# Electricity Provision and Tax Mobilization in Africa*

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October 5, 2017

**Abstract**

In this paper, we provide evidence on how the provision of social infrastructure such as reliable electricity can be leveraged to increase taxation in developing countries, particularly Sub-Saharan Africa (SSA). First, using comprehensive data from the latest round of Afrobarometer Survey we estimate, via the instrumental variable approach, the effect of access and reliability of electricity on tax compliance attitudes of citizens in 36 SSA countries. Evidence from the paper shows a strong positive effect of electrification on tax morales with potentially strong externalities. Also, we find that reliability of supply is crucial in explaining the impact of electricity access on attitudes towards taxes. Second, we provide suggestive evidence on national identity as one channel driving this impact. Access to social amenities such as electricity, induces a sense of national identity among citizens, thereby incentivizing them to contribute, through taxes, towards the effective functioning of the state. Third, using data from the most recent World Bank's Enterprise Survey and under conservative assumptions, we estimate that countries in the region could in total generate additional tax revenues in excess of 9.5 billion dollars (4.3% of total tax revenue) per annum solely by resolving issues pertaining to electricity shortages. Put together, we conclude that the financial returns associated with public investments towards improving access and reliability of electricity are substantial, and could be harnessed to augment the financing gap in the sector.

*This paper is a part of a series of background papers to the "Regional Study on Electricity Access in Sub-Saharan Africa" produced by the Office of the Chief Economist (AFRCE) in the Africa Region, World Bank

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# 1 Introduction

Access to electricity has been identified as a major constraint to socio-economic development in Sub-Saharan Africa (SSA). Currently, over 600 million people in the region lack access to electricity (IEA, 2015), and even in areas connected to the grid, the quality of supply is unsatisfactory as households and firms often endure several episodes of blackouts, with dire economic consequences (Forster and Steinbuks, 2009; Hardy and McCasland, 2017). Estimates suggest that electricity shortages cost African economies nearly 2-4 per cent of GDP annually, thereby constraining economic growth and the fight against poverty (Kende-Robb, 2015). The gravity of the situation is evident in the urgency of ambitious regional initiatives such as the African Development Bank's "Light Up & Power Africa"[1] and the United States government's "Power Africa"[2] programs – both of which seek to crowd in both public and private capital investments in the region's power sector.

This reality presents SSA governments with a policy dilemma. Investing in the infrastructure needed to guarantee reliable mass electrification requires significant revenue mobilization. Yet the ability to raise revenue depends on economic growth, which is partially dependent on improvements in the rates of access to reliable electricity. This raises concerns about the ability of African governments in raising the needed capital to finance the required investments in the power sector.

Furthermore, the financial outlays required to provide universal electricity access are beyond fiscal capability most economies in the region. For instance, estimates suggest that the cost of achieving universal access to electricity in the region by 2030 will be in excess of $50 billion per annum[3]. Compounding this challenge is the fact that while expansion in access is important, the gains from electrification in the region can be fully realized only if

[1]The African Development Bank has the ambitious goal of achieving universal electricity access in the region by 2025. For details see here: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Brochure_New_Deal_2_red.pdf

[2]*Power Africa*'s goal is to increase installed capacity in the region by 30,000 megawatts and add 60 million new electricity connections. See here: https://www.usaid.gov/powerafrica

[3]This estimate is considered conservative as it does not account for the cost of maintenance (Rosnes and Vennemo, 2012, p. 1327)

the resultant supply is both stable and reliable. Otherwise, countries in the region face the risk of missing their ambitious development targets despite incurring the huge investment costs involved in expanding access.

In this paper, we argue and show that the provision of quality infrastructural services such as (reliable) electricity is a mechanism through which governments in developing countries can use to mobilize the needed tax revenues for development. The logic of our argument is simple. On the one hand, connection to the grid can potentially be a signal of government's commitment to the provision of social infrastructure and services, and therefore reinforce the sense of an implicit fiscal pact between citizens and their governments. On the the other hand, the lack of access to such social infrastructure may engender protest actions in the form of refusal to pay taxes to the state, as citizens judge the state as incapable of honoring the fiscal pact. Moreover, it is also noteworthy to emphasize that the quality of social infrastructural services matters as well, especially in urban areas. Poor quality service delivery such as incessant blackouts can be viewed as evidence of government's incompetence, and may suppress citizens' sense of national identity, or their willingness to quasi-voluntarily comply with tax policy. Evidence from the literature suggest that public goods provision is at the heart of the fiscal contract between citizens and their respective governments (Timmons, 2005; Bratton, 2012; Timmons and Garfias, 2015). As a result, the supply of public goods can on the one hand induce positive attitudes among citizens towards honoring their tax obligations, while the government on the other hand, uses the mobilized tax revenues to finance future expenditures.

In line with the above, this paper therefore addresses two policy relevant questions: To what extent does access to (reliable) electricity influence reported measures of tax compliance and tax morales in SSA? What are the tax revenue implications associated with resolving the extant issues of unreliable electricity supply in the region. In other words, what are the losses in tax revenue resulting from electricity shortages and its impacts on productive sectors?

Our empirical strategy is summarized as follows: first, we explore the effects of electricity access and reliability on tax compliance attitudes of residents in SSA. With the aid of a comprehensive individual-level survey data from the latest round of the Afrobarometer survey(Round 6: 2014-15) matched with other secondary data on national and subnational indicators, we estimate the effect between electricity connectivity and reliability (at both the household and communal levels) on self reported measures of tax compliance. Second we explore the mechanisms underlying the effect of electricity access and reliability on tax compliance. OLS estimates of the relationship between electricity access and measures of tax compliance are plausibly biased due to the possibility of reverse causality. This therefore limits the extent to which causal interpretations can be assigned. To overcome this challenge, we rely on the instrumental variable approach. Using GIS data on electricity transmission network in Africa, we compute the transmission network density for each second administrative boundary (i.e., district) in the region as an instrument for access and reliability of electricity. The intuition behind the instrument is that, households or communities located in a district (i.e. second administrative boundaries/regions) with high transmission network density have a higher probability of being connected to the grid and receiving quality electricity supply relative to being located in a district with less dense transmission network (Brown and Sedano, 2004; Chakravorty et al., 2014).

Based on the results from the above we proceed in the third part to examine the tax revenue implications of the negative impact of persistent electricity shortages on firm productivity and growth in Africa. Under conservative assumptions on the effect of electricity shortages on firm productivity and growth, and with the aid of firm-level data from the Enterprise Survey dataset among other secondary data sources, we estimate the tax revenue losses as a result of unreliable power supply in 36 countries. The estimated revenue losses is assumed as the implied tax revenue gains that will accrue to these economies by fixing supply irregularities in the power sector.

The key findings of the paper are summarized as follows. We find a strong and positive

impact of electricity access and reliability on attitudes towards taxes. The impact is not only restricted to household access to electricity but also community access as well. More importantly, we also document that the level of impact rises with the quality of supply. In other words, moving from a lower tier (quality) of access improves significantly the attitudes towards taxes. This underscores the importance and urgency of African to resolve the challenges of reliability in the electricity sector.

Additionally, findings from the paper reveal the presence of spillover effects in the impact of electrification on attitudes towards taxes. Extending grid connection into a community improves the willingness to pay taxes even for individuals without household connection to electricity. This finding supports that notion that the salience of infrastructural services plays a key role in enforcing the social pact between citizens and governments in developing countries.

Further, we document national identity as an important mechanism through which the electricity provision affects attitudes towards taxes. Our findings show a positive relationship between electricity connectivity and high levels of reported national identity. Combined, these pieces of evidence suggest that a fiscal pact pertains in SSA. That is, when citizens enjoy reliable access to social infrastructure– such as electricity – they in turn, are more likely to report relatively higher levels of tax morale and national identity.

Our findings have substantial implications for revenue mobilization in Africa. Results from the simulations show significant losses in tax revenue in excess of 9.5 billion dollars (4.3% of total tax revenue) in 36 African countries. The losses are highest in countries such as South Africa, Angola, Nigeria, Kenya, and Ghana. In sum, our findings provide suggestive evidence that provision of reliable electricity supply in SSA can generate significant fiscal returns to economies in the region, enough to make such investments fiscally sustainable in the long run.

These findings speak to a small but growing literature on taxation and the fiscal implications of public goods provision in Africa (Levi et al., 2009; D'Arcy, 2011; Ebeke and

Ehrhart, 2011; Drummond et al., 2012; Sacks, 2012; Ali et al., 2014; Bodea and Lebas, 2016). Ali et al. (2014) for instance find that tax-compliance attitudes strongly correlate with generalized levels of public good provision in Kenya, Uganda and South Africa. We build on this literature by focusing on a specific public good and providing a clear evaluation of the causal mechanisms that link government performance to tax attitudes in 36 African states. Our analysis is the most extensive examination of individual-level tax attitudes in SSA that we are aware of.

The focus on electricity supply also allows us to evaluate the firm-level implications of public goods provision in African states. Existing studies highlight the effects of electricity access on job-creation (Dinkelman, 2011); as well as the negative impact of unreliable electricity supply on firm productivity (Fisher-Vanden et al., 2015; Allcott et al., 2016a; Mensah, 2016). We extend this strand of research by showing the effects of this negative impact of unreliable power supply on firm-level returns on the ability of SSA governments to raise tax revenue. Our very conservative model simulations show non-trivial revenue losses incurred by SSA governments as a result of firm-level inefficiencies.

