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**Article**

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# Electricity fluctuations and tax revenue in Sub-Saharan Africa: insights from a bias-corrected linear dynamic panel model

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## ABSTRACT

Electricity is an important ingredient for development; however, inadequate electricity supply and its frequent fluctuations adversely affect the productivity and profits of small and medium enterprises in sub-Saharan Africa (SSA). In turn, the adverse effects pose challenges to economic growth and subsequently narrow further the low tax base in the region. Information regarding the macroeconomic effects of electricity fluctuations on the tax base in SSA is limited, thus calling for a detailed and refined study of this nature to analyse the effect of electricity fluctuations on the tax base in SSA. A bias-corrected linear dynamic estimator is employed for the analysis using a panel dataset for 41 SSA countries from 2000 to 2022. The results show that electricity consumption is positively related to the tax base in SSA while electricity fluctuation creates fiscal losses in terms of narrowing the tax base. Specifically, gross capital formation and informal economic activities are adversely affected by electricity fluctuations. This is a dramatic dampening effect that requires policy attention. The results indicate that the African governments in SSA need to increase investments in (including renovation of) the electricity infrastructures and diversify sources of energy into visible and tangible levels. This is because unreliable supply of electricity denies these countries the benefit of digital transformation, especially internet access. Sustaining the pace of stable and reliable electricity is paramount for economic growth and the growth of tax revenue in SSA countries. The article offers a highlight in energy policy review to include reliability as a prime concern for elevating economic growth and tax base in SSA countries.

## IMPACT STATEMENT

The findings suggest that African countries should speed up renovating/investing in electricity infrastructures that would enable expanded access to electricity and the Internet, among other digital transformation opportunities. Furthermore, policymakers and communities in SSA should continue expanding their knowledge on another source of energy (including renewable energy) in view of ensuring sustainable and reliable access to electricity in the region to support economic growth and subsequent expansion of the tax base.

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## Introduction

The frequent electricity outages, distribution loss and low consumption levels have long-term implications in straining economic growth, firms' productivity, poverty reduction and revenue mobilization in SSA. The SSA countries need to expedite electrification into their long-term investment agenda and realise that electricity is one of the necessary inputs for economic transformation (Muhithi & Lusambo, 2022). Shortage of electricity generates severe impacts because it obstructs modern technology adoption and lowers the quality of delivery of public services such as healthcare, and education. The challenge is further exacerbated by the ongoing impact of global warming, fuel price risks, and rising electricity demand (Shah et al., 2023). Inclusive strategies such as proper waste management, good environmental policy and efficient utilization of natural resources offer a good opportunity to improve green electricity

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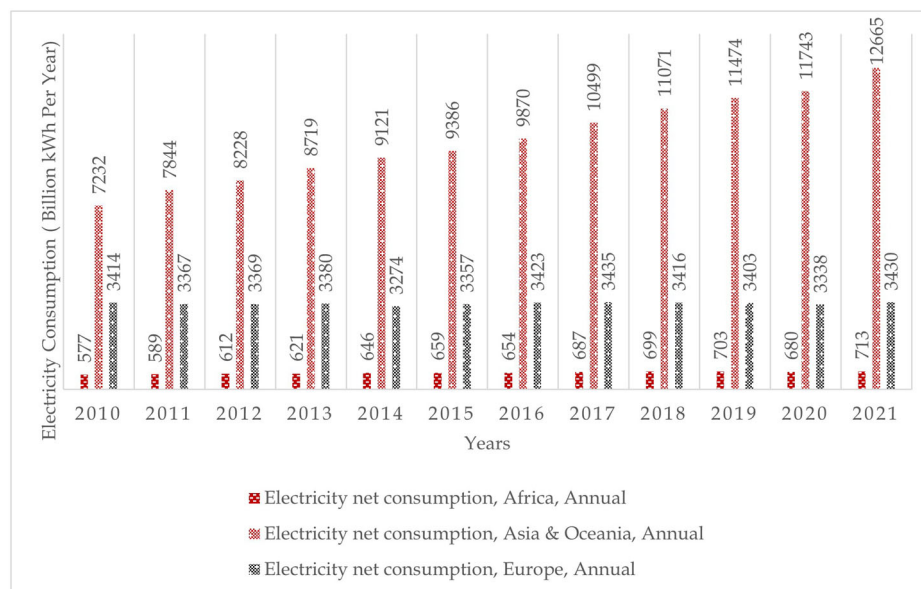
generation (Shah et al., 2023). On a similar note, Abbas et al. (2024) iterated that mega-infrastructure positively affected the tourism activities which subsequently, elevated the quality of locals' life. Corroborating this claim Li et al. (2022), emphasised a strong corporate social responsibility among employees in small and medium enterprises as a key strategy for reducing tax avoidance that affects business firms' performance. Furthermore, policy initiatives and investment agenda must go hand in hand in strengthening Information, Communication, and Technology (ICTs) and electricity infrastructures that ensure stable and reliable electricity for enhancing economic growth and tax base in SSA.

Attaining a sustainable economic growth and tax base is a set of inclusive factor inputs including access to stable and reliable energy. Despite this fact, low electricity access and consumption present a fundamental challenge towards elevating growth, and poverty reduction in sub-Saharan Africa (SSA). The report issued by Global Energy (2023) indicates that the total consumption of electricity in the region in the year 2022 was around 722 Terawatt Hours (TWh) which is seventeen times lower compared to the consumption level in Asia (12,674 TWh), six times in North America (4659 TWh) and four times in Europe (3315 TWh). Further, it is estimated that 594.14 million people in SSA do not have access to electricity compared to 102.83 million (South Asia), 43.81 million (East Asia and Pacific), and 61,452 in (Europe and Central Asia) (Ritchie et al., 2023). Further, stylised fact shows that rural and urban populations with access to electricity in the region are 28.52% and 78.18% respectively, compared to South Asia where 93.61% (rural) and 99.72% (urban) and low-income countries 30.44% (rural) and 70.10% (urban) in that order.

Apart from the low rank in access and consumption of electricity, SSA faces multiple challenges in terms of stability, reliability, and quality of electricity (Blimpo et al., 2020; Kaseke & Hosking, 2013; Wang et al., 2023). The production of electricity and its transmission losses in SSA are completely erratic. The average electricity consumption over decades has been around (653.33 billion Kilowatt-Hours (kWh) per year) which is quite below 17.76 times (9821 billion kWh per year) in Asia and Oceania, and 4.81 times (3383.83 billion kWh per year) in Europe (see, Figure 1).

