

ORIGINAL ARTICLE

China and Africa: A new narrative on debt sustainability and infrastructure financing

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ABSTRACT

Strategic and collective efforts are needed from both the creditors and borrowing countries facing the looming debt crisis, with a full understanding of what are good debts and what are bad debts depending on how they are used. The current narrative on debt sustainability often ignores the issue of what a government owns (assets) versus what a government owes (liabilities). While conventional approaches largely focus on the liability side, the kinds of assets a country tries to build are vital to economic development and debt sustainability. This paper proposed a new narrative on debt sustainability and thoughts on infrastructure financing under the circumstance of debt restructuring. The empirical part of the study presented both the conventional and a novel method to investigate the role of completed infrastructure projects, co-financed and jointly built by China and African countries, focusing on whether and to what extent they have addressed infrastructure bottlenecks. Both methods validate the hypothesis that China-financed and completed projects match the host country's most backward sectors and address their development bottlenecks. These completed projects form a part of a country's public operational assets that generate essential social services, jobs, government revenues, exports and growth.

KEYWORDS

debt sustainability; public sector balance sheet; infrastructure financing; development bottlenecks; debt restructuring

1. Introduction

Public sector assets are undervalued in the debt sustainability narratives. Assets and liabilities are recognized as the two sides of any corporation's or private individual's balance sheet. However, it is less well understood that governments have not only liabilities but, most importantly, assets. In a country's public sector balance sheet, its public sector assets would be worth at least twice the country's GDP and often much more than its debt, if properly measured using accrual accounting (IMF, 2018). Nevertheless, current discussions on debt sustainability in general and debt restructuring often leave out public assets—an important side of the public sector balance sheet.

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In an environment characterized by rising interest rates and high uncertainty (World Bank, 2022), the best way to avoid a global recession is not to stop investment but to continue to invest in public assets in the Global South. Public assets are able not only to generate a positive yield, but also to support a sustainable structural transformation, generate jobs and revenues, and promote economic growth. Focusing on net worth as the most comprehensive fiscal measure would help to incentivize investments that stimulate economic growth. If properly targeted, new investment would also increase the value of the assets and thereby improve net worth (assets less liabilities), a more relevant fiscal measure than just debt over GDP and cash (Yousefi, 2019).

This paper voices the concerns from the Global South on the current narrative, which has only focused on liabilities, or debt over GDP, without looking at the asset side of the public-sector balance sheet. This paper examines the following questions:

- What is missing in the current narrative on assessing sovereign debt issues?
- Are infrastructure projects undervalued public assets or merely debt burdens?
- What if we investigate the projects and activities financed or co-financed by China through South-South Cooperation? Do they result in public assets or debt only?
- What are the implications for promoting sustainable development in the post-pandemic era?

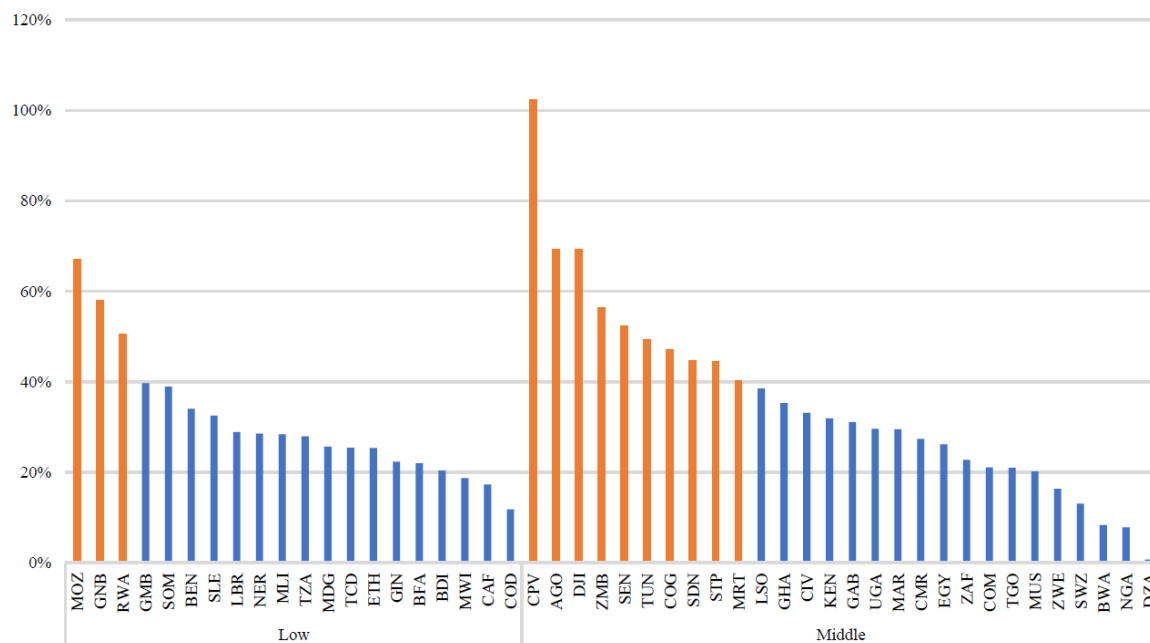
Section 2 of this paper contains a descriptive analysis of the indebtedness of African countries. Section 3 presents our rationales for the view that public assets are key to debt sustainability. Section 4 presents our main empirical analysis regarding how to identify bottlenecks in hard and soft infrastructure, whether and to what extent China has helped Africa address their bottlenecks in sectors such as water, electricity, transportation, telecom and Internet, health, education, environment protection and government effectiveness. Section 5 concludes with policy recommendations and alternative options aiming to achieve the 2030 Sustainable Development Goals (SDGs) in the post-pandemic era.

2. A descriptive analysis of debt in African countries

2.1. Africa's growing debt crisis: Whom is the debt owed to?

Focusing now on Africa, we first use the conventional indicators of debt-to-GDP and debt-to-exports ratios to look at debt in that region. We utilize data from the World Bank's International Debt Statistics (IDS). Among all African countries, 49 of them have frequently reported to this system and have available data on external debt stocks only up to 2021 (World Bank, 2022). Here, we focus only on the public and publicly guaranteed (PPG) external debt, which comprises long-term external obligations of public debtors, including the national government, public corporations, state-owned enterprises, development banks and other mixed enterprises, subnational governments, autonomous public bodies, and external obligations of private debtors that are guaranteed for repayment by a public entity. In general, the conventional indicators for the observed African countries are consistent with the pre-pandemic level (see Wang and Xu, 2022 for the 2019 analysis).

The average debt-to-GDP ratio of the 48 African countries with available data in 2021 was 24.4%, among which 8 countries had a ratio of over 50%. Of the 48 African countries with available



Source: World Bank IDS data (World Bank, 2022), accessed in January 2023.

Figure 1. External debt stocks as a percentage of GDP by income group, at the end of 2021.