On the policy front, this paper presents suggestive evidence that investments in universal electricity access in SSA have the potential to be fiscally sustainable in the long run. However, we also find that the quality of electricity connectivity will matter, as it affects both the productive sectors of the economy as well as individual-level attitudes towards tax compliance. Our dual analysis of both household and firm level implications of increased electricity access provide a glimpse into the general equilibrium implications of fiscal outlays associated with the target of universal access. Evidence from this paper provides plausibly enough justification that electrification policies in Sub-Saharan Africa should not be focused solely on grid expansion, but also on improving the quality of power supply.

Hereafter the paper proceeds as follows. In the next section we discuss the contextual background of our study, highlighting the state of electricity access and the nature of the fiscal pact between voters and governments in Africa. Section 3 outlines our empirical strategy

and describes the data used in our analyses. In Section 4 we present and discuss our findings. Section 5 concludes the paper.

# 2 Conceptual Framework and Context

In this section we present a brief exposition on the conceptual framework underpinning our hypothesis by examining the theoretical link between taxation and the fiscal pact. The section concludes with an overview of the state of electrification in Sub-Saharan Africa.

## 2.1 Taxation and the Fiscal Pact

Taxes are the lifeline of states. However, the cost mobilizing taxes are relatively high. First, it requires significant amounts of state capacity – because of the need to make legible all taxable economic activity within a given jurisdiction; and the coercive apparatus needed to enforce the tax code and monitor tax collectors. Thus the requisite administrative-bureaucratic structures needed to design and implement tax policy often require long-term investments in both human capital and physical infrastructure. Second, cost-effective taxation requires a high degree of voluntary compliance among the general public. From the perspective of taxpayers, there are strong incentives against paying taxes. Not only do taxes entail an effective "loss" of income, they also constitute contribution to the financing of public goods for which there are strong incentives to free ride (Feld and Frey, 2007). Yet states can only invest in so much of the taxation infrastructure before such investments cease to be cost-effective. For these reasons, tax collection often involves explicit state incentives to encourage quasi-voluntary public compliance with the tax code.

Such incentives typically include both an exchange relationship (through the provision of public goods and services) and the threat of costly punishment (for both the state and taxpayers). Because the cost of enforcing the tax code is inversely correlated with the willingness of individuals to comply with the tax code, the higher the tax morale (quasi-voluntary

compliance with the tax code), the less costly it is for the state to enforce the tax code. The nature of the implicit exchange relationship (anchored on the provision of public goods) determines the willingness of taxpayers to voluntarily comply with the tax code. Evidence from the extant literature shows that the provision of public goods and services induces citizens to pay taxes, in anticipation of the continued provision of the same (Timmons, 2005).

Lastly, other factors that may positively influence tax morale – for example, a strong sense of civic duty, national identity, or cultural affinity to the ruling coalition – may also serve to lower the cost of tax collection. Orviska and Hudson (2003) for instance show evidence that an individual's sense of civic duty is an important indicator of their likelihood to express support for tax evasion. In the same vein, Kasara (2007) finds that within Africa, farmers who are co-ethnics of presidents tend to be taxed at relatively higher rates than non co-ethnics; and argues that this is because co-ethnicity with an incumbent president reduces informational asymmetries between the state and taxpayers. In line with these previous findings, we hypothesize that national affinity operates by reducing the incentive to hide information about income from the state revenue authorities. And that this is why higher reported rates of national affinity is positively correlated with self-reported levels of attitudes towards tax compliance.

We summarize the underlying relationship between public goods provision and tax compliance attitudes on the one hand, and the role of mechanisms like national identity on the other hand in Figure 1; and examine this relationship using survey data from 36 African countries. The provision of public goods reinforces both affinity to the nation (national identity) and the fiscal pact that underlies the exchange relationship of paying taxes and in return enjoying public goods and services.

The foregoing discussions demonstrate that the existence of a functioning fiscal pact between taxpayers and governments serves the purpose of lowering the effective cost of tax collection. High levels of public tax morale – motivated both by a sense of civic duty or national identity and the implicit exchange relationship through the provision of public goods

and services – obviate the need for governments to expend resources in the close monitoring of economic activities (both at the individual and firm-level) and in punishing violators of the tax code. It is also clear that successful tax mobilization is dependent on both state capacity (ability to target potential tax sources, deter tax evasions, and provide public goods) and legitimacy (the ability to elicit quasi-voluntary tax compliance by the general public). The former observation links taxation to state development (Bates and Lien, 1985; Tilly, 1990; Olson, 1993); while the latter emphasizes the importance of the implicit social contract that underpins the fiscal pact between states and citizens (Levi, 1988; Andreoni et al., 1998).

Much of the literature on the development of state-level fiscal capacity has tended to focus on the longue durèe. The stylized account is that the need for revenue to pay for inter-state wars forced early modern states to establish the organizational capacity required to effectively enforce taxation (Tilly, 1990; Besley and Persson, 2008). Such organizational architecture included both the bureaucracy required to administer a tax regime and the coercive capacity to deter tax avoidance. A related argument is that states typically build or restructure their extractive capacities during crises that call for a re-negotiation of the social contract. For example, Scheve and Stasavage (2010) find that most advanced democracies were able to impose relatively higher tax rates on top earners during wars; and that this was politically feasible precisely because it was viewed as a bargain with low-income earners who served in the wars.

An emerging literature has recently attempted to extend this strand of the literature into the context of weak states. Ali et al. (2014), Prichard (2015), and Bodea and Lebas (2016) examine the dynamics that inform both the attitudes and practice with regard to tax compliance in Africa. The common thread in these works is that a state's extractive (coercive) capacity alone is not enough to explain observed rates of tax compliance in the region. Public goods also matter. In general, the findings suggest that citizens of African states are less likely to report positive attitudes regarding tax compliance if the state does not provide public goods, or if they live in localities where non-state actors serve as credible

alternatives the state and provide the same public goods and services.

Indeed, the reciprocal logic of the fiscal pact is doubly important in a context of weak states precisely because these states often lack the coercive and informational capacities to enforce compliance in the first place.[4] Briefly stated, an implicit fiscal pact can serve as a substitute for an independently (coercively) developed state extractive capacity. This is particularly important in a region like Sub-Saharan Africa that has historically been plagued by perennial state weakness (Herbst, 2000). Our findings in this paper suggest that having a strong fiscal pact – buttressed by the reliable provision of (quasi) public goods and services – will be a key determinant of the region's realized levels of extractive capacity and concomitant tax revenue mobilization.

## 2.2 Electricity Connectivity in Sub-Saharan Africa

Electrification rates in SSA are among the lowest in the developing world, with access rates averaging 35.3% in 2012. Currently, more than 600 million people in the region are not connected to the grid; and if left unmitigated the number is expected to increase over the next two decades (Lee et al., 2016; Christensen et al., 2015). There is also a wide gap in access between rural and urban communities, with averages of 15% and 72%, respectively (World Bank, 2015). This reality has in the recent past spurred policy attention, with a focus on the need to expand rural electrification in a bid to achieve universal access by the year 2030. A few countries have registered impressive achievements in this regard, including South Africa, Cape Verde, Ghana, and Gabon, where on average at least 40% of the rural populations are connected to the grid.

In order to increase the rates of connectivity, African states will require significant investments in installed capacity and distribution. And in order to have the desired effects on

[4]It is worth noting that the contemporary international system's bias against inter-state warfare reduces the possibility of state fiscal capacity development along the channels identified by Tilly (1990). See also Thies (2007) and Herbst (1990) on the difference between capacity-enhancing and capacity-destroying wars. The latter types of wars have been more prevalent since 1945 – especially in Sub-Saharan Africa – on account of "frozen" borders backed by juridical sovereignty (Jackson and Rosberg, 1986).

economic performance, some of these investments will have to be channeled towards guaranteeing reliable supply. The lack of reliable supply is a major problem confronting many economies in SSA. Data from the World Bank's Enterprise Surveys indicate that the frequency of power outages in a typical month in the region averages 8.5 times, with each episode lasting approximately 4.2 hours. The chronic unreliability of supply negatively impacts both firm-level productivity and overall economic performance Mensah (2016).

Overall, there is a general country-level positive correlation between rates of electricity consumption and economic performance (Ouedraogo, 2013). The same trend is corroborated by firm-level evidence. For instance, Neelsen and Peters (2011) find that electrification in southern Uganda had the effect of crowding in market demand, thereby positively impacting the bottom lines of micro-enterprises in the region. In the same vein, Peters et al. (2011) find that grid extension in rural Benin had a direct positive effect on the creation of new firms. In related work, Dinkelman (2011) finds that rural electrification had a net positive effect on employment in South Africa. Combined, these works suggest potential positive economic impacts of increasing electricity access in SSA, on account of its effects on firm-level productivity. Increased productivity and employment, in turn, is likely to result in higher tax revenues for African governments. Also figure 2 gives some credence to our assumption of the positive correlation between electricity access and tax compliance. As a general matter, rates of tax mobilization across Africa are positively correlated with rates of access to electricity. In the next section we delve into the empirical evaluation of the claims stated above.