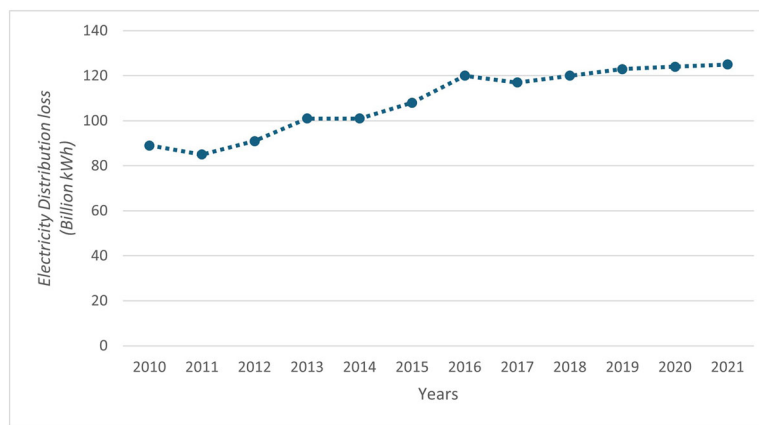
In SSA, electricity distribution losses have also been amplified over time exerting more pressure on electricity sustainability. Apart from low electricity access, electricity consumption is also low and there is evidence of high electricity distribution loss as shown in Figure 2.

The gravity of frequent electricity outages and their distribution loss is evident given the population and urbanisation growth in SSA. Thus, there is a pressing need to strengthen the existing electricity infrastructures in the region. It is for this reason that the United Nations Sustainable Development Goal 7 (SGD7) emphasizes the need to ensure access to affordable, reliable, sustainable, and modern energy for all. However, predictions suggest that the cost of attaining universal access to electricity in SSA by



**Figure 1.** Electricity consumption (Billion kWh Per Year) in SSA from 2010 to 2021.

**Source:** Construct from U.S. Energy Information Administration (EIA, 2010–2021).



**Figure 2.** Electricity distribution loss (Billion kWh Per Year) in SSA from 2010 to 2021.

**Source:** Construct from U.S. Energy Information Administration (EIA, 2010–2021).

2030 will be more than \$50 billion each year. The trade-off of this investment will be viable only if losses are decreased by 5% and the resultant supply is both stable and reliable (Thomas & Fung, 2022).

The effects of electricity on firm performance (Amos & Zanhoun, 2019; Azimoh et al., 2017; Fried & Lagakos, 2023; Nguimkeu & Okou, 2021; Olkkonen et al., 2023; Winklmaier et al., 2020) and on the overall economic growth (Andersen & Dalgaard, 2013; Dagnachew et al., 2017; Falchetta et al., 2021; Lawal et al., 2020) are well documented. Nevertheless, frequent power outages have been a common feature in most of the SSA countries (Andersen & Dalgaard, 2013; Cole et al., 2018; Farquharson et al., 2018; Kaseke & Hosking, 2013; Mensah, 2016), affecting not only growth but also the revenue mobilisation. A strand of literature shows that power outages have a strong impact on economic growth (Blimpo et al., 2020). Supporting the same claim, Chen et al. (2023) showed that reducing power outages by 1% would elevate global economic growth by 2.16% and that reducing electricity outages by 1% would significantly improve the economic growth in SSA.

There is less documentation on the effects of electricity fluctuation on the tax base in SSA at the macro level. Thus, this article fills in this gap by examining the effects of “electricity outages” proxied as “electricity consumption fluctuations” on the tax base using a bias-corrected estimator robust to several heteroscedasticity and cross-sectional dependence following the endogenous growth model.

## Literature review

Analysing the joint effects of power outages frequency and duration of outages on the performance of firms (Osei-Gyebi & Dramani, 2023) showed that one unit increase in outage frequency and its duration reduces yearly sales of firms by \$114.9 in SSA. Furthermore, the same study revealed that small-size firms in SSA incurred \$408.89 losses relative to larger firms due to the combined effects of power outage and duration of occurrence. A similar argument was made by Foster and Steinbuks (2009) that frequent power outages heterogeneously affect large companies and small business turnovers. Endris and Kassegn (2022) documented that inadequate access to electricity constrained the growth of Micro, Small, and Medium Enterprises (MSMEs) in Ethiopia. The prolonged frequency of power outages is detrimental to output and firms’ profitability and productivity, especially for electricity-sensitive industries (Alam, 2013; Thomas & Fung, 2022; Xu et al., 2022).

Furthermore, Cole et al. (2018) found that firms’ sales in SSA would increase by 85.1% if the experiencing power outages that average 75% are reduced to 44.8%. Blimpo et al. (2018) argued that solving issues related to electricity shortages could enable SSA to collect additional revenues of \$9.5 billion equivalent to 4.3% of total tax revenues per annum. These losses undermine the public provision of social services. Arguably, electricity fluctuations in SSA on average dragged the economic growth by 2.1% albeit lowering firms’ sales by 4.9% (Eberhard 2011). Employing a general equilibrium model, Fried and Lagakos (2023) showed the long-run general equilibrium impacts of power outages are much larger in developing countries and argued for these countries to put strategies that shall reduce/eliminate power outages at the centre of their development agenda.

Investigating the performance of the 16 World Bank Solar Home System (SHS) implemented solar projects (Shyu, 2023) acknowledged that low subsidies and investment support constrain the availability of stable and reliable electricity in SSA. Additionally, poor risk management, high cost of credit services and inadequate partnership between local banks and microfinance institutions contribute largely to low electrification rates in developing countries. In a similar argument, Chen et al. (2023) and Iorember et al. (2023) revealed that an increase in bank lending correlates with the spread and availability of renewable energy. The convenient way to put in place resilient renewable energy is for the fiscal stance and monetary policy to flexibly smoothen credit risks and capital charges with the consideration of environmental sustainability. Evidence shows that green financing and environmental tax significantly improve investment in renewable energy and economic growth while geopolitics risks underscore such initiatives (Abbas et al., 2024; Dong et al., 2023; Yan & Haroon, 2023). A study by Cheikh and Zaid (2023), confirmed that adverse geopolitical incidence adequately affects the diffusion of alternative sources of energy. The findings indicate that less developed countries must diversify their economies away from traditional energy sources (Khan et al., 2023; Liu et al., 2023).