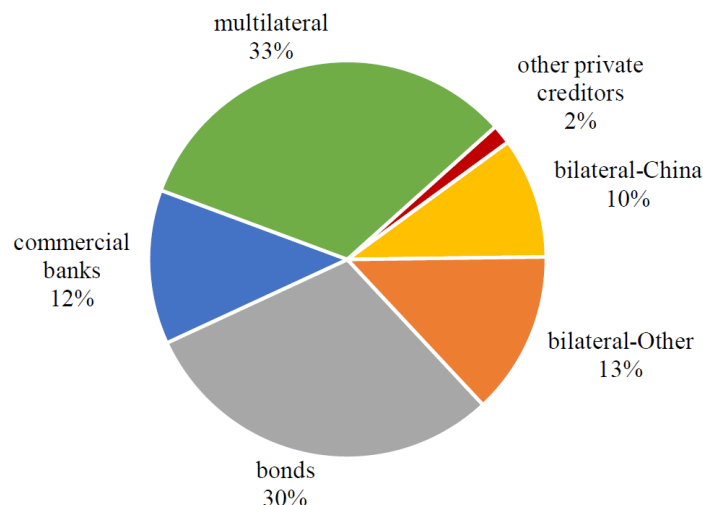
data on debt-to-GNI, the average was 59.7%, among which 22 had a debt-to-GNI ratio of over 50%. Of the 40 African countries with available data on the debt-to-export ratio, the average was over 26%. However, averages are often misleading. The debt accumulation pattern is diverse and country-specific. First, these conventional indicators vary among different countries. Taking the debt-to-GDP ratio as an example, two low-income African countries (14.3% of the low-income group) now have a debt-to-GDP ratio of over 40%, while 10 middle-income African countries' debt-to-GDP ratios are over benchmark (one-third of the middle-income group).

The decomposition of the external debt stocks varies widely among these countries. The external debt stock can be divided by private and public creditors and can be further divided into the debt owed to bilateral creditors, multilateral creditors, bonds, commercial banks, and other private creditors. For all 49 countries studied, debt to multilateral creditors such as IDA and IBRD accounts for 33% of the total, debt to bilateral creditors accounts for 23%, and 30% is owed to bondholders.

The debt ratios owed to China differ from country to country. On average, external debt to China accounts for 9.8% of the total debt stocks for the 49 African countries studied, which is lower than that for multilateral organizations (33%). For 36 of these countries, the external debt to China is less than 20%. However, Djibouti's debt to China makes up almost 56% of the country's total external debt, the largest in this analysis.

2.2. Concerns over the debt sustainability framework

The governments and economists of developing countries have voiced many complaints about the Debt Sustainability Analysis (DSA) and its mechanism (see Akyüz, 2007; Goldstein, 2003; Gray et al. 2008; Hostland and Karam, 2005; Lin and Wang, 2021). First, the calculation of "debt" does not distinguish those for investment from those for consumption (salaries and pensions); it thus has an anti-investment bias, which is not unrelated to the neoliberal disregard of the role of



Source: World Bank IDS data (World Bank, 2022), accessed in January 2023.

Figure 2. Decomposition of Africa’s external debt stocks, at the end of 2021.

government in economic growth and development. This anti-investment bias in the DSA for low-income countries is markedly outmoded in the current global environment where investment in public assets is badly needed (Gallagher and Wang, 2020; Kaplan, 2018; Lin and Wang, 2017a, p. 66–67; Mazzucato, 2015). Further, it neglects public assets formed after completing an investment project. Second, if the eligible low-income countries violate these benchmarks, they will be defined as being in “debt distress” and will lose access to global capital markets, causing a “sudden stop” in financing for development. Third, to date, DSAs do not include climate or other sustainability risks, nor do they account for crucial investment needs for climate adaptation or achieving the 2030 Agenda for Sustainable Development. They need to be based on realistic assumptions and account for climate risks and spending needs to scale up investment in climate resilience, the transition to a green economy, and the 2030 Agenda set forth by the United Nations. Eligibility for debt relief should be determined in a substantially enhanced DSA carried out by the International Monetary Fund (IMF) and the World Bank in close partnership with debtor governments, with inputs from other institutions (Volz et al., 2020).

Under pressure from the Global South, the IMF Executive Board approved a new framework for debt sustainability for market access countries (MACs), which became operational in early 2022. The new framework includes broader and more consistent debt coverage, a longer projection horizon, new tools at multiple horizons based on superior analytical methods that account for countries’ structural characteristics and enhanced transparency in the bottom-line assessments. Furthermore, the new tools support probabilistic debt sustainability assessments, as required by the Fund’s lending framework (IMF, 2021). However, nothing was mentioned about how to incorporate the other side of the balance sheet: that is, public assets and net worth.

3. Public assets are key to debt sustainability

The current debt sustainability framework is intended to balance the countries’ financing needs with their ability to repay, but it undervalues the public assets as a basis for development. In particular, it fails to recognize that the public sector balance sheet positions of countries that

invest the proceeds of borrowing are stronger than those that use debt to finance consumption spending. The failure to reflect this difference, by focusing on debt rather than net worth, not only fails to measure debt sustainability accurately, but also misleads and has an anti-investment bias. Indeed, infrastructures such as hydro power stations, power grids, roads, ports, and bridges are assets of the public sector, which generate revenues and create jobs, and are essential for economic transformation and sustainable development of the host countries.

A better understanding of what government owns (assets) and what government owes (debt) would promote better long-term financial management as well as help meet near-term needs. One of the significant potential benefits of using accrual accounting and a balance sheet approach to public financial management is the attention it focuses on the assets on a government's balance sheet, encouraging more reliable information on which assets the government owns and what those assets are worth, and better systems of asset management. In response to COVID-19, governments have taken a greater role in their economies and increased the size of their balance sheets. Nevertheless, their fiscal positions are more fragile than before. Under these circumstances, the value that can be extracted from the assets held by governments will become increasingly crucial, whether it is in the revenue generated by commercial assets or the services provided by assets that are held for public policy reasons (Ball, Detter, Amin-Salem, and Walker, 2020).

A focus on net worth (assets less liabilities) as the most comprehensive fiscal measure would encourage public investment, better management of public assets, and thereby a larger fiscal space (Ball, Detter, Amin-Salem, and Walker, 2020). Furthermore, research shows that economies with higher public sector net worth experience shallower recessions and recover faster in the aftermath of economic downturns (Yousefi, 2019). However, little attention has been paid to measuring public assets in the current debt discussions.

Governments everywhere and at every level own a vast array of commercial assets. According to the IMF, the value of public assets globally is twice that of global stock markets, twice that of global GDP and much larger than public debt. However, unlike listed equity assets, this public wealth is often unaudited, unsupervised and unregulated. Even worse, it is almost entirely unaccounted for in most countries. As a consequence, when formulating their budgets, most governments largely ignore the assets they own and fail to recognize that they could generate substantial yields that open up much-needed fiscal space. Governments could use this headroom to kick-start growth or buffer themselves from future shocks, without resorting to debt, exhausting existing savings, or being forced to revert to excessively painful austerity measures (Ball, Detter, Amin-Salem, and Walker, 2020).

