This is external debt (including short-term and long-term debt) to GDP of country under study.	*World Bank Development Indicator Database*
INV	Infrastructure investment	The amount of China's infrastructure investment received by each African country.	*China Global Investment Tracker*
RE	Recipient	A dummy variable which takes the value of one if a country in Africa received China's infrastructure project investment, otherwise it is zero	*China Global Investment Tracker*
R4I	Resource for infrastructure deal	A dummy variable that takes the value of one if the African country is involved in R4I deals, otherwise it is zero.	*China -Africa Research Initiative*
GDP	Gross domestic product growth rate	Rate of growth of host country GDP	*World Bank Development Indicator Database*
ECX	Exchange rate	Real exchange rate of the host country.	*International Monetary Fund Database*
INQ	Institutional quality	This is arithmetic mean of six governance indicators.	*World Governance Indicator Database*
NR	Natural resources	Ratio of host country total natural resources rent to GDP.	*World Bank Development Indicator Database*
TO	Trade openness	Ratio of trade (export plus import) to China divided by host country GDP	*World Bank Development Indicator Database*
INR	Interest rate	This rate of return on investment of country under study.	*World Bank Development Indicator Database*
LO	Legal origin	Dichotomous variable which takes the value of 1 if listed African firm is in country that is practicing British common law, otherwise 0 for French civil law.	La-Porta et al. (1999)
INF	Existing Infrastructure	Broadband subscriptions per 100 people.	*World Bank Development Indicator Database*
POPU	Population growth	Growth rate of the population	*World Bank Development Indicator Database*
DI	Domestic investment of the African country	Ratio of African countries' gross capital formation to GDP.	*World Bank Development Indicator Database*
INFL	Inflation	Rate of change of consumer price index	*World Bank Development Indicator Database*
PR	Project loans	The amount of African's debt to China.	*China-Africa Research Initiative Database*

Appendix 2. Variance Inflator Factor

	VIF	1/VIF
Existing infrastructure	1.58	0.63
Domestic investment	1.52	0.66
Population growth	1.44	0.69
Institutional quality	1.42	0.70
Project Loan	1.37	0.73
Recipient	1.32	0.76
Resource for infrastructure	1.29	0.77
Trade openness	1.28	0.78
Legal origin	1.24	0.81
Inflation rate	1.16	0.86
Interest rate	1.15	0.87
GDP growth rate	1.11	0.90
Exchange rate	1.09	0.92
Mean VIF	1.3	.

Appendix 3. Odd ratio of the Infrastructure Investment

Variable	Odd ratio
Infrastructure investment	0.706
R4I	0.219
Project loans	0.770

Note: Odd ratio is as [Ln P(y = 1)/P(y = 0)], if greater than or equals to one implies debt trap, otherwise no-debt trap crisis (less than one).

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