Diversifying to renewable energy depends on the nature of regulatory authority and its autonomy in setting and controlling electricity prices. Independent and competitive regulatory agencies can achieve efficiency in the energy market (Sirin et al., 2023; Song, 2023); however, its interactions with the politics of the state must be given special consideration. Additionally, financial constraints, business regulation, and information asymmetry may adversely affect the efforts to achieve SDG-7 (Lin et al., 2023). Arguing in a similar vein, Ramzan et al. (2023) recommended governments to implement flexible tax reform policies by targeting investment in innovative renewable energy. Empirical studies using Granger causality, GMM, fixed and random effects models have augmented energy consumption in the production function as a necessary input (Arawomo et al., 2018; Eggoh et al., 2011; Lawal et al., 2020; Wolde-Rufael, 2006). These studies have documented that energy consumption has a positive and significant relationship with economic growth.

Other scholars have used the endogenous growth model to analyse the role of education and good healthcare in economic growth exhausting time series (Cetin & Dogan, 2015; Islam & Alam, 2022; Jalil & Idrees, 2013), cross-sectional (Nurvita et al., 2022; Ridhwan et al., 2022) and dynamic panel set up (Adeleye et al., 2022; Andersen & Dalgaard, 2013; Dialga & Ouoba, 2022; Gaidhani et al., 2022; Gaies, 2022; Mabrouki, 2023; Rangongo & Ngwakwe, 2019; Sharma, 2018; Soegiarto et al., 2022; Sultana et al., 2022). Numerous studies have delved greatly into the effect electricity outages at firm level (Alam, 2013; Blimpo et al., 2018; Cole et al., 2018; Osei-Gyebi & Dramani, 2023; Wang et al., 2023; Xu et al., 2022) and on growth (Ali et al., 2020; Fried & Lagakos, 2023; Ghazouani et al., 2020; Lin & Liu, 2016; Magazzino et al., 2021; Mezghani & Haddad, 2017).

However, there are limited studies that have linked electricity fluctuations with tax revenue at the macro level (Babajide & Brito, 2021; Blimpo et al., 2018; Osei-Gyebi & Dramani, 2023). Nevertheless, these studies did not account for the cross-sectional dependence challenges. It is therefore hypothesized that power outages adversely affect the SSA efforts in mobilising the needed revenue to finance social amenities and reducing the intensity of poverty. However, the documentation of the effect of electricity outages on tax revenue in SSA at the macro level is limited. Thus, this article bridges this gap by examining the effects of electricity fluctuation on the tax base in SSA. Specifically, an extension of knowledge is based on two rationales: First, examining the effect of electricity fluctuation on tax base in SSA at the macroeconomic perspective and second, a bias-corrected estimator robust to several heteroscedasticity and cross-sectional dependence as opposed to the traditional panel models is used to derive the results following the endogenous growth model.

## Methods and materials

### *Conceptual underpinning*

The endogenous growth model predicts that the transformation of any economy depends largely on the factor inputs such as technological advancement and transfers, physical and human capital, and the good health of its population (Romer, 1996). The effective use of factor inputs is also the function of the availability of reliable and quality electricity. The sub-optimal provision of electricity will endanger



the augmented productivity derived from the use of these inputs. Unreliable electricity supply affects firms' sales in general (Cole et al., 2018; Wang et al., 2023; Xu et al., 2022), and particularly firms with no access to power generators.

The endogenous growth model predicts that effective utilization of labour and capital equipment is very critical in enhancing growth and hence tax base (Romer, 1990). With frequent electricity outages and rationing, labour productivity becomes low (Endris & Kassegn, 2022; Fried & Lagakos, 2023). Hence, Governments' and firms' electricity-sensitive activities may stop operating for a while or operate at the higher cost of generators (Sovacool, 2021). For instance, manufacturing firms' productivity slows down albeit affecting sales turnovers, small, and medium business stop their operations (e.g., carpentry and welding) refrigerated perishable goods become obsolete, and incubated poultries are extremely exposed to death risk zones. Based on a general equilibrium approach (Fried & Lagakos, 2023) cemented that electricity outages reduce productivity by creating idle resources, disheartening the scale of incumbent firms, and pushing out the entry of new firms. All these consequences have adverse effects on the timely delivery of goods and services to the final consumer and consequently, affect corporate and consumption taxes. Nevertheless, tax evasion can be exacerbated because of the high cost incurred by the private sector in operating generators (Sovacool, 2021). Similarly, instability in electricity can significantly discourage potential investors. In some cases, investors shift to other countries where working facilities are established. These departures tend to lessen employment, income, and growth which ultimately affect tax revenue collections.

Theoretically, the socioeconomic welfare of the states is determined by the quality of education and innovation, the state of healthcare provision and access to social amenities such as clean water and quality housing (Alkire et al., 2022; Mango et al., 2021). The functionality of these important welfare determinants depends on the availability of stable and affordable electricity. Intermittent electricity outages in this context, put at risk the speed of reducing poverty. It goes the same with high costs of power which reduce the free accessibility to electricity for families, and companies of limited economic funds (Amadi, 2015; Salite et al., 2021). Acute consequences such as an increase in students' anxiety (Fawaz & Samaha, 2021; Ibrahim et al., 2016), an increase in mental health, as well as maternal and child health challenges (Koroglu et al., 2019; Rubin & Rogers, 2019) are caused by power outages. Physiological effects on the vulnerable community also emerge when electricity blackouts occur especially when these blackouts occur at night (Rubin & Rogers, 2019). Once the electricity is gone, the use of charcoal and gasoline further exposes the community, especially elders to carbon monoxide (CO) poisoning (Casey et al., 2020; Stoppacher et al., 2008). The ultimate effect of the frequency of power outages on the socioeconomic life of the community is compounded by a decrease in production, sales, and spoilage of refrigerated perishable goods like milk, meat, and fish, consequently bringing heavy revenue and welfare losses.

The nexus between electricity consumption and tax revenue collections is explained through the endogenous growth model. As put forward by Romer (1996), the use of technological innovations goes hand in hand with the use of Information and Communication Technology (ICT). Studies have shown that increasing ten percentage points in the growth of ICT/Internet of the Things (IoT) connections per inhabitant is associated with a 0.23 percentage point increase in total factor productivity growth (Edquist et al., 2021). ICT, therefore, will continue playing a pivotal role in shaping tax collection in SSA. This is because these countries have massively digitalized their tax collection systems. For instance, Value Added Tax (VAT) is substantially captured with the use of ICT where its functionality depends entirely on the availability of reliable electricity. Unreliable and volatile electricity may have an influence on tax collections from VAT. The situation undermines business performance, especially for those having no capacity for voltage backup or generator machines. It is worth noting that, the cost of maintaining generators is huge given that the price of fuel has plummeted to almost 50% within two years. The effect of the reliability of electricity on taxation can be traced through tax revenue losses caused by the negative impact of electricity blackouts on the productive sectors of the economy.