Both assets and liabilities (including debt) are important for decision-makers. For example, the most important country-specific fiscal factor driving bond yields hence appears to be government net worth (Peppel-Srebrny, 2018). The IMF not only continues to reinforce the need for governments to understand their real estate assets so as to achieve better management, but has also demonstrated how a better understanding would have an impact on the cost of capital (Koshima et al., 2021). Tools for measuring a sustainable economy and debt levels, using standard accrual accounting and budgeting techniques, have been included in IMF manuals for more than two decades.

It is time for markets and rating agencies to look more kindly at the increase in public debt if there are productive assets on the other side of the balance sheet. The IMF data on government

assets shows that when governments know what they own, they can make better use of the assets for the well-being of all their citizens. Public assets are a vast unknown and untapped resource. The value of public commercial assets is twice that of global stock markets, and twice that of the global GDP (IMF, 2018). The largest segment of any portfolio of public commercial assets is real estate. In fact, government-owned commercial real estate assets account for a significant portion of each country's land. However, governments typically know about only a fraction of these properties, since they do not have a comprehensive list of the assets nor even a proper underlying *cadastre* or land registry, a system that defines the dimensions, locations and titles of all land parcels (Detter, 2021).

Improved management of government assets also has a positive impact on a country's sovereign credit rating, which reduces its cost of borrowing. Clearly, the monetization of public assets generates receipts that can be used to pay down existing debt, reduce the need for new borrowing, or build the government's financial buffers. Reducing a government's debt load, or a slowdown in its pace of accumulation, and increasing government financial assets directly improve key metrics that the three global rating agencies use in their sovereign rating models. In addition to assisting sovereign credit ratings, more efficiently managed assets would contribute to a higher rate of real GDP growth, generate dividends or other cash flows for the government budget, and lower operating costs, all are major benefits to society (Ball et al., 2021; Lin's publications from the perspective of the New Structural Economics, 2012, 2014, 2018). The current research on public sector balance sheets, and on "what governments own and owe" is welcome since it emphasizes that it is "public sector net worth" that matters (IMF, 2018).

This rationale applies to Africa as well. The total value of public assets in Africa is most likely in excess of \$5.2 trillion (IMF, 2018). If professionally managed inside a Public Wealth Fund (PWF), they could generate an additional \$80 billion in revenues every year (or 3% of GDP annually), which is more than most countries collect in corporate taxes (IMF, 2019). Namely, public assets are a vastly underestimated and untapped resource in Africa, especially considering the large land areas and green natural endowments, and the potential for urbanization and agglomeration, which can increase the value of the real estate.

African heads of state from 24 countries have called for improvement of the traditional DSA in "Dakar Call for Action": "***We believe that public sector assets and liabilities should now form the basis of country-specific risk analysis beyond traditional debt sustainability analysis.***" (item 14, Dakar Call to Action, 9 July 2022). The asset and liability picture in Africa is not as dismal as when it is seen only from the DSA lens, which ignores the asset side. However, the data are not comprehensive and are far from adequate. There is a great need for these countries to conduct an asset mapping and measure these assets carefully so that they can be better managed professionally.

4. How to address bottlenecks by building public assets

The COVID-19 pandemic has highlighted the critical importance of tackling bottlenecks in infrastructure. For many low- and lower-middle-income countries, the pandemic has exposed more fundamental deficiencies in both hard and soft infrastructure, such as a lack of healthcare personnel and resources, from hospital beds to ventilators. For some, it is the inability to deliver clean water, electricity, and sanitation that is choking the economy.

A core problem is that all that traditional North-South aid did not adequately address infrastructure bottlenecks in the last 70 years. Since the 1960s, over \$4.6 trillion (in constant 2007 dollars) in gross official development assistance (ODA) has been transferred to developing countries, including bilateral and multilateral aid. Despite this, a substantial amount of the world’s population remains in extreme poverty and is experiencing stagnant growth. A recent study has found that the IMF’s structural adjustment programs, which require countries to undertake policy reforms in exchange for loans, undermine investor confidence and increase sovereign borrowing costs (Reinsberg et al., 2022). This partly explains why African countries have often welcomed Chinese development finance and investment. In the last few years, there was media hype about China-financed projects that have caused a “debt trap” without looking at the asset side of the public sector balance sheet.

Several recent empirical studies have presented a balanced picture of China’s development cooperation in Africa. A recent book *Banking on Beijing* pointed out that “***there are several reasons why Chinese development projects might be equally effective as—or even more effective than—development projects from OECD-DAC aid agencies and multilateral development banks (MDBs)***” (Dreher et al., 2022, p. 197). Their empirical evidence “***shows that irrespective of political bias, Chinese development projects improve socioeconomic outcomes at both national and subnational scales***” (Dreher et al., 2022, p. 228).

Here, we investigate further the “relevance” of China financed/co-financed and completed projects, namely, whether they are targeting the African countries’ most urgent needs, and test the hypothesis of whether and to what extent these completed projects have addressed bottlenecks in African countries.

4.1. Method 1: Whether projects are most relevant for Africa’s development needs

In order to enable a cross-sectional comparison of infrastructure development data among different investment sectors, we need to create a standardized “infrastructure development index” to quantify the “bottlenecks” of host countries. First, we collected data on hard infrastructure development in four sectors: water, energy, transportation, and telecommunication, and soft infrastructure in development in four sectors: education, governance, environment, and health, which resulted in a panel dataset of nine broad indicators of hard and soft infrastructure needs across all 54 African countries from 2000 to 2017 using data from the World Bank, the Institute for Health Metrics and Evaluation (IHME) and GlobalEconomy.com (**Table 1**).

Then, for country i , we establish an index to rank and define its relative position at the **sectoral infrastructure development** level. Denote D_{ij} as the country’s level in sector j , the index in sector j is:

$$X_{ij} = \frac{D_{ij} - \bar{D}_j}{S_j}$$

where \bar{D}_j refers to the arithmetic mean of D_j across all countries and S_j refers to the standard deviation. This allows us to quantify the development of a sector of a country in terms of X_{ij} . A positive value of X_{ij} means that development is above average, and a negative value indicates a

Table 1. Sectors and Indicators for Bottleneck Identification

Category	Indicator and unit
Hard infrastructure	Hard infrastructure
<ol style="list-style-type: none"> 1. Water 2. Energy 3. Road/rail/port/air transportation 4. Telecommunication 5. Internet access 	<ol style="list-style-type: none"> 1. People using at least basic drinking water services (percent of population), 2000–2017 (Source: WDI). 2. Access to electricity (percent of population), 2000–2017 (Source: WDI). 3. Road quality, 2006–2017; Railroad infrastructure quality, 2009–2017; Port infrastructure quality, 2006–2017; Air transport infrastructure quality, 2006–2017, using the Borda’s method (Source: The Global Economy). 4. Mobile cellular subscriptions (per 100 people), 2000–2017 (Source: WDI). 5. Individuals using the Internet (percent of population), 2000–2017 (Source: WDI).
Soft infrastructure	Soft infrastructure
<ol style="list-style-type: none"> 1. Education 2. Health 3. Environment 4. Government effectiveness 	<ol style="list-style-type: none"> 1. Learning-adjusted years of school, 2017, and literacy rate, adult (total percent of people aged 15 and above), average of 2000–2017 using the Borda ranking method (Source: WDI). 2. Healthcare access and quality index, 2016 (Source: IHME). 3. CO₂ emissions (metric tons per capita), average of 2000–2017, and Annual deforestation (percent of change), average of 2000–2015 using the Borda method (Source: WDI). 4. Government effectiveness of the worldwide governance indicators, average of 2000–2017 (Source: WGI).