In this paper, we go beyond the firm-level analyses present in extant works, and focus on the potential aggregate effect of increasing electricity access across different African economies. Notice that our estimates are inherently conservative, in that the figures on potential revenue increases are based on assumptions about firm-level improvement in productivity and the associated increase in tax payments. Taxation from the household sector is unaccounted for, mainly due to data unavailability. Thus the actual gains in tax revenues

are likely to exceed our simulated estimates.

# 3 Empirical Strategy and Data

This section presents the empirical strategy of the paper as well as a description of the data and construction of key variables for the analysis.

## 3.1 Empirical Strategy

The empirical analysis of this paper is structured into two main parts. The first part, utilizes survey data on individuals and households to understand the implications of electricity access and reliability on tax compliance attitudes. Building on the findings from the household/individual analysis, we then proceed, in the second part, to simulate the potential tax revenue gains from the provision of reliable electricity using available data from the firm sector.

### 3.1.1 Electricity Provision and Tax Compliance

To estimate the effect of electricity access and reliability of supply on our set of outcome variables, let us consider the following parsimonious model expressed in equation(1)

$$y_{icdj} = \alpha + \beta E_{ijdc} + \delta X_{jdc} + \gamma Z_c + \epsilon_{ijdc} \tag{1}$$

where $y_{ijdc}$ is the outcome variable(s) including indices of tax compliance and national identity of individual $i$ living in community $j$, district $d$ and country $c$; $E$ is a measure of electricity access and/or degree of reliability of supply; while $X$ and $Z$ are vectors of community and country characteristics; with $\epsilon_{ijc}$ as the error term. Admittedly, estimations of the effects of electricity access and reliability on tax compliance attitudes and national identity require strong assumptions in order to assign causal interpretations. Factors such as simultaneity between electricity access and the outcome measures of tax compliance and national identity

raises issues of endogeniety. Also, the possibility of measurement errors in our measure of tax compliance index posses an additional challenge to identification of casual effects.

To address these concerns of identification, we adopt the instrumental variable approach, using the density of electricity transmission network as an instrument for electricity access and reliability. The intuition behind the instrument is that, households or communities located in a district (i.e. second administrative boundaries/regions) with high transmission network density have a higher probability of being connected to the grid and receiving quality electricity supply relative to being located in a district with less dense transmission network (Brown and Sedano, 2004; Chakravorty et al., 2014). Arguably, the relationship between transmission density and reliability is less straightforward than the relationship with access. On the one hand, a high transmission density increases the probability of having an electricity substation which converts the high-voltage electricity from the transmission lines into low(medium) voltage for onward distribution via medium and low voltage power distribution lines to communities and households. On the other hand, as argued by Chakravorty et al. (2014),without an increase in generation capacity, an expansion in grid network will not necessarily translate into the quality of electricity provision. As a result, the sign of the first stage correlation between the instrument and reliability cannot be determined ex-ante, even though a priori, a strong correlation is expected.

A key identifying assumption underlying our instrument is that the placement of transmission lines are not correlated with any (observable or unobservable) determinant of our outcome variables. For instance if the placement or geographic distribution of the transmission network is highly correlated with pre-existing social, economic or political factors, then our identifying assumption(s) is violated, hence making the instrument invalid. However, we argue that the placement of transmission lines is to a large extent exogenous. This is because, unlike power distribution lines, the placement of transmission lines between the generation plant and endpoint of the lines follow a least cost approach which are largely determined by the topography of the landscape. Construction of transmission network is capital intensive,

and the cost increases with elevation. As a result, the placement of these lines are done to minimize cost. Another factor in the placement of transmission lines is minimum distance. Every power network incurs losses in transmission and distribution, and these losses increases with distance from the generation plant. Therefore, in the spirit of cost(loss) minimization, placement of transmission lines arguably follow a least distance approach between the source and endpoint. Additionally, in the African context, many of these transmission lines extend beyond national boundaries as part of the subregional power pools. Therefore the possibility of local socioeconomic or political factors influencing the placement of transmission lines is minimal, other things being equal. Nevertheless the use of transmission network density as an instrument has been applied in the literature (see for instance: Chakravorty et al., 2014).

Consequently, we estimate our baseline model using the two-stage instrumental variable regression (2SLS) as specified in equations 2 and 3

$$y_{icdjc} = \alpha + \beta E_{ijdc} + \delta X_{jdc} + \gamma Z_c + \epsilon_{ijdc} \tag{2}$$

$$E_{ijdc} = \alpha + \psi TD_{dc} + \delta X_{jdc} + \gamma Z_c + \mu_{ijdc} \tag{3}$$

where $TD_{dct}$ is the instrument (transmission network density), while all other variables remain as previously defined.

#### 3.1.2 Simulation of Tax Revenue Gains from Reliable Electricity Provision

We simulate the tax revenue gains from an improvement in the quality of electricity supply by estimating the present value of future tax revenue losses attributed to the effects of power outages on the industrial sector. The underlying reasoning is that the state losses significant tax revenue due to the negative impact of power outages on firm revenue and profits. Therefore a complete elimination or reduction in outages by fixing the problems of the power sector in the respective countries will, other things being equal, lead to tax revenue savings. We hypothesize two potential channels through which outages affect tax payments

from the industrial sector: intensive and extensive margins. On the intensive margin, outages reduces the profitability of existing firms thereby reducing tax payments from these firms, other things being equal. On the extensive margin, electricity supply irregularities constitute a distortion in the business environment and can constrain the establishment of new firms and hence stiffing expansion in the tax net, other things being equal.

Thus the total tax revenue losses(gains) for each country $j$ is estimated using the expression in equation (4).

$$TTAX_j = \sum_{t=1}^{n} \delta^t((\tau_j + \theta_j) \times CITRev^*_{jt}) \tag{4}$$

where $\tau_j$ and $\theta_j$ represent respectively, the share of tax total tax payment(s) of existing firms lost due to the negative effects of electricity shortages on the operations of existing firms, and the percentage increase in the tax base resulting from new businesses created in response to the provision of reliable electricity; while $\delta^t$ and $t$ represent discount factor and years respectively. $CITRev^*$ is the (potential) corporate income tax (CIT) revenue accruing to the state in the absence of power outages. Details on the steps and assumptions underlying the simulations of the tax revenue loss(gains) are detailed in Appendix 7

## 3.2 Data

The analysis relies heavily on data from the Afrobarometer and Enterprise Survey datasets complemented with data from other secondary sources including the Firm Informality Survey, Mo Ibrahim Index on African Governance, Worldwide Government Revenue Database and World Development Indicators. Summary statistics of the data used in the paper are presented in Tables 1 and 2.

### 3.2.1 The Afrobarometer Data

The Afrobarometer is a survey of public attitudes on democracy, governance, economic conditions, and related issues in their respective African countries. The survey currently contains data from over 35 African countries collected during the period 1999-2015. Data from the latest round (2014/2015) of the Afrobarometer series is used for the analysis. The dataset is georeferenced covering 7,137 towns and villages in 31 countries in SSA; 62% of which are rural.

In this paper, we define tax morale as an individual's expressed attitude towards the obligation to pay taxes to the state. Within the survey, respondents are asked a set of questions regarding the responsibilities of citizens in paying taxes. We therefore develop an index of tax morale based on the opinions expressed by respondents on the responsibilities of citizens regarding tax payments. Specifically, the index is computed by taking the average responses on: i) whether the individual agrees that people must pay taxes; ii) whether refusing to pay taxes is a legitimate protest action; iii) whether the government should have the right to collect taxes; iv) whether they trust tax officials or administration. We interpret the index as a measure of tax compliance attitudes of individuals. The index varies between 0 and 1 with a the larger value implying higher possibility of tax compliance. For robustness check, we compute a variant index of tax compliance using the principal component analysis (PCA).

Across the 31 countries, we observe a fairly high possibility of tax compliance with a mean tax morale index of 0.62. Comparing the index between rural and urban communities, we find marginal differences, with an average of 0.63 and 0.61 respectively. A similar pattern is observed for each component of the tax moral index, except trust in tax officials or administration, where less than half of the interviewees responded in the affirmative, indicating a generally lower degree of trust for tax officials (see Table 1)

Next, we compute an index of national identity. This variable measures the extent to which individuals identify themselves more with their country relative to an ethnic group.

It is an ordinal variable ranging from 1 to 5 where a larger value, implies that an individual identifies himself more with the country relative to his(her) ethnic group. Overall, we observe a relatively high degree of national identity, with a mean index of 3.8.

Data on the provision of basic social infrastructure such as community access to electricity, pipe-borne water, school, hospital, paved roads and reliability in electricity supply are also used. Two measures of the quality of electricity supply are used in the analysis: households' perceived measure of reliability, and electricity supply reliability in the community. Household electricity reliability is a five point scale ranging from 1 to 5 , with the lowest rank (1) referring to households connected to the grid but without electricity for use and the highest rank (5) for households with uninterrupted access to electricity. Using this data, we compute the aggregate electricity reliability index in the community as the share of households with reliable access to electricity (i.e., with a score of 4 or 5). The index ranges between 0 and 1: the higher the index the higher the extent of reliability in the community and vice versa. With the exception of school access, the data shows significant gaps in access to infrastructure between urban and rural communities. For instance, the share of communities with access to grid electricity is nearly twice the share of rural communities with grid access. Interestingly however, reliability in electricity supply appears to be a major problem for both urban and rural households.