The tax base of any country is determined by the level of economic activity (GDP). The GDP is either determined by the total expenditure, sectorial contributions or output produced using factor inputs. Implicitly, tax effort in a panel set-up is expressed as:

$$T_{i,t} / GDP_{i,t} = \varphi + \varphi_1 GDP_{i,t}^{pc} + c_{i,t}^{ef} + \varepsilon_{i,t} \quad (1)$$

where  $GDP^{pc}$  is the proxy variable for GDP countries. Let's consider the simplified version of Research and innovation (R&D) (Romer, 1990, 1996) and express output ( $GDP_{it}$ ) as the function of the evolution of factor inputs such as labour ( $l_{i,t}$ ), capital ( $k_{i,t}$ ) and technology ( $a_{i,t}$ ). For simplicity, it is assumed that there are two sectors in the economy where these inputs are used, a good procuring sector where output is produced and an R&D sector where additional stock of knowledge is nurtured. Part of the labour force ( $l_{i,t}^{rd}$ ) is employed in research R&D while the rest ( $1 - l_{i,t}^{gs}$ ) goes direct into the sector that produces goods and services. Similarly, a portion of the capital stock ( $k_{i,t}^{rd}$ ) is utilized in R&D and what is left ( $1 - k_{i,t}^{rd}$ ) is utilized in producing goods and services. As conventionally acknowledged in the literature, both sectors use the full stock of knowledge ( $a_{i,t}$ ). Following the endogenous growth model (Romer, 1996), and as applied by Zerbo (2017) the quantity of output (GDP) produced by country  $i$  at time  $t$  is expressed as:

$$GDP_{i,t} = \left[ \left[ \left( 1 - k_{i,t}^{gs} \right) \left( k_{i,t}^{rd} \right)^{\alpha_1} \right] \left[ a_{i,t} \left( 1 - l_{i,t}^{gs} \right) \left( l_{i,t}^{rd} \right)^{1-\alpha_1} \right] \left[ 1 - c_{i,t}^{ef} \right]^{1-\alpha_1-\alpha_2} \right] e_{i,t}^{ut}, \quad 0 < \alpha_1 < 1 \text{ \& } \alpha_2 > 0 \text{ or } < 0 \quad (2)$$

The efficient use of the factor inputs is the function of stable and affordable electricity. Other things being equal, constant returns to scale hold in Eq. (2). The production of new ideas is explained by the quantities of labour and capital used in research and on the level of technology as moderated by electricity availability.

$$\dot{a}(it) = J[\partial[g_k k(i,t), g_l l(i,t), a(i,t)]] c_{i,t}^{ef} \quad (3)$$

Evoking the cobb-Douglas production function, Eq. (3) can be reparametrized as:

$$\dot{a}(a,t) = Z \left[ [g_k k(i,t)]^\beta [g_l l(i,t)]^\gamma a(i,t)^\sigma \right] c_{i,t}^{(ef)\emptyset}, \quad Z > 0, \beta \geq 0, \gamma \geq 0, \emptyset \leq 0 \quad (4)$$

At this point, no restriction is made on how increases in the stock of knowledge affect the production of new knowledge (education); indeed, no restriction is placed on  $\sigma$  in Eq. (4). However, if  $\sigma = 1$ ,  $\dot{a}$  is directly related to  $a$ ; and the effect eventuates if  $\sigma > 1$  and becomes weaker only if  $\sigma < 1$ . Nevertheless, the spillover effects will depend on the availability of stable electricity ( $\emptyset$ ). Until now the saving rate as in the case of the Solow model (Solow, 1987), is assumed to be constant and determined within the model (exogeneous). Also, depreciation is set to zero for simplicity. Therefore,

$$\dot{k}(i,t) = sGDP(i,t) \quad (5)$$

To this end, population growth is exogenously determined within the model, and it grows at rate  $n$ .

$$\dot{l}(i,t) = nl(i,t), \quad n \geq 0.$$

## Empirical model

From the theoretical perspective, substituting Eq. (2) into (1) tax efforts equation can be reparametrized as:

$$T_{i,t}/GDP_{i,t} = \left[ \left[ \left( 1 - k_{i,t}^{gs} \right) \left( k_{i,t}^{rd} \right)^{\alpha} \right] \left[ a_{i,t} \left( 1 - l_{i,t}^{gs} \right) \left( l_{i,t}^{rd} \right)^{1-\alpha} \right] c_{i,t}^{ef} \right]^{\phi}, \quad 0 < \alpha < 1 \text{ \& } \phi > 0 \text{ or } < 0 \quad (6)$$

The country's tax base (tax handles) is well acknowledged in the literature. Let denote these tax handles as 'x'. The empirical counterpart of Eq. (6) with tax handles inclusive can be linearized as follows:

$$T_{i,t}/GDP_{i,t} = \varphi + \varphi_1 \ln GDP_{i,t}^{pc} + \varphi_2 \ln k_{i,t}^* + \varphi_3 \ln l_{i,t}^* + \varphi_4 e_{i,t}^{ef} + \varphi_n x_{i,n}^* + \mu_i + v_i + \varepsilon_{i,t}, \quad (7)$$

where  $T_{i,t}/GDP_{i,t}$  is tax to GDP ratio,  $\ln k_{i,t}^*$  denotes capital stock used to produce goods and services proxied as fixed capital formation (% GDP),  $\ln l_{i,t}^*$  represents the labour used to produce goods and services measured as labour force (aged 15–64% total labour force),  $c_{i,t}^{ef}$  capture the effects of the electricity fluctuations and  $x_{i,n}^*$  denote the other tax handles such the share of agriculture in GDP-the hard sector



to tax, open economy measured as the ratio of the sum of export and import to GDP, foreign direct investment (% GDP), manufacturing as % GDP, service industry % GDP, inflation (annual growth %) and, informal economic activities (% GDP).