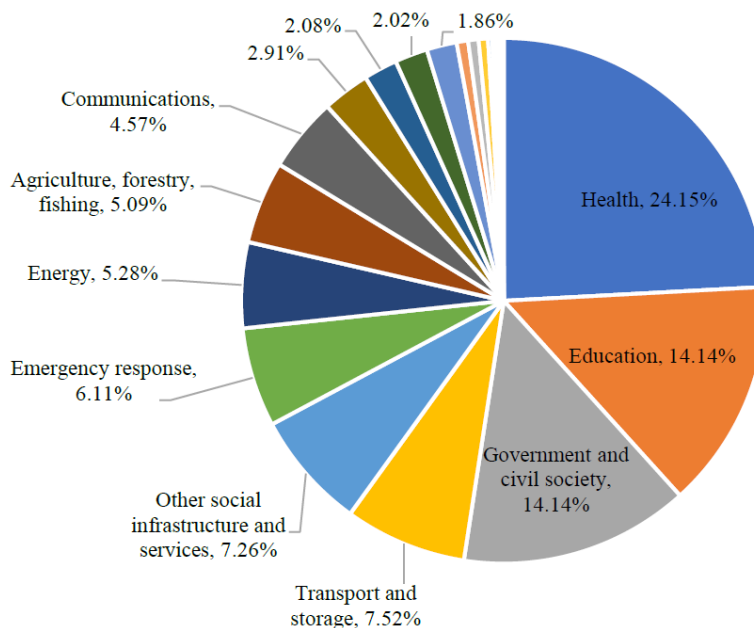
backward sector compared with other African countries¹.

Since the investment in hard and soft infrastructure follow quite different patterns, we have divided the research into two parts to look into the investment in hard and soft infrastructure separately.

4.1.1. Infrastructure projects in Africa financed/co-financed by China

For the dependent variable, we utilized only the completed projects financed or co-financed by China in each sector in 2000–2017, documented by the Global Chinese Development Finance Dataset, version 2.0, developed by AidData at the College of William & Mary. We kept only those projects that were marked “completed” and those which were checked by a triangulation method to be “recommended for aggregates”. Our subset consists of 3126 projects in Africa, all completed and “recommended for aggregates”, distributed in 24 sectors: action relating to debt (58); agriculture, forestry, fishing (159); banking and financial services (2); business and other services (5); communications (143); developmental food aid/food security assistance (65); disaster prevention and preparedness (2); education (442); emergency response (191); energy (165); general budget support (8); general environmental protection (7); government and civil society (442); health (755); industry, mining, and construction (63); other commodity assistance (18); other multisector (22); other social infrastructure and services (227); population policies/programmes and reproductive health (1); reconstruction relief and rehabilitation (1); trade policies and regulations (20); transport

¹ For environment sector, the original data is CO₂ emission, so we have to take negative values of the source data to construct the infrastructure development index.



Source: Aiddata.org, accessed on 28 November 2021.

Figure 3. Decomposition of the 3126 completed and “recommended for aggregates” projects in Africa financed or co-financed by China in 2000–2017, by sector.

and storage (235); water supply and sanitation (91); and unallocated/unspecified (4). See **Figure 3** and **Table A1**.

4.1.2. Hard infrastructure

The spatial distribution of hard infrastructure projects financed/co-financed by China is discrete across countries. To find out whether completed Chinese investment projects are associated with the development bottlenecks in country i and sector j , we use a discrete probability model, where China’s completed projects in sector j in country i as the dependent variable, and X_{ij} (index of infrastructure development) as the independent variable. Denoting China’s investment decision in country i , sector j , as Y_{ij} taking the values 0 and 1 (0 for no investment project and 1 for completed investment project²) and introducing T_1 , T_2 , and T_3 as dummy variables for sectors (T_1 for energy, T_2 for telecommunication, and T_3 for transportation, and water is the left out sector because of multicollinearity), we can construct the following probit model (assuming that the residuals obey the standard normal distribution). The normal form of a probit model is:

$$P(y_k | \mathbf{x}) = \Phi(\mathbf{x}_k \boldsymbol{\beta}) \equiv \int_{-\infty}^{\mathbf{x}_k \boldsymbol{\beta}} \varphi(t) dt \quad (1)$$

We can transform (1) into (2) and (3):

² Due to the low number of investment projects in the internet sector, we included these investments in the closely related telecommunication sector and cancelled the separate study of the internet sector.

$$Y_k = \begin{cases} 1 & y_k^* > 0 \\ 0 & y_k^* \leq 0 \end{cases} \quad (2)$$

$$y_k^* = \beta_1 x_k + \alpha_1 T_1 + \alpha_2 T_2 + \alpha_3 T_3 + \varepsilon_k (k = 1, 2, \dots, i * j, \dots, n) \quad (3)$$

Note that now we use y_k^* instead of y_k and k as the subscript because we have merged data from different countries and sectors into one regression model.

4.1.3. Soft infrastructure

The spatial distribution of soft infrastructure projects differs significantly from hard infrastructure projects, where there tends to be a number of soft infrastructure projects located in the same host country. In order to utilize the full information, we choose to investigate the relationship between the number of Chinese investment projects in a given country's given sector in soft infrastructure and its sector development index with a linear regression model. Using the same independent variables, "infrastructure development index", denoting the number of China financed and completed projects in country i , sector j , as Y_{ij} , and introducing T_1 , T_2 , and T_3 as dummy variables between sectors (T_1 for environment, T_2 for education, and T_3 for governance, and the left-out sector is health), the linear regression model is as follows:

$$y_k = \beta_1 x_k + \alpha_1 T_1 + \alpha_2 T_2 + \alpha_3 T_3 + \varepsilon_k (k = 1, 2, \dots, i * j, \dots, n) \quad (4)$$

4.1.4. Regression results: Probit model and linear model

Either hard or soft infrastructure projects, China-financed and co-financed projects have matched the host country's most urgent needs (bottlenecks). However, there are significant sectoral differences, as indicated by the sectoral parameters, which leave space for future study on China finance and co-financed projects in different sectors with regard to the project amounts and other attributes, after controlling for the countries' income levels.