Further, socioeconomic attributes of individuals such as age, gender, education level, employment status,household size, type of housing, asset ownership (TV and mobile phone) are also included in the analysis.

### 3.2.2 The Enterprise Survey Data

The analysis on the tax revenue gains uses data from the Enterprise Survey which is a dataset on firm performance and their constraints to doing business. The dataset is available for most countries in the region between 2002 and 2015. In this analysis, we focus on a section of the dataset collected between 2006 and 2015, mainly due to the harmonization of the

survey methodology since 2006. Also for each country in the dataset, we focus on the latest round of the survey.

To obtain a measure of the impact of outages on firm revenue, we compute the weighted average of the share of firm revenue lost due to power outages. Firms in the dataset vary in terms of sales, size, production, industry composition, extent of dependence on electricity for production activities, among others. As a result, using the arithmetic mean of the share of firm revenue lost due to outages, may over or under-estimate the impact. We resolve this potential problem by using weighted rather than arithmetic average.

Further, there are concerns about the accuracy of firms' self-reported estimate of the impact of outages on their revenue. For instance, firms may over-estimate the impact in their quest to draw the attention of policy makers to resolve the challenges in the power sector. Alternatively, firms might find it difficult to actually predict the direct and indirect impact of outages on their production and consequently, revenue. Hence, the effect of measurement errors in the impact estimate cannot be overemphasized. An alternate measure of the impact of outages can be obtained by estimating an econometric model that corrects for the endogeniety between outage intensity and firm revenue. Mensah (2016) estimates the impact outages on firm revenue and productivity using the enterprise survey data from several SSA countries. The paper employs the instrumental variable approach in estimating the impact of outages using firm level panel data from the enterprise survey between 2003-2015. Therefore to validate the our self-reported impact estimate, we compare the tax revenue simulation results from the self-reported estimates with the simulation results based on estimates from Mensah (2016). It must be emphasized that, the data on South Africa as used in Mensah (2016) dates back to 2003, which falls outside our preferred data period used in the computation of the self-reported impact estimates. Therefore, for ease of comparison and without loss of generality, we re-estimate the model in Mensah (2016) using the same data while excluding South Africa. Additional data on willingness of informal firms to register and their reasons for not registering are obtained from the firm informality survey

which is a variant of the enterprise survey data, but focusing solely on informal firms.

### 3.2.3 Supplementary Data Sources

The above datasets are complemented with data on country level indicators. In the analysis of the effects of electricity access and reliabilty on tax compliance and the potential mechanisms, country level indicators such as total population, GDP ppp, share of urban population, population density, value added of agriculture and service sectors as a share of GDP, natural resources rents (% of GDP) from the World Development Indicators database; the Mo Ibrahim Index on African Governance (IIAG) from the Mo Ibrahim Africa Foundation; the Polity IV index on democracy; and the Ethno-Linguistic Fragmentation Score (Fearon 2003). The Mo Ibrahim Index on African Governance (IIAG) provides an annual assessment of the quality of governance in every African country. The index ranges from 0 to 100, the higher the better. Ethno-Linguistic Fragmentation Score provides a measurement of ethnic, linguistic, and religious fractionalization. It reflects the likelihood that two people chosen at random will be from different ethnic groups. The Polity index on democracy ranges from -10 (hereditary monarchy) to +10 (consolidated democracy). Additionally, we utilized georeferenced data on electricity transmission network in Africa from the Africa Infrastructure Country Diagnostic database.

In the analysis of the tax revenue implications of improved and reliable supply of electricity, we complement the impact estimates from the enterprise survey data with data on Corporate Income Tax (CIT) revenue % GDP from the Worldwide Government Revenue Database of the IMF[5]. The most recent data available for most of the countries considered in this paper is 2012. As a result, we compute the average CIT revenue % GDP between 2010 and 2012. In some few countries with no data the tax revenue during this period, we use the most recent available data as proxy. Also, we the average real GDP between 2010 and 2015, from the World Development Indicators, as the baseline GDP. Combining these

[5]https://www.imf.org/en/News/Articles/2015/09/14/01/49/pr15374

data, we compute the real CIT revenues for each country as our baseline tax revenue data. Further, we assume a baseline discount rate of 10% as used in Steinbuks and Foster (2010), and Trimble et al. (2016).

### 3.3 Instrument Construction

As highlighted in the previous section, we compute transmission network density at the district level as an instrument for electricity access and reliability at both household and community levels. To compute the instrument, we rely on three sets of georeferenced data: the second administrative boundaries in Africa from GADM[6]; electricity transmission network; and enumeration areas of the Afrobarometer survey.

First we overlay the geocordinates of the enumeration areas onto the administrative boundaries to match the survey areas to their respective districts based on their geo-location. The resulting shapefile together with the shapefile on the transmission network are used in computing the instrument. Using the Spatial analyst tool in ArcGIS, we compute the line density–defined as the total length of the grid lines divided by the area of the polygon–for each district. Figures 3 and 4 show respectively the geo-location of the survey communities and the distribution of the network density across the study area.

## 4 Results

The analysis of the paper is structured as follows: In the first part, we focus on the individual(household) data from the Afrobarometer data to estimate the effects of electricity access and reliability on tax compliance and tax morales. In addition, we examine the mechanisms driving this relationship by estimating the impact of electricity access on individuals' sense of national identity. Unfortunately, analyzing the relationship at firm level is an empirical challenge since there is no available dataset on firms attitudes towards taxes. Nevertheless,

[6] http://www.gadm.org/about

the results from the household sector pertains for firms as well particularly given the fact that the former supplies labor force to the latter. Building up on the results from the individual(household) analysis, we proceed to simulate the potential tax revenue gains from the provision of reliable electricity. Again given the relative difficulty in quantifying tax payments at household(individual) level, this section focuses solely on firms.

## 4.1 First Stage IV Results

Table (3) presents the results of our first stage IV regression. The results show strong and positive correlation between transmission network density and electricity access as well as reliability. Thus an increase in the density of grid network increases the probability of having access to electricity and also the likelihood of having quality service delivery.

The AP first stage F test of weak instrument also reveals a sufficiently high F statistic in all cases except column 1: an indication that the transmission density is a reasonably strong instrument for electricity access and reliability in their respective first stage regressions.

## 4.2 Electricity Access and Reliability on Tax Compliance

To analyze the effect of electricity access and reliability on tax compliance, we estimate our model using measures of access and reliability at household and community level. In each case we add controls for community and country level heterogeneity to absorb observable differences that would otherwise bias the parameter estimate of interest. Results are shown in Table (4). In Columns 1 and 2, we estimate the effect of electricity access in the community and household respectively on individuals' tax compliance attitudes. The results show that extending the national grid to a community has a significant positive effect on residents' attitude toward paying taxes. The effect becomes even stronger when we consider households' connection to grid electricity. In Columns 3 and 4, we estimate the effect of reliability at communal and households levels on the tax compliance attitudes. Again, the results shows strong positive impact of access to reliable electricity on attitudes towards taxes.

In spite of the importance of both access and reliability in explaining variations in tax compliance attitudes as shown in in Table (4), we argue that reliability in plays a crucial role for sustainable economic growth and hence tax revenue mobilization. As shown by Allcott et al. (2016b), reliability plays a crucial role on firm performance and the overall growth of the productive sector. To this end, we further investigate the effect of reliability on tax compliance by decomposing the reliability measure into tiers of reliability. This will allow us to disentangle the relative importance of the various tiers of reliability on tax compliance. In addition, we also estimate the impact along rural-urban dimensions by splitting the sample into rural and urban residents . This will enable us to analyze the effect of reliability on tax attitudes conditional on demographic conditions (i.e. rural vs urban communities). The results, shown in Table (5) are estimated using OLS due to the empirical challenge of finding sufficient number of instruments required to satisfy the "order condition" for identification (i.e. having at least as many instruments as the number endogenous variables). However, the results in Table (4) establishes a causal impact of reliability on tax compliance, hence we argue that the results in Table (5) can to a large extent be ascribed causal interpretations.

Turning to the results, we observe that households connected to grid lines but without electricity (Level 1) have a lower incentive to pay taxes compared to unconnected households. On the other hand, connected households with regular supply of electricity have favorable attitudes towards taxes relative to unconnected households. Also, the level of impact increases with the degree of reliability in supply. These results suggest that factors such as power outages encourage negative public attitudes towards honoring their tax obligations. Thus citizens may use non-payment of taxes as a form of protest action against poor service delivery on the part of the state and utility companies. The results in also show significant rural urban differences in terms of the effect of reliability on tax compliance. These differences offers an interesting importance of reliability across rural and urban households. It shows that while reliability is a key determinant of attitude towards taxes, the effect is large and stronger for urban than rural households. These results provides suggestive evidence that

reliability perhaps matters more for urban than rural households in explaining individuals' attitudes towards honoring their tax obligations.