Existing studies indicate that some estimate techniques are useful to estimate the coefficients in Eq. (7). These techniques range from fully modified Ordinary Least Square (OLS) (Emmanuel et al., 2024), the dynamic GMM (David & Sever, 2024; Yao & Jin, 2024), traditional panel models (Cuceu et al., 2024), structural equation model (Abbas et al., 2024) and many more that play various roles in parametric and non-parametric estimations. Naudé (2004) and Fisman and Svensson (2007) noted, the estimation techniques especially OLS cannot account for omitted bias, outliers and unobserved heterogeneity and may result in inefficient estimates. Nickell (1981), however, claims that the application of the traditional linear panel models with lagged dependent variables is not recommended while dealing with short time horizons. In his argument, including the lagged endogenous regressor in a panel bias (dubbed the Nickell bias) shall lead to estimated coefficients that are biased and unreliable. In this way, a specific approach that accounts for heteroscedasticity and cross-sectional dependence was applied to understand the channel through which electricity fluctuations affect the tax base in SSA. To correct the bias embedded in the traditional panel estimators, (Breitung et al., 2022; Everaert & Pozzi, 2007) suggest the use of linear dynamic panel models that overcome the challenges related to traditional panel estimators. Similarly, Kweka (2023) applied the same approach in analysing the effect of terms of trade on tax revenue in SSA. Therefore, following the approach of Breitung et al. (2022), a bias-corrected estimator of the linear dynamic panel model is expressed in Eq. (8).

$$t_{i,t} = \sum_{j=1}^p \varphi_j t_{i,t-j} + \varphi_j c_{i,t}^{ef} + \varphi_j (c_{i,t}^{ef} \times x'_{i,t}) + \varphi_j x'_{i,t} + \mu_i + \nu_i + \varepsilon_{it} \quad (8)$$

where  $t_{i,t}$  denote the tax to GDP ratio. In Eq. (8), the electricity fluctuation variable interacts with exogenous variables to trace the indirect effects on the tax revenue base in SSA. In this study, a bias-corrected linear dynamic random effect estimator is used for deriving the results. It is also shown that OLS is biased when applied to traditional panel models due to cross-sectional dependence challenges (Kweka, 2023). Further, in its process of analysis, a bias-corrected method of moments estimators for the dynamic panel model (Arellano & Bover, 1995; Arellano & Honor, 2001; Breitung et al., 2022; Kripfganz, 2016, 2019) was also adopted. This approach was employed because it accounts both endogeneity, heteroscedastic errors, and higher-order autoregressive models as compared to the traditional panel models. Thus, the estimated coefficients are based on one-step Diff-GMM as Eq. (9) indicates:

$$\Delta t_{it} = \Delta t_{i,t-1} + \Delta c_{i,t}^{ef} + \Delta x'_{i,t} + \xi_{i,t} \quad (9)$$

### Data type, source, definitions, and measurement

In this study, secondary data were collected from 41 SSA countries. At the centre of the objective, these data were used to assess the effect of electricity fluctuations on tax revenue collection at the macro level. Data on tax revenue were obtained from UNU-Wider Government Revenue 2023. Other tax base determinants variables such as the GDP per capita growth rate (a proxy variable for GDP Growth rate) is expected to portray a positive effect on tax revenue (Amoh et al., 2024; Feindouno et al., 2024). Following the approach by Moore (2023) agriculture % GDP, is included in the tax model and is expected to have a significant negative effect on tax revenue.

Similarly, literature shows that trade openness (% GDP) can either increase or decrease tax revenue, however, its effect shall depend on the strength of the economy under consideration. Studies such as Khuong et al. (2021), Kweka (2023) and Moore (2023) have included informal economic activities (% GDP) in estimating Eq. (8). The findings from these studies indicated that informal economic activities have negative impacts on tax revenue in SSA. Variables such as, gross fixed capital formation % GDP and labour force % of total population were extracted from the World Development Indicators (2000–2022). These variables are commonly augmented in growth models and are hypothesized to have positive impact on economic growth (Bist, 2018; David, 2019; Ghosh, 2019; Misra, 2020; Romer, 1996; Zhao

et al., 2024). Electricity consumption data were obtained from the U.S. Energy Information Administration (EIA) 2023. Following Azam (2020), Chica-Olmo et al. (2020), and Kongkuah et al. (2022) electricity consumption/fluctuation (a proxy variable for energy consumption) is included in a growth model and trace its impact on tax revenue. It is hypothesised that the use of electricity enhances growth and tax revenue while its frequent fluctuations demean the growth of tax base. Electricity consumption fluctuation was measured using the standard deviation following the proposed approach by Dawe (1996). This approach is preferred for analysis since it uses a moving average window to filter a series whereby the average difference between the observed series and its moving average in two years is calculated (see, Kweka, 2023). Definitions of the used variables are presented in Appendix.

### Descriptive statistics

Over the past two decades, electricity consumption in SSA averaged 7.274 kWh. The maximum and minimum electricity consumption has ranged between 220.397 and 29.342 kWh respectively. The low amount of electricity consumption corresponded with the average USD 1769.769 GDP per capita. Within the same period, SSA country's tax to GDP remained at 11.901% a ratio that is below the recommended threshold of 20% to spur economic growth (Gaspar et al., 2016). Table 1 presents the descriptive statistics of the used variables.

Two basic inputs namely labour (proxied as the percentage of total labour force aged between 15 and 64) and capital (proxied as growth fixed capital formations % GDP) averaged to 66.23 and 5.13%. As it is shown in Table 1, electricity consumption diverged from the mean value by almost 29.325 times. The skewness and kurtosis are within the recommended range for normally distributed data. The GDP per capita and electricity consumption were transformed into logarithms in the interest of meeting the normality assumptions.

### Correlation matrix

In Table 2, the correlation matrix of the variables of interest is presented. It shows that the tax to GDP ratio is positively and negatively related to electricity consumption and informal economic activities respectively. However, there is no evidence of multicollinearity. Table 2 presents the correlation matrix of the variables used in this article.

The evidence of no multicollinearity is supported by the Variance Inflation factor test (VIF) as shown in Table 3 in which the computed values are within the recommended thresholds (Vörösmarty & Dobos, 2020).