In summary, the data has shown that China's investment in these African countries in the past two decades has a significant positive correlation with a country's most backward infrastructure sectors which means that these projects are largely relevant to the country's needs. In World Bank's jargon for project evaluation, these results show high "relevance" and efficacy, meaning these projects are well targeted to the country's bottlenecks. However, we do not have sufficient country-specific data to evaluate their efficiency or impact. It must be pointed out that this quantitative study also has some shortcomings rooted in the lack of data and possible generalization errors.

4.2. A novel method to identify Africa's bottlenecks

The above regressions provide a general test for the relevance of China-financed and completed projects, but they cannot identify Africa's bottlenecks. To identify infrastructure bottlenecks in Africa, we utilize the panel dataset of nine broad indicators of hard and soft infrastructure needs across all 54 African countries from 2000 to 2017, as shown in Table 1 above.

Table 2. China financed and co-financed projects in Africa vs. sector development index

China Finance and co-financed projects in Africa		
	(1)	(2)
	Hard infrastructure ³	Soft infrastructure ⁴
Sector development index		
<i>Hard infrastructure</i>	-0.217^{***}	
	(0.075)	
Transportation	-0.700^{***}	
	(0.203)	
Energy	0.096	
	(0.247)	
Mobile	0.254	
	(0.25)	
<i>Soft infrastructure</i>		-0.819^{**}
		(0.342)
Environment		-11.222^{***}
		(0.911)
Education		-6.139^{***}
		(0.92)
Governance		-4.852^{***}
		(0.911)
Constant	0.182	10.976 ^{***}
	(0.194)	(0.703)
N	321	214
Pseudo r-squared	0.092	
Prob > chi2	0.000	
R ²		0.440
adj. R ²		0.427
Prob > F		0.000

Note:

- 1). Standard errors in parentheses
- 2). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
- 3). For hard infrastructure, the probit model is used as the dependent variable is a discrete, zero-one variable. For soft infrastructure, linear regress used as the dependent variable is the number of projects in each sector and country.
- 4). For each regression, one sector is left out due to the multicollinearity, which can be seen as the base.

³ Given the natural of the hard infrastructure projects, which are normally of large investment amount and located in relatively fewer countries, we adopted the probit model to examine the relationship between the locating of China financed/co-financed projects in Africa and the hard infrastructure development index of the host countries.

⁴ In contrast, the soft infrastructure projects are more likely to locate in more countries and of lower amount. Thus, we used a simple linear *regression model* in this case.

For each indicator and country, we first calculated the average value during the observed period. We then separated the countries into two income groups: middle-income and lower-income. Second, for each country within its income group, we determined the ranked order (in percentiles) of each indicator. For most of the indicators, a higher ranking order (in percentiles) indicates better access within the income group and hence lower urgency for investment. The exception is the category of the environment, where a higher ranking order (percentile) indicates more emissions or greater deforestation within the income group, and hence more urgency for investment.

For each country, we identified four out of five hard-infrastructure indicators and three out of four soft-infrastructure indicators as bottlenecks. We ordered these bottlenecks by the level of urgency from 1 (most urgent) to 4 (least urgent) for hard infrastructure and 1 to 3 (most to least urgent) for soft infrastructure. For each country, the lowest ranking hard or soft indicator within its income group was defined as “Bottleneck 1”, that is, the bottleneck with the greatest needs, the second lowest ranking as “Bottleneck 2”, and so on. The two highest-ranking hard indicators and the highest-ranking soft indicator for each country were not considered bottlenecks, since their urgency was minimal. This process can be expressed as follows:

$$\text{Bottleneck 1 for country } i = \min(R_{i,j}), \text{ where } j = 1, \dots, s$$

$$\text{Bottleneck 2 for country } i = \min(R_{i,j-1}), \text{ where } j = 1, \dots, s$$

where s denotes the total sectors in hard or soft infrastructure categories.

Figure 4 shows the results of the process of identifying bottlenecks. We note that Africa’s bottlenecks have evolved over a relatively long period of time, and that, for some indicators, what constitutes a bottleneck has changed with time. Most African countries have made progress throughout the last decade of development, in both soft and hard infrastructure. For example, while access to the internet was not a major bottleneck for many countries in earlier years compared to the other sectors, it is now becoming a more urgent need for many. This also coincides with the global digital revolution trend in the past two decades.

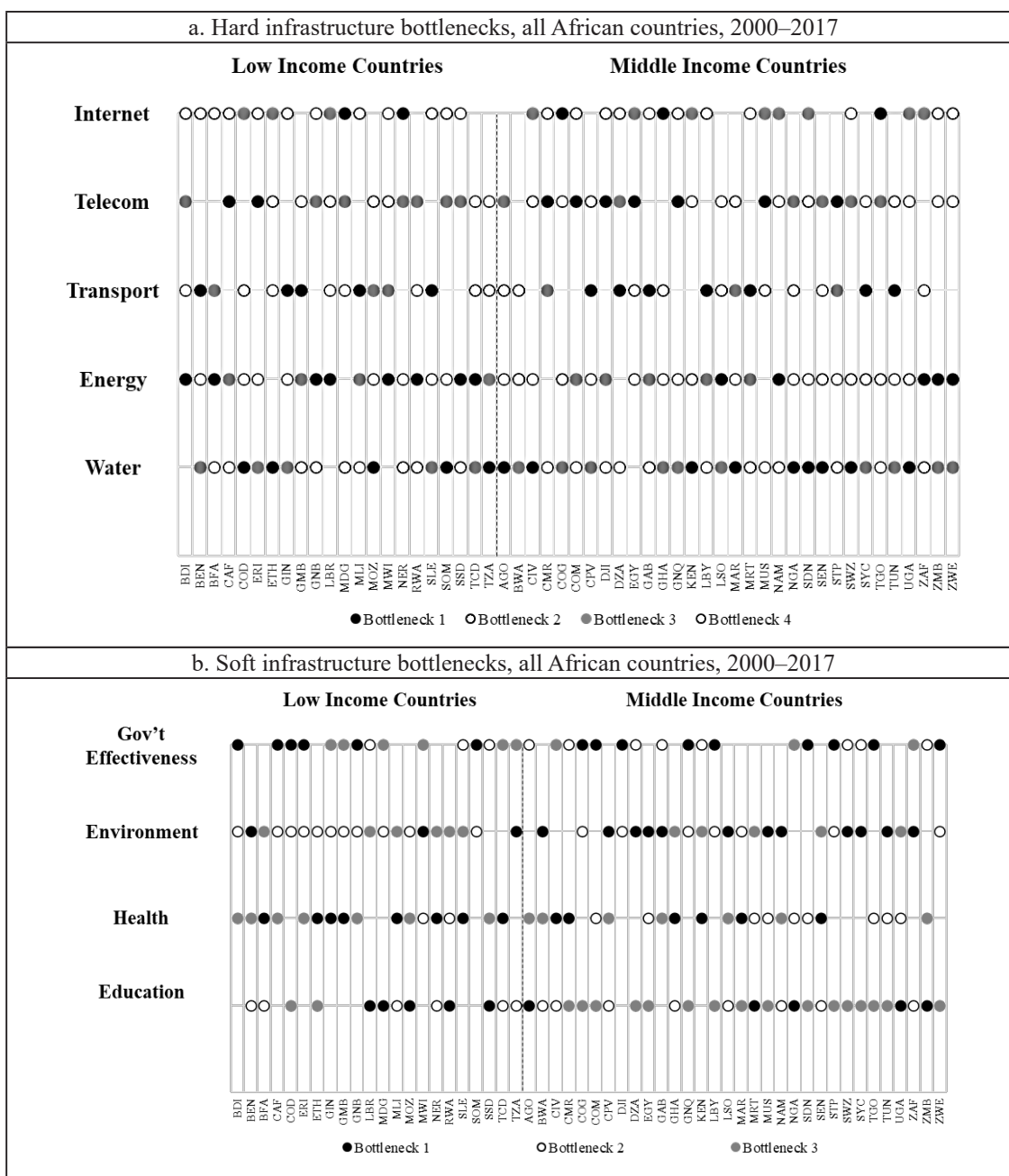
4.3. Did infrastructure projects financed/co-financed by China in Africa address bottlenecks?