To further understand the factors driving these results, we estimate the effect of reliability on each of the four components of our tax moral index as shown in Tables 6 , respectively. The results in Columns 1-3, suggest that access to reliable electricity supply of electricity increases the probability of individuals in accepting their civic responsibility of paying taxes, whether non-tax payment is a legitimate protest action, and also recognizing the right of the state taxing citizens to finance its activities respectively. However, contrary to expectations, we find a negative effect of electricity access on trust in tax officials (Column 4). Nonetheless, these results go to confirm the importance of electrification on tax compliance. Thus, in the case of many SSA countries with a large informal sector and narrow tax base, expansion in visible infrastructure such as electricity, without compromising on quality of supply, can be viable strategy to expand the tax base and increase government revenues.

In the final part of this section, we examine the effect of electricity access and reliability on tax compliance attitudes conditional on the sector of employment of the individual. Thus we compare the effect of electricity access and reliability on attitudes of public and private sector employees in relation to tax compliance. The results (Table (7)) show striking differences in the impact between the two categories. The results for public sector are not significant and appear less robust as the first stage F test of weak instrument are in most cases very low. Also our dataset is clearly dominated by private sector employees, as the sample size for the latter is almost seven folds the sample size for public sector employees. The results for private sector employees nonetheless, shows significant and positive impact of electricity access and reliability irrespective of the level of measure, i.e. community or households. Taking this results into perspective, these findings provide suggestive evidence to African governments on the role of access to reliable electricity as a potential channel in expanding the tax net particularly to the large informal economy in the private sector.

## 4.3 Externalities

So far, we have explored the effect of the salience of quasi-public goods such as electricity services in inducing positive attitudes towards taxes. A key question that suffices is to what extent do the provision of reliable electricity generates spillovers on the attitudes of households or individuals lack private access to these quasi-public goods? In other words, are there any externalities in the impact of the provision of reliable electricity on tax compliance?

To answer this question, we extend the analysis to individuals residing in communities with access to utilities such as electricity, but do not have access to in their homes. Thus we estimate the effect of communal access to electricity on tax compliance attitudes of individuals in unconnected households. We compare this results with the effect of a complementary quasi-public good, pipe-borne water. The results (Table 8) show a significantly positive spillover effect of having electricity access in the community on the tax attitudes of individuals in unconnected households. We however, find a negative spillover effect in relation to access to water. The outcome of a positive spillover effect of electricity access, is indicative of the salient attributes that comes along with grid connection. Intuitively, this results simply suggest that, extending expanding access to electricity to communities can foster positive attitudes in the minds of citizens towards honoring their tax obligations.

## 4.4 Mechanisms

In this section, we argue and provide evidence on the role of national identity as a potential channel through which the access and reliable provision of electricity affect tax compliance attitudes of citizens. The main premise advanced is that the provision of social infrastructural services like electricity tend to whip-up a sense of national identity among citizens, by giving them a sense of belonging as well as an assurance that their contributions to the national purse is worthwhile as they will in turn receive an equitable share of the "national cake".

To test this claim, we estimate the effect of electricity access on the perceived sense of national identity of individuals, while controlling for possible confounding factors such as

the progress made in democratic governance (Polity IV), support for opposition parties, and the share of the country's population that are natives of the president's ethnic group. These factors are key political economic considerations that operates in different dimensions to influence an individual's sense of identity with the state vis-a-vis his/her ethnic group. As a results we interact these measures with our variable of interest, access to electricity in the community.

From the results in Table 9, we find significant net effect of electrification on national identity. Interestingly, we find that extending electricity to communities in countries with a higher share of people from the same ethnic group as the president of the country promotes ethnic identity at the expense of national identity. Therefore, electrification programs to communities with strong ethnic ties with the president of the country is likely to induce a sense of belonging to the particular ethnic group by its members as the project may be seen as a reward by the native leader for their support during elections. That aside, the overall impact of electrification on national identity is however positive, albeit at a reduced level of impact due to the negative ethnic-induced impact.

Also, the interaction between being a sympathizer of the opposition party and access to electricity is not statistically significant. This suggest that extending electricity access to sympathizers of opposition parties does not in anyway influence their level of association with national course. Again, we do not find any differences in the effects of electrification on national identity between rural and urban communities.

#### 4.4.1 Robustness Checks

To validate the results of the analysis, we compute alternative measures of the tax compliance index using the principal component analysis (PCA). Using the index from the PCA, we estimate the effect of access and reliability of electricity at the communal level on the tax compliance. The results remain robust as the estimates are quantitatively and qualitatively similar to the main results in Table (10). Thus we conclude that the provision of reliable

electricity is a positive and strong driver of tax compliance in many African countries.

## 4.5 Fiscal Implications of Reliable Electricity Supply

The preceding analyses suggest that reliable access to electricity is a positive correlate of tax compliance. Thus, reducing the supply deficiencies and inefficiencies in the power sector, will create a sense of good will among citizens of African countries to honor their tax obligations.

In lieu of the above, we present in this section, evidence on the potential gains in tax revenue accruing from the business sector following a complete elimination of outages and the associated unreliability in electricity provision in the region. This is done by estimating the tax revenue losses attributed to power outages over a two year period should the current challenges in the power sectors of the respective countries remain unresolved.

To begin with, we compare the simulation results based on the two measures of outage impact to enable us ascertain whether there is any systematic difference in the simulated revenue losses(gains) between the self-reported estimates and the econometric estimates from Mensah (2016) for 14 SSA countries. As shown in figure 5, there are no systematic differences in the simulated tax revenue losses between the two impact estimates. The largest gaps between the two estimates are observed in Nigeria, Ghana and Congo DR, where the self-reported losses are larger for the former and smaller for the latter. A possible reason for the an over-estimation of the self-reported impact estimates in some countries may be the over-reliance of firms in these countries on generators for electricity generation due to the incessant outages they experience. For example, data from the enterprise survey reveal that 79% of firms in Nigeria rely on generators for electricity during power holidays. As stated before, for the most part, the tax losses are fairly similar. Thus on the basis of the comparison, we argue that the self-reported impact estimates provide a good measure of the associated impacts of power outages on firm revenue and profitability for countries that were not included in the impact estimate analysis. Therefore we proceed to simulate the tax revenue losses due to outages by relying on the self-reported impact estimate. All estimates

are expressed in constant US (2010) dollars.

Results on the average annual loss in tax revenue due to outages (see figure 6), reveal that South Africa, Angola Nigeria, Ghana, and Kenya record the highest losses in excess of $300 million per annum. Nigeria and South Africa are the biggest economies in SSA, with large industrial sectors, therefore, the impact of unreliable power supply on firms performance and consequently their tax payments is expected to be higher. Expressing these losses in terms of total tax revenues, Angola(15.1%), Congo DR(8.9%), Nigeria (6.8%), Gabon (6.3%) and Mali (5.1%) are top five countries with significant revenue losses. On the whole, the results reveal significant revenue losses to countries in the region. In other words, these tax revenue losses represent additional tax revenue gains that could be mobilized, other things being equal, following a complete elimination of power outages in the respective countries. Also considering the huge deficits in government revenue across countries in the region, the importance of the tax revenue savings from an improvement in the quality of electricity supply cannot be overemphasized. More so, the enormity of the tax revenue savings underscores the economic benefits of having an efficient power sector to propel the engine of growth and development.

# 5 Conclusion

This paper presents evidence of the effects of electricity access and reliability on tax compliance attitudes of individuals, and further analyze the fiscal implications of improving reliability in electricity supply in SSA.

Using a comprehensive data from the Afrobarometer Survey complemented with other relevant data sources, we find a strong positive impact of electricity access on tax compliance. More importantly, we find that reliability of electricity supply matters crucially in explaining the effect of access on citizens' attitudes towards taxation in SSA. Additionally, we find strong positive spillover effects in the impact of reliable access to electricity. In other words,

extending grid connection to a community induces positive attitudes of residents towards honoring their tax obligations even if the individual's household is yet to be connected to electricity. The results further show that one mechanism through which access and reliability of electricity affect tax compliance attitudes is its effect on national identity. Access to electricity improves citizens' sense of "belongingness" to the state as opposed to ethnic groups and therefore increases willingness to contribute resources (taxes) for the effective functioning of the state.

Finally, the paper examines the fiscal implication of improving reliability in electricity supply by estimating associated the tax revenue gains from a complete elimination of power outages. Simulations on tax revenue losses(gains) reveal that countries in the region can generate significant tax revenues in excess of $ 9.5 billion (4.5% of total tax revenue) every year by just resolving reliability constraints in the electricity sector.

The policy prescriptions stemming from the paper include the following: first, expanding access to electricity, particularly in rural communities can inure significant economic and fiscal benefits to the country. Second, while efforts at expanding grid access is important, improving reliability in supply should be given equal attention, as blackouts have the tendency to induce protest actions in the tax attitudes of citizens. Third, a complete elimination of power outages has the potential to generate significant tax revenues that can in turn to be used to refinance investments in to the electricity sector.