### Panel cointegration tests

The multivariate panel cointegration frameworks of Kao (1996), Pedroni (2004) and Persyn and Westerlund (2008) are used to test the long-run relationship between tax base and its determinant in SSA. It is worth noting that Kao can accommodate more than seven variables while Pedroni and Westerlund panel cointegration tests are restricted to less than seven variables. Kao's panel cointegration

**Table 1.** Descriptive statistics.

Variables	Max	Mean	SD	Skewness	Kurtosis
Tax _GDP ratio	60.95	11.901	8.626	1.559	6.589
GDP Per Capita	14222.549	1769.769	2089.69	2.51	9.973
ln(GDP Per Capita)	9.563	7.014	.907	.612	2.639
Manufacturing_ GDP	35.215	9.705	6.653	.997	4.832
Gross Fixed Formation_ GDP	79.401	19.806	11.016	.59	4.615
Labour Force (Annual Growth%)	90.959	66.234	11.014	.06	2.446
Import _ GDP	116.035	33.826	18.148	.854	4.869
Inflation (Annual Growth %)	43.438	8.017	10.775	2.035	6.868
Informal economy -GDP	65.308	35.076	14.761	-1.136	4.077
Agriculture_ GDP	63.831	22.181	14.424	.35	2.414
Service industry_ GDP	77.02	42.447	14.09	-1.22	5.187
Electricity consumption (kWh)	220.397	7.276	29.342	6.147	40.002
ln(Electricity consumption (kWh))	5.395	0.037	1.885	.042	3.222

Source: Based on data from, WDI, 2000–2022.

**Table 2.** Matrix of correlations.

Variables											
Tax _GDP ratio	1.000										
GDP Per Capita Growth	0.282	1.000									
Manufacturing_ GDP	0.234	0.240	1.000								
Gross Fixed Formation_ GDP	−0.026	0.241	0.006	1.000							
Labour Force (Annual Growth%)	0.021	−0.459	−0.061	−0.055	1.000						
Import _ GDP	0.288	0.253	0.239	0.445	−0.179	1.000					
Inflation (Annual Growth %)	0.010	−0.025	−0.067	−0.044	0.092	−0.164	1.000				
Informal economy	−0.088	−0.242	−0.040	−0.173	0.146	−0.135	0.055	1.000			
Agriculture_ GDP	−0.424	−0.661	−0.249	−0.121	0.195	−0.221	0.083	0.145	1.000		
Service industry_ GDP	0.268	0.233	0.246	0.103	−0.168	0.270	−0.207	−0.160	−0.147	1.000	
ln(electricity consumption (kWh))	0.200	0.315	0.297	0.197	0.142	−0.038	0.173	−0.163	−0.296	0.239	1.000

Source: Based on data from, WDI, 2000–2022.

**Table 3.** Variance inflation factor.

	VIF	1/VIF
Tax _GDP ratio	2.572	.389
Agriculture_ GDP	1.921	.52
ln(electricity consumption (kWh))	1.64	.61
Import _ GDP	1.582	.632
Labour Force (Annual Growth%)	1.493	.67
Gross Fixed Formation_ GDP	1.434	.697
Service industry_ GDP	1.286	.778
Manufacturing_ GDP	1.274	.785
Inflation (Annual Growth %)	1.14	.877
Informal economy	1.107	.904
Mean VIF	1.545	.

Source: Based on data from, WDI, 2000–2022.

**Table 4.** Panel cointegration test.

	Kao	Pedroni	Westerlund
Modified Dickey–Fuller	−9.9846* (0.0000)	Modified Phillips–Perron	−2.0228** (0.0215)
Dickey–Fuller	−4.7210* (0.0000)	Phillips–Perron	−5.4382* (0.0000)
Augmented Dickey–Fuller	−2.7805* (0.0000)	Augmented Dickey–Fuller	−5.0699* (0.0000)
Unadjusted- Modified Dickey–Fuller	−13.8185* (0.0000)		
Unadjusted- Dickey–Fuller	−5.8284* (0.0000)		

\* $p < 0.1$ .

\*\* $p < 0.05$ .

\*\*\* $p < 0.01$  are the respective significant levels at 1, 5 and 10%.

Source: Based on data from, WDI, 2000–2022.

rejected the null hypothesis of no cointegration at a 1% level of significance. The same conclusion is supported by the Pedroni and Westerlund panel cointegration tests whereby variables were restricted to basic tax determinants (ln(GDP Per Capita), Gross Fixed Formation (% GDP), Labour Force (Annual growth %) and ln(Electricity consumption (kWh)). Specifically, Pedroni's Modified Philip-Peron rejected the null hypothesis of no panel cointegration at a 5% level of significance as shown in [Table 4](#).

The findings in [Table 4](#) confirm the existence of the long-run relationship between the tax base and its determinants in SSA. It is, therefore, of interest to investigate the influence of electricity consumption level and its fluctuations on the performance of tax revenue in SSA.

## Results and discussion

### Tax revenue and electricity consumption level in SSA

[Table 5](#) shows the channel through which electricity consumption affects tax revenue performance in SSA. It is shown that using the OLS estimator in the traditional panel fixed and random effects model (OLS-FEM and OLS-REM) will lead to biased estimates because they suffer from cross-sectional dependence

**Table 5.** Tax revenue and electricity consumption in forty-one countries in SSA.

Tax/GDP	B-CLD-FEM	B-CLD-REM	OLS-FEM	OLS-REM
L.Tax/GDP	0.797*** (0.128)	0.961*** (0.008)	–	–
D. (ln GDP per capita)	2.492 (2.335)	2.845** (1.133)	1.394 (3.190)	1.484 (3.193)
Economic openness	0.002 (0.010)	–0.005*** (0.002)	0.021 (0.017)	0.024 (0.016)
Gross Capital Formation* electricity consumption	0.011 (0.008)	–0.001 (0.003)	0.017 (0.016)	0.016 (0.016)
Labour force*electricity consumption	–0.013 (0.009)	–0.010*** (0.003)	–0.002 (0.022)	–0.007 (0.022)
D. (Inflation Annual Growth %)	–0.019** (0.009)	–0.022*** (0.006)	–0.028** (0.010)	–0.028*** (0.010)
Informal* electricity consumption	0.021*** (0.007)	0.014*** (0.003)	0.015 (0.009)	0.015 (0.009)
GDP per capita* electricity consumption	–0.106 (0.097)	0.018 (0.017)	–0.225 (0.235)	–0.165 (0.220)
D. (Agriculture/GDP)	–0.039 (0.024)	–0.042** (0.019)	–0.028 (0.022)	–0.027 (0.022)
Manufacturing/GDP* Electricity	0.012 (0.014)	0.006** (0.003)	0.035 (0.028)	0.038 (0.027)
Service industry/GDP*electricity	0.006 (0.006)	–0.003** (0.001)	0.026* (0.015)	0.024* (0.014)
Electricity	0.486 (0.684)	0.574* (0.333)	0.409 (1.009)	0.407 (1.002)
FDI/ GDP	0.008 (0.013)	–0.002 (0.007)	0.041 (0.026)	0.042 (0.027)
GDPP sq* Electricity	0.000 (0.001)	0.000 (0.000)	–0.001 (0.003)	–0.001 (0.002)
Constant	2.098 (1.498)	0.507*** (0.102)	10.430*** (0.997)	10.194*** (1.688)
Pesaran C-D Test			0.000***	0.000***
Hausman test ( <i>p</i> -value)	0.05	0.000***	–	–
AR (2)	–	0.510	–	–
Hansen J-P-Value)	–	0.112	–	–
Observations	1271	1271	1271	1271

Standard errors in parentheses.