To what extent did infrastructure projects financed/co-financed by China match up with Africa’s bottlenecks? A short answer is that Chinese-financed and co-financed projects matched up with African countries’ bottlenecks for 76.1% of the 468 hard infrastructure and 73.4% of the 1246 soft infrastructure projects in 2000–2017.

We merged the datasets on bottlenecks and China-financed and co-financed projects by country code, which allowed us to see if the locations of the China-financed projects matched those of the bottlenecks in the period of 2000–2017, hitting the bottlenecks in recent years. We also calculated some probabilities of projects “hitting” the bottlenecks, using the following method:

$$\text{Probability of (hitting one of the 4 bottlenecks)} = (\text{number of matches})/\text{total projects}$$

$$\text{Probability of (hitting the Bottleneck } i) = (\# \text{ of projects hitting Bottleneck } i)/\text{total projects}$$



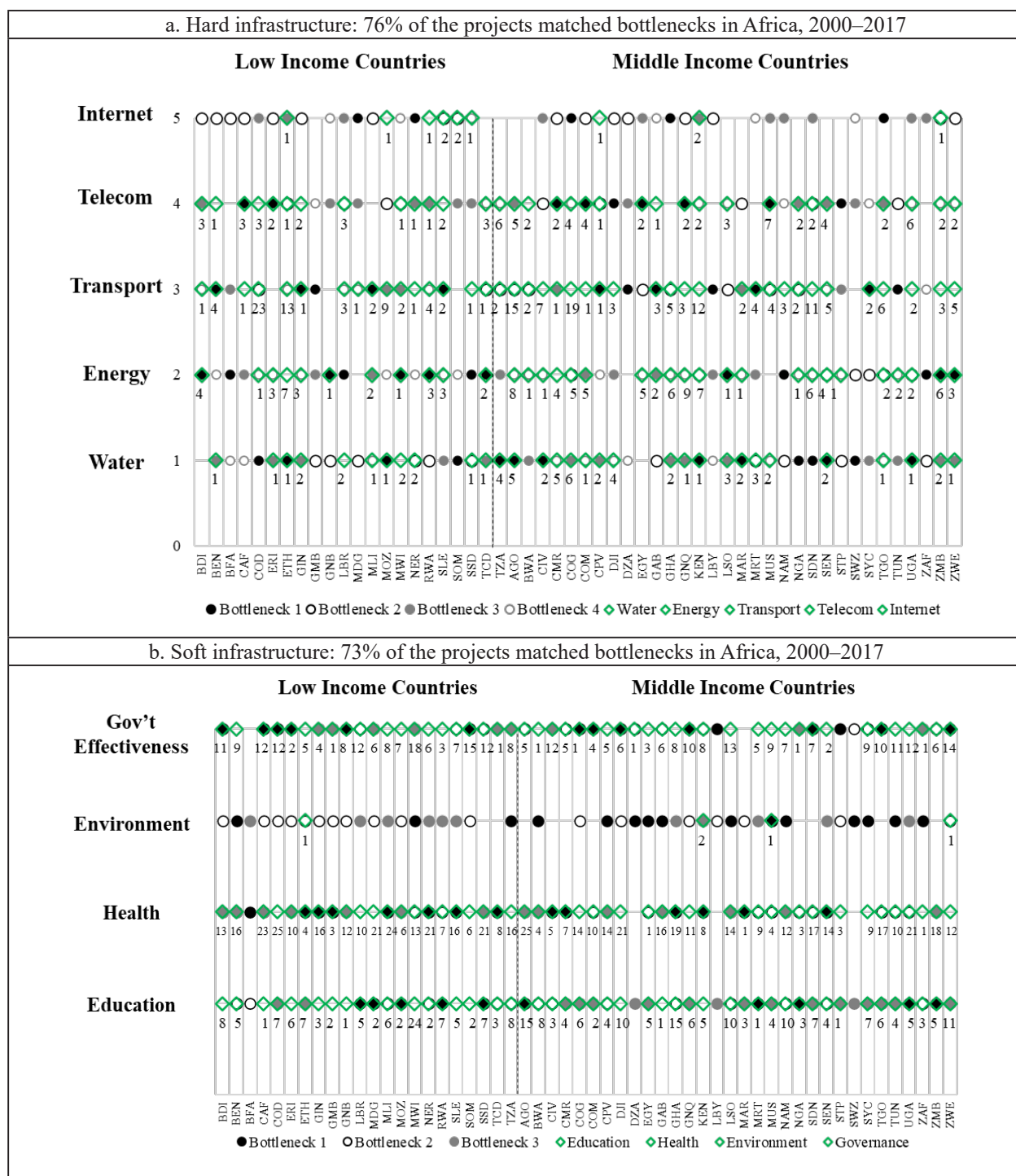
Source: Authors. For methodology, see Step 1 in Lin and Wang, 2017b, p. 124–129.

Figure 4. Infrastructure bottlenecks: All African countries, 2000–2017.

The result is as follows:

In hard infrastructure, the probability of hitting Bottlenecks 1 to 4 was 17.5%; of hitting Bottleneck 2 was 19.9%; of hitting Bottleneck 3 was 12.8%; and of hitting Bottleneck 4 was 25.9%. The total probability of hitting one of four bottlenecks was 76.1%.

In soft infrastructure, the probability of hitting Bottlenecks 1 to 3 was 30.0%; Bottleneck 2, 21.3%; and Bottleneck 3, 27.1%. The total probability of hitting one of the three bottlenecks was 73.4%.



Note: The previous two steps were merged using country codes. The numbers below each row indicate the number of projects matched in that particular subsector/indicator.