# 6 Tables

Table 1: Summary of key variables used for the analysis

| | All | | | Urban | | | Rural | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Obs | Mean | Std. Dev. | Obs | Mean | Std. Dev. | Obs | Mean | Std. Dev. | Min | Max |
| electricity in the community | 47937 | 0.660 | 0.474 | 18769 | 0.935 | 0.247 | 28568 | 0.472 | 0.499 | 0 | 1 |
| piped water in the community | 47937 | 0.625 | 0.484 | 18769 | 0.866 | 0.341 | 28568 | 0.460 | 0.499 | 0 | 1 |
| paved road in the community | 47937 | 0.578 | 0.494 | 18769 | 0.765 | 0.424 | 28568 | 0.447 | 0.497 | 0 | 1 |
| school in the community | 47937 | 0.890 | 0.313 | 18769 | 0.9129 | 0.284 | 28568 | 0.874 | 0.332 | 0 | 1 |
| hospital in the community | 47937 | 0.644 | 0.479 | 18769 | 0.730 | 0.444 | 28568 | 0.580 | 0.494 | 0 | 1 |
| Frequency of electricity availability | 47924 | 1.871 | 1.617 | 18765 | 2.986 | 1.313 | 28559 | 1.122 | 1.360 | 0 | 5 |
| Tax Index | 47937 | 0.622 | 0.278 | 18769 | 0.632 | 0.269 | 28568 | 0.615 | 0.287 | 0 | 1 |
| Agree must pay taxes | 47937 | 0.641 | 0.480 | 18769 | 0.687 | 0.464 | 28568 | 0.611 | 0.487 | 0 | 1 |
| Legitimate to refuse to pay taxes | 47937 | 0.683 | 0.465 | 18769 | 0.689 | 0.463 | 28568 | 0.681 | 0.466 | 0 | 1 |
| Government right to collect taxes | 47937 | 0.719 | 0.450 | 18769 | 0.745 | 0.436 | 28568 | 0.699 | 0.459 | 0 | 1 |
| Trust tax officials/administration | 47937 | 0.444 | 0.497 | 18769 | 0.405 | 0.491 | 28568 | 0.468 | 0.499 | 0 | 1 |
| Respondent's Gender | 47937 | 0.497 | 0.50 | 18769 | 0.50 | 0.50 | 28568 | 0.496 | 0.50 | 0 | 1 |
| Respondent's Age Group | 47650 | 2.121 | 0.805 | 18688 | 2.04 | 0.771 | 28363 | 2.172 | 0.821 | 1 | 5 |
| Respondent's Education Level | 47806 | 3.393 | 2.166 | 18732 | 4.290 | 2.082 | 28475 | 2.788 | 2.007 | 0 | 9 |
| Employment Status | 47709 | 0.379 | 0.485 | 18687 | 0.451 | 0.498 | 28424 | 0.333 | 0.471 | 0 | 1 |
| The size of the Household | 47865 | 3.884 | 2.372 | 18732 | 3.80 | 2.292 | 28535 | 3.945 | 2.428 | 1 | 10 |

Table 2: Summary Statistics of data used in Simulations

| **Variable** | **Mean** | **Std. Dev.** | **Min.** | **Max.** |
|---|---|---|---|---|
| Tax Revenue % GDP | 17.03 | 8.65 | 1.55 | 50.7 |
| Profit Tax rate | 41.09 | 13.83 | 13.6 | 73.3 |
| Discount rate (%) | 10 | 0 | 10 | 10 |
| CIT loss from existing firms(%) | 11.18 | 8.61 | 3.24 | 45.85 |
| CIT loss from new firms(%) | 13 | 0 | 13 | 13 |

Table 3: First Stage IV Estimates

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Electricity Access | | Reliable Electricity | |
| | Town | HH | Town | HH |
| Transmission Density | 1.714*** | 2.772*** | 3.515*** | 3.218*** |
| | (0.58) | (0.45) | (0.44) | (0.44) |
| F Stat | 8.708 | 37.651 | 63.836 | 54.428 |
| Observations | 33423 | 33338 | 33419 | 33338 |

Notes: Robust standard errors in parentheses clustered at Primary Sampling Unit(PSU) level. Fstat is the IV First Stage F test of instrument strength. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 4: Effect of Electricity Access and Reliability on Tax Compliance

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | IV Regression | | | |
| Electricity Access in Town | 0.346* | | | |
| | (0.18) | | | |
| Household Connected to Grid | | 0.216** | | |
| | | (0.09) | | |
| Reliable Electricity in Town | | | 0.169** | |
| | | | (0.07) | |
| Household has Reliable Electricity | | | | 0.186** |
| | | | | (0.08) |
| F Stat | 8.708 | 37.651 | 63.836 | 54.428 |
| Observations | 33423 | 33338 | 33419 | 33338 |

Notes: Robust standard errors in parentheses are clustered at Primary Sampling Unit(PSU) level. Fstat is the IV First Stage F test of instrument strength. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 5: Effect of Electricity Access and Reliability on Tax Compliance

| VARIABLES | (1) All | (2) Urban | (3) Rural |
|---|---|---|---|
| Frequency of electricity availability | | | |
| Level 1 | -0.018** | 0.009 | -0.023** |
| | (0.008) | (0.016) | (0.010) |
| Level 2 | 0.014* | 0.028** | 0.004 |
| | (0.007) | (0.011) | (0.011) |
| Level 3 | 0.017** | 0.022* | 0.022 |
| | (0.008) | (0.012) | (0.014) |
| Level 4 | 0.027*** | 0.036*** | 0.026*** |
| | (0.006) | (0.010) | (0.009) |
| Level 5 | 0.033*** | 0.053*** | 0.010 |
| | (0.007) | (0.011) | (0.011) |
| Constant | 0.192*** | 0.198*** | 0.172*** |
| | (0.035) | (0.055) | (0.045) |
| Observations | 43,560 | 16,365 | 26,603 |
| R-squared | 0.037 | 0.043 | 0.039 |

Robust standard errors in parenthesis and clustered at the primary sampling unit level. Estimations are done using OLS. The survey sampled across 7,137 communities/towns, 4,435 of which in the rural area and 2,702 in the urban area. The independent variable of interest is the availability and the reliability of electricity for those who are connected. The responses ranged from 1 to 5, where 5 represent the highest level of availability. The reference category is no access to electricity. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score. Dependent variable is tax morale. The index on tax morale is an average of responses on i- whether the respondent agrees that people must pay taxes; ii- whether refusing to pay taxes is a legitimate protest action; iii- whether the government should have the right to collect taxes; iv- whether they trust tax officials or administration.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 6: Effect of Electricity Access and Reliability on Tax Compliance

| | All | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Frequency of electricity availability | | | | |
| Level 1 | -0.022 | -0.170*** | 0.086** | -0.072* |
| | (0.039) | (0.041) | (0.040) | (0.038) |
| Level 2 | 0.173*** | 0.062* | 0.065* | -0.128*** |
| | (0.034) | (0.033) | (0.035) | (0.033) |
| Level 3 | 0.120*** | 0.066 | 0.186*** | -0.153*** |
| | (0.041) | (0.041) | (0.040) | (0.039) |
| Level 4 | 0.196*** | 0.089*** | 0.060** | -0.031 |
| | (0.029) | (0.029) | (0.030) | (0.028) |
| Level 5 | 0.171*** | 0.073** | 0.036 | 0.088*** |
| | (0.032) | (0.033) | (0.034) | (0.031) |
| Constant | -1.575*** | -0.008 | -0.570*** | -1.267*** |
| | (0.166) | (0.150) | (0.159) | (0.145) |
| Observations | 43,560 | 43,560 | 43,560 | 43,560 |

Robust standard errors in parenthesis and clustered at the primary sampling unit level. Estimations are done using OLS. The survey sampled across 7,137 communities/towns, 4,435 of which in the rural area and 2,702 in the urban area. Dependent variables are dummy variables used to construct the tax moral index which are respectively: i- whether the respondent agrees that people must pay taxes; ii- whether refusing to pay taxes is a legitimate protest action; iii - whether the government should have the right to collect taxes; iv- whether they trust tax officials/administration. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 7: Effects of Access and Reliability on Tax Compliance by Sector of Employment

| | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
|---|---|---|---|---|---|---|---|---|
| | Private Sector | | | | Public Sector | | | |
| | IV Regression | | | | | | | |
| Electricity Access in Town | 0.265* | | | | 0.062 | | | |
| | (0.159) | | | | (0.278) | | | |
| Household Connected to Grid | | 0.173* | | | | 0.139 | | |
| | | (0.094) | | | | (0.604) | | |
| Reliable Electricity in Town | | | 0.170* | | | | 0.038 | |
| | | | (0.096) | | | | (0.172) | |
| Household has Reliable Electricity | | | | 0.187* | | | | 0.062 |
| | | | | (0.104) | | | | (0.274) |
| F Stat | 13.968 | 54.26 | 65.889 | 48.601 | 4.73 | 1.7 | 12.081 | 3.118 |
| Observations | 21152 | 21103 | 21148 | 21103 | 2319 | 2311 | 2317 | 2311 |

Notes: Robust standard errors in parentheses clustered at Primary Sampling Unit(PSU) level. Fstat is the IV First Stage F test of instrument strength. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 8: Spillover Effects of Electricity Provision on Tax Compliance