\**p* < 0.1.\*\**p* < 0.05.\*\*\**p* < 0.01.

challenges (Boukhelkhal, 2022). The existence of the cross-sectional dependence is validated by the Pesaran C-D test as shown in Table 5. To avoid this challenge, I estimated the results using a bias-corrected linear dynamic panel estimator following (Breitung et al., 2022) in which both bias-corrected linear dynamic fixed and random estimators are used. However, the results are based on a bias-corrected linear dynamic random (B-CLDREM) effect model/estimator as supported by the Hausman test. Furthermore, the *p*-values of AR (2) are high, so the null of no autocorrelation cannot be rejected, suggesting that the random effect estimator is consistent.

The findings reveal that the tax revenue base in SSA improves consistently with the magnitude of the use of electricity. A one-point increase in using electricity is associated with the improvement in the tax base in SSA by 0.574% over the study period. Indeed, the World Bank Enterprise Survey data (Blimpo et al., 2018) corroborates these findings with evidence that electrification has positive and significant effects on tax compliance and attitude. These findings emphasise the importance of ensuring stable and reliable access to electricity for expanding the tax base. This is consistent with the fact that most of the tax collection systems have been integrated with electricity use in SSA (Jemiluyi & Jeke, 2023; Milogolov & Berberov, 2022). Further analysis shows that the interaction of electricity consumption and informal economic activities has a positive and significant relationship with tax base improvement in SSA. Based on a bias-corrected linear dynamic panel random effect model, tax revenue in SSA improves by 0.014% because of the interaction the informal economic activities and electricity usage. Arguably, the International Labour Organisation (ILO) (2018), reported that informal economic activities account for 90% of all small and medium-scale enterprises and provide about 50–60% of jobs in SSA. Thus, there is a huge opportunity for improving the tax base in SSA by continuously stepping in effort in formalising the informal economic activities albeit availing them with stable electricity in SSA.

It is also observed that electricity plays a pivotal role in contributing to the increase of tax base through the manufacturing industry (see, Table 5). The findings show that the coefficient of the interaction terms (manufacturing industry and electricity consumption) is positively related, and statistically significant at a 5% level. Thus, a one-point increase in the interaction terms is associated with an improvement of the tax base by 0.006% in SSA. The findings also reveal that the interaction of the gross fixed formation and electricity consumption has no significant effect on tax revenue in SSA. This can be explained by the fact that SSA countries use less electricity compared to other regions as stated earlier.

The study findings reveal that agriculture impacts significantly negatively on tax revenue collection in SSA. This observation has also been confirmed by Mawejje and Sebudde (2019) and Oz-Yalaman (2019). It is intriguing to note that the interaction of formal labour participation and electricity use has negative and significant adverse effects on tax revenue in SSA. For instance, the findings from a bias-corrected linear dynamic panel random effect estimator show that the tax base in SSA is reduced to almost 0.010% by the interaction terms of the formal labour force and electricity use. These results indicate that the tax base is adversely affected by the inadequacy of access to and use of electricity by the formal labour force. Other control variables such as the service industry and open economy have a negative and significant relationship with the tax base in SSA.

### ***Tax revenue and electricity consumption fluctuations in SSA***

In Table 6, the estimated results for the effect of electricity fluctuations on tax revenue performance in SSA are presented. A bias-corrected linear dynamic random panel estimator is used to derive the results. Generally, electricity fluctuations have detrimental effects on the tax base in SSA. The estimated coefficient is negative and statistically significant at the 1% level. That is a one-point deviation of the current

**Table 6.** Tax revenue and electricity consumption fluctuations in forty-one countries in SSA.

Tax/GDP	B-CLD-FEM	B-CLD-REM	One-Step Diff- GMM	OLS-FEM	OLS-REM
L. (Tax/GDP)	0.774*** (0.107)	0.968*** (0.007)	0.675*** (0.024)	–	–
GDP growth rate (% Annual)	0.025 (0.025)	0.040** (0.016)	0.033* (0.019)	0.036 (0.027)	0.038 (0.027)
Economic openness	–0.007 (0.009)	–0.003* (0.001)	–0.002 (0.006)	0.007 (0.016)	0.011 (0.016)
Gross capital formation*electricity fluctuations	–0.001 (0.003)	–0.012** (0.006)	–0.011* (0.006)	–0.025* (0.013)	–0.021* (0.012)
Labour force*electricity fluctuations	0.007 (0.005)	0.003** (0.002)	0.007 (0.014)	–0.014 (0.015)	–0.015 (0.014)
D. (Inflation Annual Growth %)	–0.015** (0.006)	–0.016*** (0.006)	0.004 (0.012)	–0.015** (0.007)	–0.015** (0.007)
Informal* electricity fluctuations	–0.021*** (0.005)	–0.013*** (0.002)	–0.022*** (0.004)	–0.019** (0.009)	–0.018** (0.008)
D. (Agriculture/GDP)	–0.042 (0.029)	–0.030 (0.022)	–0.016 (0.017)	–0.025 (0.026)	–0.025 (0.026)
Manufacturing*electricity fluctuations	–0.014 (0.013)	–0.001 (0.003)	–0.014 (0.012)	0.003 (0.035)	–0.003 (0.036)
Electricity fluctuations	–0.647* (0.332)	–0.606*** (0.218)	–3.955 (8.027)	0.100 (0.537)	0.106 (0.514)
GDPPSQ	–0.000 (0.000)	–0.000*** (0.000)	–0.000* (0.000)	–0.000* (0.000)	–0.000** (0.000)
FDI/ GDP	–0.002 (0.015)	–0.006 (0.007)	0.003 (0.013)	0.039* (0.021)	0.043** (0.021)
Constant	1.610 (1.437)	–0.377 (0.311)		6.929*** (1.772)	6.668*** (2.066)
Pesaran CD –Test			–	0.000***	0.000***
Hausman Test ( <i>p</i> -values)	0.05	0.0000	–	–	–
ar (2) ( <i>p</i> )	–	0.5310	0.3370	–	–
Hansen J-Test ( <i>p</i> -values)	–	0.1117	0.0013	–	–
Observations	1230	1230	1271	1230	1230

Standard errors in parentheses.