Figure 5. Infrastructure projects financed/co-financed by China matched with bottlenecks for 76% of hard infrastructure projects and 73% of soft infrastructure projects in Africa during 2000–2017.

4.4. Implications of this work

This work, among several other empirical studies, debunks the claims among Western countries and media that China practices so-called “rogue” activities and “debt trap diplomacy”

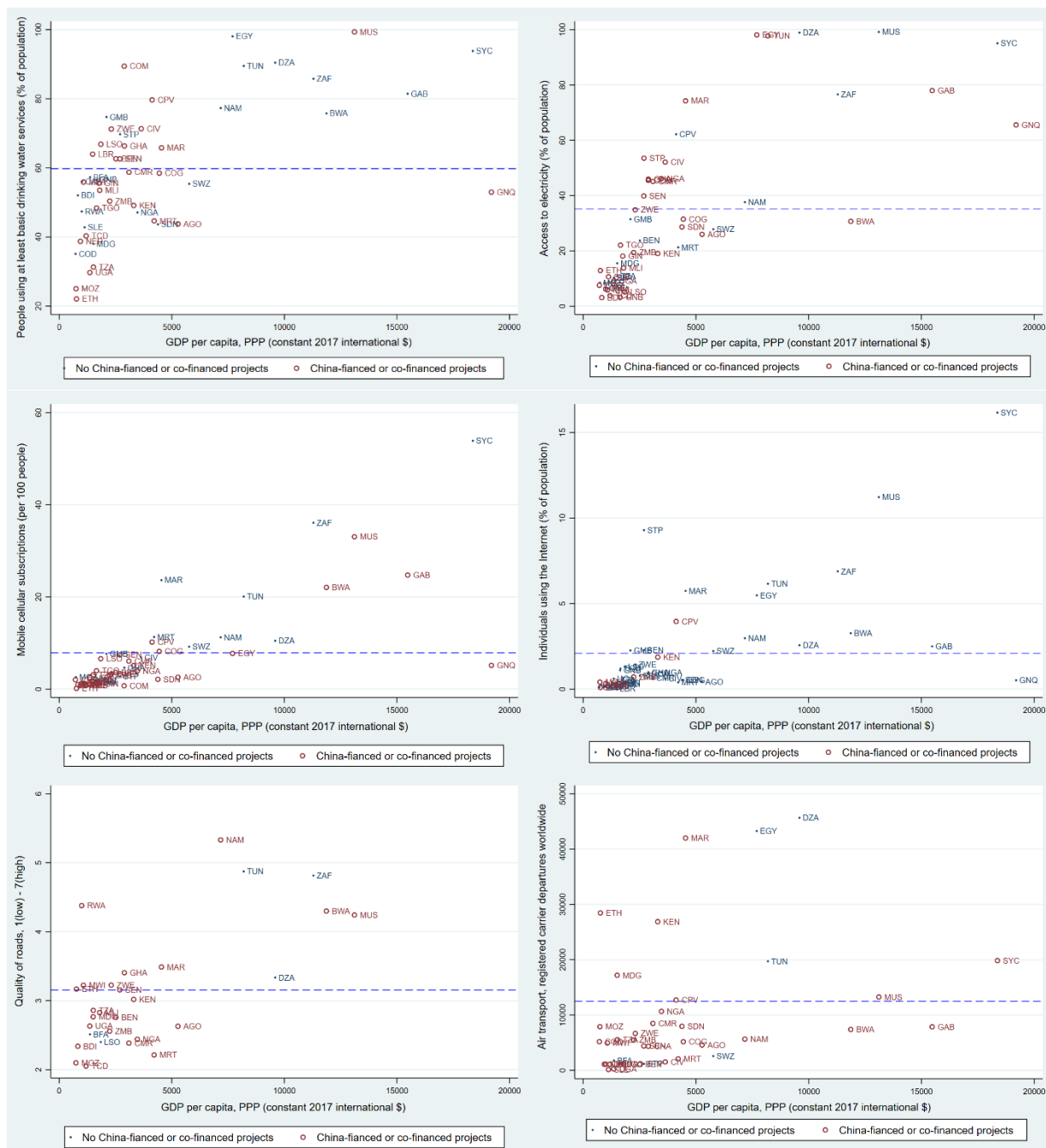
(Brautigam, 2011; Brautigam, 2020; Lin and Wang, 2017a; Wang and Xu, 2022). Infrastructure, such as hydropower stations, power grids, roads, ports and bridges, are public sector assets. These infrastructures can generate revenues and create jobs. If planned carefully, this can help generate economic growth, develop manufacturing, create jobs and reduce poverty. Infrastructure financing is of such strategic importance, and, in places, the financing gap is so large that it is necessary to encourage international investment to fill it.

The completed projects are proven to have helped mostly low-income countries in Africa to address the most backward subsectors, and that is, they helped to address low-income countries' development bottlenecks. **Figure 6** shows the distributive relationship between China sponsored/cosponsored completed projects, development bottlenecks, and initial GDP per capita. In six hard infrastructure subsectors of clean water, electricity, roads, airports, telecom and Internet, China sponsored/cosponsored completed projects are most often carried out in countries whose initial income level is among the lowest and with below-average infrastructural development status at the initial level. This implies most of these infrastructure projects are well targeted.

In the current narrative, too little attention has been paid to the public assets financed and constructed by Chinese investments jointly with the host countries. In Africa alone, Chinese companies have utilized various funds to help African countries build and upgrade more than 10,000 km of railways, nearly 100,000 km of highways, nearly 1000 bridges and 100 ports, and 66,000 km of power transmission and distribution. They have also helped to install 120 gigawatts (GW) of power-generating capacity, a communications backbone network of 150,000 km and a network service covering nearly 700 million user terminals. Built and operated by Chinese companies, the Mombasa-Nairobi Railway was the first modern railway to be built in Kenya in 100 years. (MOFCOM, 2020; The State Council Information Office of the People's Republic of China, 2021). It bears repeating that these completed projects have formed a part of African countries' public assets, and generated large externalities that benefit all other sectors and other investors.

Similar results have been documented in some empirical research focusing on certain hard infrastructure projects financed or co-financed by China in Africa. Tang and Shen (2020) found that after the Bui Dam's completion in Ghana, the likelihood for households living in the treatment regions having access to electricity increased by about 4%, by using two difference-in-differences models to identify change in the likelihood of having access to electricity, and to own several electric appliances among over 29,000 local households receiving electricity transmitted from the Dam. Chinese investments in Africa significantly bridged Africa's infrastructure gap. The OECD (2012) notes that China's investment in infrastructure "has helped develop infrastructure in fragile and low-income states, which may otherwise not have had access to market finance or even to donor fundings which tend to focus on social sectors in these countries".