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Conditioned on | | | |
| | No HH Access to Elec | | No HH Access to Pipe-borne Water | |
| | IV Regression | | | |
| Electricity Access in Town | 0.901* | | 0.372*** | |
| | (0.539) | | (0.139) | |
| Piped Water in Town | -0.209 | -0.454 | -0.098*** | -0.076** |
| | (0.128) | (0.587) | (0.037) | (0.033) |
| F Stat | 2.893 | 0.581 | 14.721 | 7.825 |
| Observations | 16626 | 16626 | 19736 | 19734 |

Notes: Robust standard errors in parentheses are clustered at Primary Sampling Unit(PSU) level. Fstat is the IV First Stage F test of instrument strength. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 9: Effect of Electricity Access and National Identity

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| VARIABLES | | All | | Urban | Rural |
| Electricity grid in the community | 0.121*** | 0.253*** | 0.139*** | 0.107 | 0.064 |
| | (0.036) | (0.047) | (0.038) | (0.085) | (0.045) |
| Electricity G X President's Ethnicity | -0.188*** | -0.298*** | -0.181*** | -0.093 | -0.133 |
| | (0.063) | (0.089) | (0.062) | (0.162) | (0.084) |
| Share of President's Ethnic Group | -0.003 | 0.107 | 0.021 | -0.110 | -0.006 |
| | (0.058) | (0.081) | (0.057) | (0.161) | (0.063) |
| President's Ethnicity X Polity IV | | -0.076*** | | | |
| | | (0.014) | | | |
| Polity IV Project Index 2013 | | 0.017** | | | |
| | | (0.008) | | | |
| ElectricityCommunity X Polity IV | | -0.031*** | | | |
| | | (0.008) | | | |
| Electricity X Pres. Ethn. X Polity IV | | 0.027* | | | |
| | | (0.015) | | | |
| Opposition | | | -0.071*** | | |
| | | | (0.027) | | |
| ElectricityCommunity X Opposition | | | -0.046 | | |
| | | | (0.033) | | |
| Observations | 38,170 | 38,170 | 38,170 | 14,669 | 22,922 |

Robust standard errors in parenthesis and clustered at the primary sampling unit level. Estimations are done using OLS. The survey sampled across 7,137 communities/towns, 4,435 of which in the rural area and 2,702 in the urban area. The dependent variable is the response to the question asking the respondents whether they identify more with their ethnic group or the country. The response is ordered in the following way: 1. only identify with their ethnic group; 2. identify more with their ethnic group than the country; 3. two identities are equally important; 4. identify more with the country than the ethnic group; 5. only identify with the country. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score.

Table 10: Alternative Estimations: Electricity Provision and Tax Compliance

| | (1) | (2) |
|---|---|---|
| Electricity Access in Town | 1.659** | |
| | (0.810) | |
| Reliable Electricity in Town | | 0.809*** |
| | | (0.307) |
| F Stat | 8.708 | 63.836 |
| Observations | 33423 | 33419 |

Notes: Dependent variable is Tax Compliance Index derived from a Principal Component Analysis. Robust standard errors in parentheses are clustered at Primary Sampling Unit(PSU) level. Fstat is the IV First Stage F test of instrument strength. All the regressions in the table control for individual/household, community, and country level variables. The individual/household level variables include the respondent's gender, age, education, quality of housing, employment status, the size of the household, and the ownership of TV or a mobile phone. The community level variables include the presence of piped water systems, paved roads, schools, and hospitals. The country level variables include the total population, the GDP ppp, the share of urban population, the population density, the value added of agriculture and service as a share of GDP, the total natural resources rents (% of GDP), the Mo Ibrahim index on governance, and the Ethno-Linguistic Fragmentation Score.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