\**p* < 0.1.

\*\**p* < 0.05.

\*\*\**p* < 0.01.

Column three presents the estimated results using one-step diff-GMM for the nexus between tax revenue and electricity fluctuations. The Hansen test is for the bias-corrected linear dynamic random and GMM models overidentifying restrictions. Tests for the second-order serial correlation AR (2) *p*-values are reported at the bottom of the table.

capacity of electricity consumption tends to reduce tax base on average by 0.606%. These findings are consistent with the study by Fried and Lagakos (2023) that synthesised that electricity outages reduce productivity because they are responsible for the emergence of idle resources that jeopardise the economies of scale of incumbent firms and also hinder the birth of new firms.

The interaction of capital formation “a proxy variable for capital investment” and electricity fluctuations has a negative and significant relationship with the tax base in SSA. This entails the need to ensure that there is adequate and stable electricity in SSA for capital investment flourishing. One of the key challenges that SSA is experiencing is the inability to mobilize adequate domestic financial resources and the potential lack of political readiness to establish electricity infrastructure; this is inevitable in the way that it shall attract private investors as Aluko et al. (2023) indicate. Arguably, integrating foreign direct investment with good governance can positively influence the availability of stable rural energy (Aluko et al., 2023; Dossou et al., 2023). Other control variables such as economic openness, and the growth rate of inflations have a negative and statistical relationship with the tax base in SSA. Further analysis shows that the tax base in SSA is adversely affected by informal economic activity (Kweka, 2023). The negative effects can be attributed to the effects of electricity fluctuations. Based on a bias-corrected linear dynamic panel random effect estimator, the tax base in SSA is reduced on average by 0.013% and its coefficient is statistically significant at a 1% level as shown in Table 6. Similar findings are observed as I re-estimated the effect of electricity fluctuations on tax performance using a one-step diff-GMM. Undeniably, electricity fluctuations/outages are continuously demeaning the efforts of formalising informal economic activities which in turn, demean the effort of expanding the tax base in SSA. Therefore, the policy efforts of formalising the informal sector should go parallel with the speed of improving electricity availability to support the expansion of the tax base. The contribution of the article to body of knowledge is twofold; first the effects of electricity fluctuation in tax base in SSA at the macroeconomic perspective is documented and second, a bias-corrected estimator robust to several heteroscedasticity and cross-sectional dependence as opposed to the traditional panel models is applied and tested using macroeconomic variables in SSA.

## Conclusion and policy recommendations

This study investigated the effects of electricity fluctuations on the tax base in SSA using a bias-corrected linear dynamic panel estimator. The study explored the channel through which electricity fluctuations affect the tax base using a pooled dataset for 41 countries in SSA between 2000 and 2022. The first-generation panel unit root tests confirmed the existence of the long-run relationships among the selected variables. The study verified that using the OLS estimator in the traditional panel fixed and random effects model is bias because they suffer from cross-sectional dependence challenges. Therefore, the reported findings are based on a bias-corrected linear dynamic random effect model/estimator. The study findings show that the use of electricity has positive impact on the growth of the tax base while its outage is detrimental to the growth of the tax base. The findings also reveal that the interaction of the gross capital formations “a proxy variable for capital investment” and electricity fluctuations significantly reduces tax revenue in SSA. Furthermore, small and medium enterprises that form a large part of the informal economic activities are adversely affected by the electricity fluctuations henceforth limiting their ability to operate efficiently and contribute to the tax base in SSA. Generally, electricity fluctuations adversely affect economic growth, subsequently narrowing further the low tax base in the region of SSA. The created fiscal loss undermines the efforts of attaining optimal provision of social services including the renovation of the existing electricity infrastructures which is directly related to the use of the Internet of Things (IoT). Intermittent electricity outage in this context, is likely to pull many people in SSA into the poverty basket. The study findings call for the need for a fiscal stance, monetary policy, and the private sector to flexibly smoothen credit risks and capital charges related to the electricity infrastructure development, innovation, and green energy financing. Specifically, the findings suggest that African countries should speed up renovating/investing in electricity infrastructures that would enable expanded access to electricity and the Internet, among other digital transformation opportunities. Furthermore, policymakers and communities in SSA should continue expanding their knowledge on another source of energy (including renewable energy) in view of ensuring sustainable and reliable access to electricity in the region to support economic growth and subsequent expansion of the tax base. This study documents the detrimental effect of



electricity outage/fluctuation on the tax base in SSA from a macroeconomic perspective. It is therefore of interest for further research in future to explore the preparedness of the SSA countries to integrate Artificial Intelligence (AI), and Future Massive Internet of Things (FM-IoTs), including the pillars of 5G/6G networks with tax revenue collection architectures.

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## Author's contributions

I Godfrey J. Kweka declare that the inception, design, data compilation, analysis and interpretation of the data as well as the writing of the manuscript were done solely by the author.

## Disclosure statement

The author declares no conflict of interest.

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## Data availability

The author confirms that raw data and do-file used in deriving the findings of this study are available from the corresponding author (GJK) on request.

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## Appendix: Definitions of the used variables

S/N	Variable	Definition
1.	Annual Growth Rate (% GDP)	Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources.
2.	GDP per capita	Annual percentage growth rate of GDP per capita based on constant local currency. GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources.
3.	Gross Capital Formation	Annual growth rate of gross capital formation based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 2008 SNA, net acquisitions of valuables are also considered capital formation.
4.	Labour Force	The labour force participation rate is the proportion of the population ages 15-64 that is economically active: all people who supply labour to produce goods and services during a specified period.
5.	Manufacturing	Annual growth rate for manufacturing value added based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. Manufacturing refers to industries belonging to ISIC divisions 10-33. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 4.
6.	Open Economy	<ul style="list-style-type: none"> <li>Annual growth rate of imports of goods and services based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.</li> <li>Annual growth rate of exports of goods and services based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.</li> </ul>
7.	Service industry	Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3 or 4.
8.	Inflation	Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used.
9.	Informal economy	Dynamic general equilibrium model-based (DGE) estimates of informal output (% of official GDP)
10.	Agriculture % GDP	The annual growth rate for agricultural, forestry and fishing value added based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. Agriculture corresponds to ISIC divisions 01-03 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 4.
11.	Electricity usage	Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants.
12.	FDI	Foreign direct investments are the net inflows of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors and is divided by GDP.