However, our own analysis points to the targeting problems afflicted 22% of completed hard-infrastructure projects and 26% of soft-infrastructure projects, meaning that they were not genuinely demand-driven. There may exist "white elephant" projects that are not closely related to the host country's urgent needs. Other studies found that Chinese investment in Africa is fraught with issues such as risky loans, moral hazards and environmental concerns rooted from informal operations. Dreher et al. (2022, p. 228) pointed out that "*Socioeconomic impacts of Chinese development projects are comparable with, if not superior to those generated by the World Bank. However,*



Source: Authors. The horizontal lines in each chart indicate the average levels for African countries with data. Completed projects (red circle) in countries below average level means that the projects target the sectoral development bottlenecks, especially in low-income countries.

Figure 6. Relationship between China-sponsored completed projects, bottlenecks and GDP per capita.

Chinese development projects may also have negative externalities, such as corruption, political instability, and environmental degradation.” Brautigam’s recent study (2022) on China and Zambia reveals that the multiplication of stakeholders has created fierce and unregulated competition for infrastructure contracts in the host country. In addition, some research document a large proportion of informal Chinese small-scale mining operators in the extractive sector with their activities exacerbating the already high mining-induced environmental problems (Crawford and Botchwey,

2017; Ofosu et al., 2020).

5. Policy options for debt restructuring from the angle of public assets

This paper argues Africa appears to be in grave debt distress when viewed using the DSA lens, but may be in better shape if viewed with the lens of a public sector balance sheet. China has actually contributed to the building of public assets that have addressed key bottlenecks in Africa's transformation, as shown in Section 4. Moreover, when countries were in debt distress, China has been more apt to be accommodating than the conventional wisdom suggests. Study finds that China has restructured and refinanced approximately \$15 billion of debt in Africa in the past two decades, through bilateral negotiation and tailoring programs to each situation (Acker et al., 2020).

Generally, a country whose public assets are more significant than their liabilities is in a better position than a conventional DSA would suggest. The country could refinance public assets based on its equity share thus far to take on more debt. It might also decide to sell those public assets to pay down debts when public revenues are on a decline. The country can select from various potential buyers, such as SWFs, if they decide to do so.

We propose the following policies be considered:

- On debt sustainability assessments, look into what the debts are for, and further investigate the debt sustainability status accounting for the public assets, and use bottleneck exercise to scrutinize new debt in developing countries. The goal would be to ensure that such debt is invested in public assets that enhance long-run growth rather than in short-term spending,
- On debt restructuring, it is high time to rethink the G20 common framework, which uses a case-by-case model, and to adopt an approach similar to that used in the highly indebted poor countries (HIPC), with all creditors including the multilateral development banks (MDBs) participating, and every creditor gets the same "equitable treatment" (See Interim Gill's speech at the Annual meetings in October 2022).
- On development finance, focus on equity as well as debt. Recognize that in some cases restructuring will still be inevitable and will require innovative approaches such as debt-for-equity and debt-for-nature swaps. (Simmons et al., 2021)
- Asset-based refinancing shall be considered as one of the options. Completed projects constituting a part of public assets, can, if professionally managed, generate revenue, employment and spillover effects. If a country's government has repaid part, say 30%, of the loans for a completed project that is in operation, that project constitutes the government's equity in the public sector balance sheet. The government could add up several of these projects' equity shares (e.g., e1, e2 and e3), package them and ask for refinancing from Sovereign Wealth Funds, green funds, or multilateral, regional or national development banks and other long-term "patient" investors. Thus, this can be called the "sum of assets" approach.
- Financial institutions should welcome opportunities to combine a loan "in distress" with a well-designed green energy/corridor project and provide asset+ based refinancing at a preferential interest rate, because it will add value to their effort in the overall goal of decarbonization. Here the experience of the China Development Bank with the Wuhu model

may be applicable (see Lin and Wang (2017b) on the Wuhu model). The reasoning is that, with urbanization and agglomeration, projects that are consistent with a country's comparative advantage would have spillover effects on such other sectors as real estate, construction and trade and services, and would promote growth and revenue generation. With prices and productivity rising, shifting from a single loan to a packaged portfolio may achieve "one plus one greater than two" over a longer time horizon.

- In the long term, a country may take completed projects already in operation with cash flows (e.g., a power generation plant or a railway) up for IPOs, divesting and diversifying from these completed projects and raising capital for other public infrastructural investment. That country might allocate a certain proportion of these shares to the country's public wealth funds (PWF), sovereign wealth funds (SWF) or national pension funds, so that all citizens could benefit. Examples include China's profitable high-speed rails from Beijing to Shanghai (and five other lines), for which the government put up for IPOs, raising funds in the stock exchanges. In general, China's regulation requires that certain proportions of shares of state-owned listed companies be given to the National Social Security Funds/pension funds so that everyone can benefit from them, similar to Singapore's GIC and Temasek. African countries can learn from these experiences of public asset management.

In sum, bilateral and multilateral creditors need to work together to design tailored restructuring plans to help African countries in easing their debt burden and expand fiscal space for a sustainable economic recovery (Qian and Wang, 2022). In pursuit of achieving sustainable development goals in the post-pandemic era, African countries need to know what the government owns (assets) and owes (liabilities), to distinguish "patient capital" from "footloose" investors, and to separate long-term (structural) and short term (liquidity) issues. In order to address the long-term structural issues, African countries need to work with patient capital holders such as MDBs and regional and national development banks by experimenting with innovative asset-based refinancing and other approaches suggested in this paper.

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Conflict of interest

The authors declare no conflict of interest.

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Appendix

Table A1. China financed and completed hard infrastructure projects in Africa: 10 major projects in selected sectors

Project title	Sector	Recipient country	Year completed
China Eximbank provides \$2.003 billion buyer's credit loan for Phase 1 of Standard Gauge Railway Project	Transport	Kenya	2017
China Eximbank loans 1.4 billion USD for Phase 2A of the Standard Gauge Railway Project	Transport	Kenya	2019
China Eximbank provides \$608 million USD loan for 1250 MW Merowe Hydroelectric Power Plant Project	Energy	Sudan	2010
China Eximbank provides \$1.2 billion loan for the Addis Ababa–Djibouti Railway Project	Transport	Ethiopia	2018
Bank of China loans \$332 million USD for Kafulafuta Water Supply System Project	Water	Zambia	2018
China Eximbank provides \$322 million USD government concessional loan for Phase 1 of the Ethiopia-Djibouti Water Pipeline Project	Water	Djibouti	2017
China Eximbank provides RMB 530 million government concessional loan for Phase 3 of the E-Government Project	Telecom	Senegal	2017
China Eximbank provides \$200 million preferential buyer's credit for NigComSat-1 Communications Satellite Project	Telecom	Nigeria	2007
CDB loans Angola \$39.2 million for Cuito water supply system	Water	Angola	2017
China Eximbank provides \$32.6 million loan for Digital Television Migration Project	Telecom	Burundi	2016

Source: The Global Chinese Development Finance Dataset, version 2.0 developed by Aiddata. We used aiddata.com version 2.0 and controlled for 3126 completed and "Recommended for Aggregates" projects in Africa. Due to space limit, this table shows a subset of the 468 projects located in five sectors for hard infrastructure.