# 7 Figures

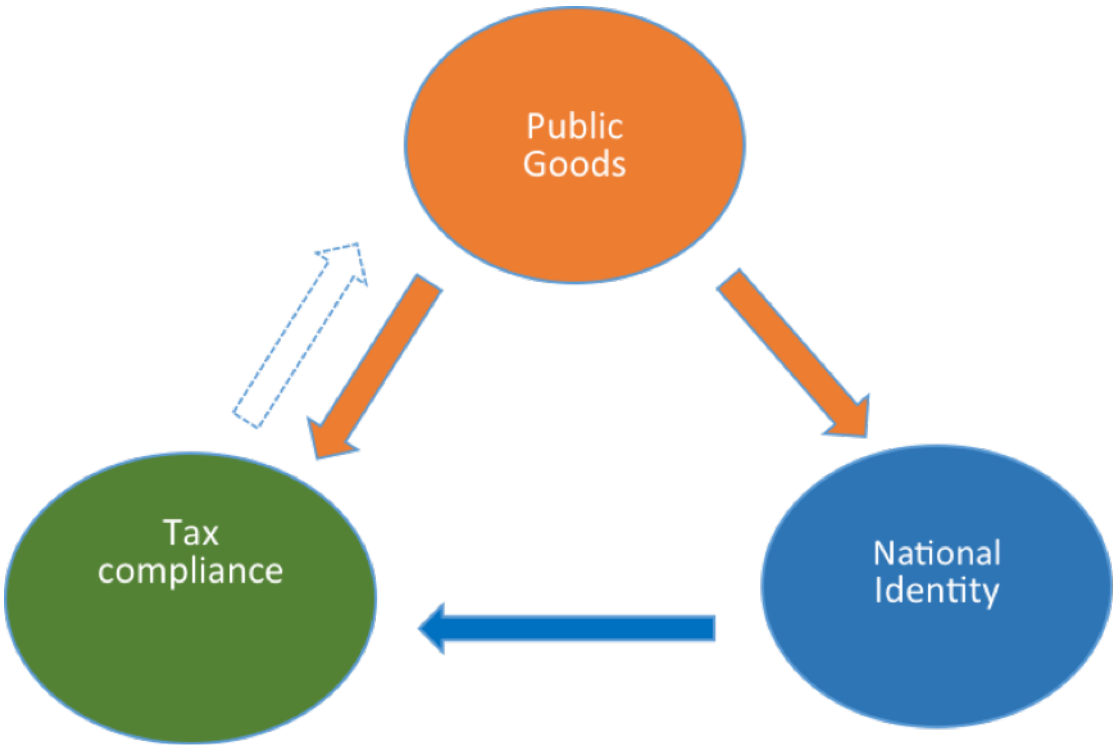


Figure 1: Virtuous cycle of taxes, public goods, and national identity

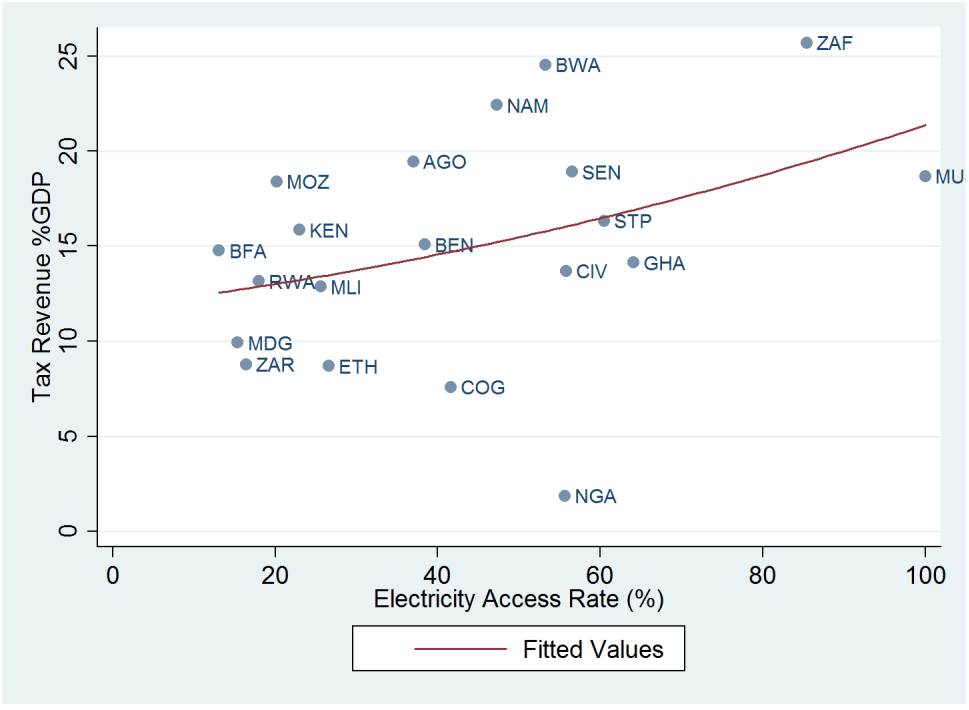


Figure 2: Electricity Access and Tax Revenue Mobilization

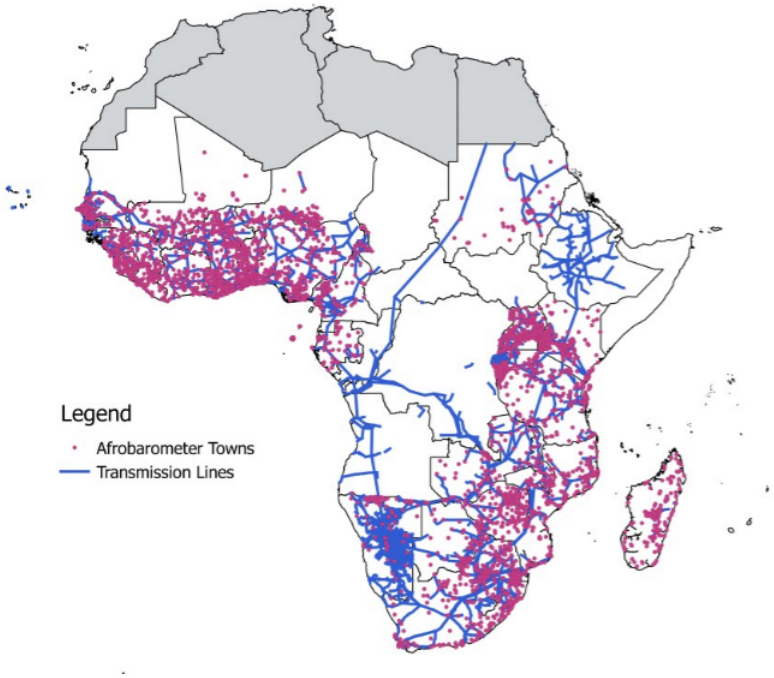


Figure 3: Afrobarometer Survey Locations

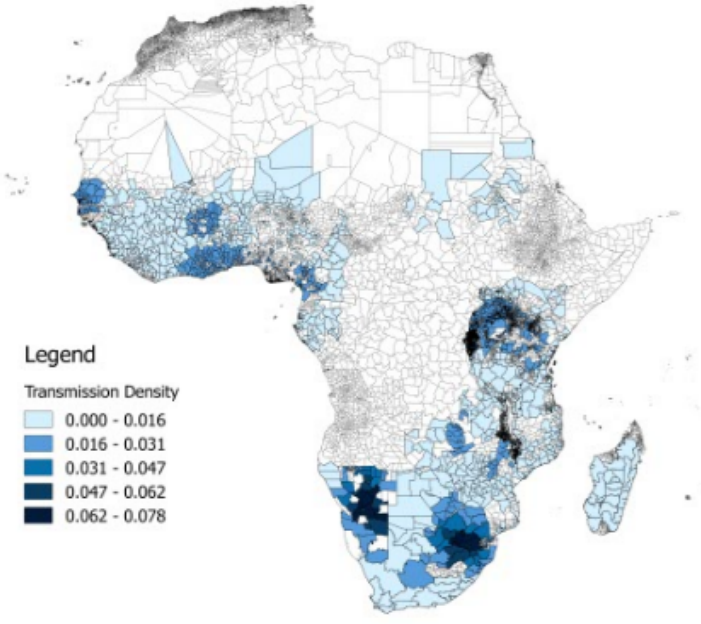


Figure 4: Variations in Electricity Transmission Density

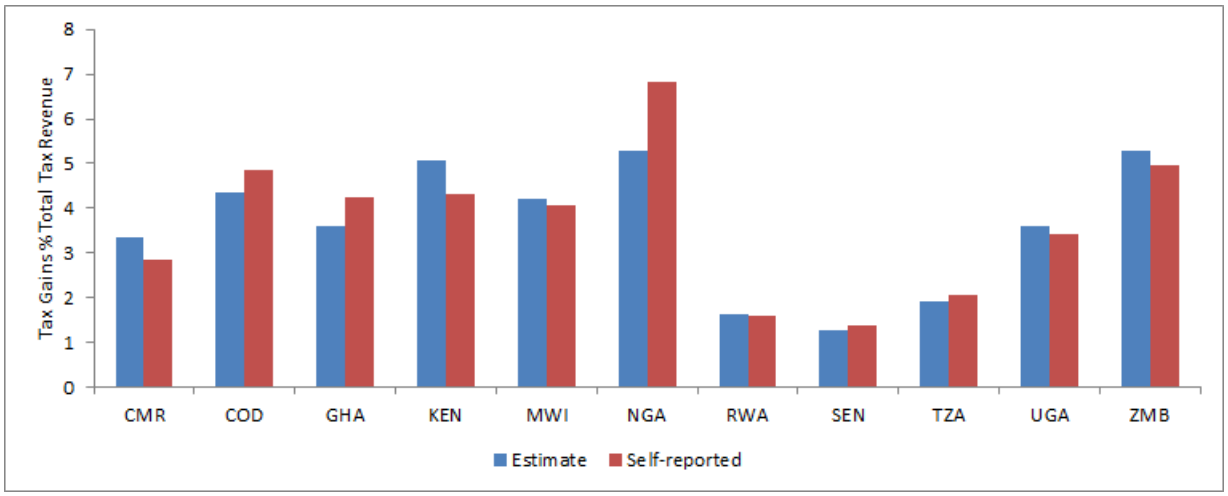


Figure 5: Comparison of Average Annual Tax Revenue Losses due to Power Outages

# Appendix

## Methodology for Tax Revenue Gains from Reliable Supply of Electricity

In this section, we describe a simple static model used to compute the potential tax revenue gains associated with provision of reliable electricity. We decompose the tax revenue gains into two main components: taxes savings from existing firms which were hitherto lost due to the negative impact of power outages on their productivity: and taxes from new firms that are created as a result of access to reliable electricity.

### 7.0.1 Tax Savings from Existing Firms

We define the tax revenue savings from existing firms following the provision of reliable electricity as equivalent to the forgone tax revenues from these firms as a result of the negative impact of outages on firm production. To begin with, we assume a representative firm $i$, which pays a share of its income and profit as tax to the state in the form of corporate income tax (CIT). The CIT payment of the firm can be expressed as

$$Tax_i = \tau \pi_i^* \tag{7.5}$$

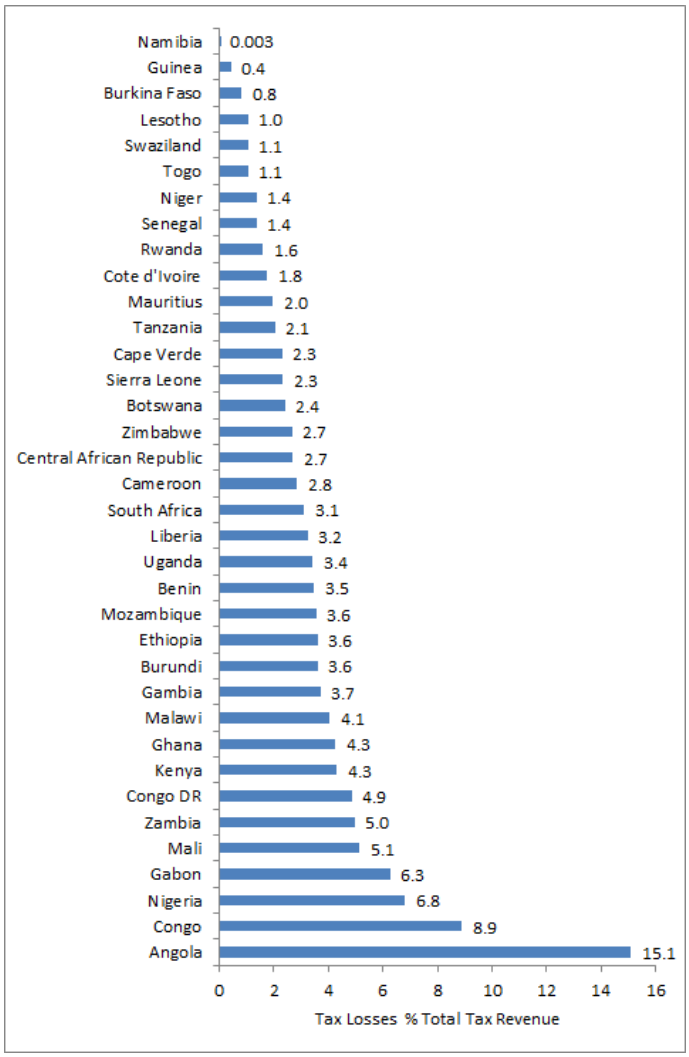


Figure 6: Average Annual Tax Revenue Losses due to Power Outages

where $Tax_i$ is the amount of profit tax paid by firm $i$, $\tau$ is the tax rate, $\pi_i^*$ is the profit level of the firm in the absence of constraints such as blackouts.

Outages reduce firm profitability due to its negative impact on production. As a result, the amount of taxes paid by the representative firm operating under electricity constraints is lower than the corresponding amount in the absence of outages, other things being equal. Using $\gamma$ as the impact of outages on firm profits, we can express the total tax payment of

the firm during periods of intense outages as

$$Tax_i = \tau(1-\gamma)\pi_i^* \tag{7.6}$$

where $0 < \gamma \leq 1$. Therefore from equation (7.6), the reduction in taxes paid by the firm as a result of outages is equivalent to the term $\tau\gamma\pi_i^*$. This suggest that the level of $\gamma$, which measures the degree of vulnerability of firms to electricity shortages, is a strong predictor of the tax payments of the firm.

At the economy-wide level, the total CIT revenue accruing to the government in a given year is the sum of all tax payments of the universe of firms in the economy and expressed as

$$TaxRev = \phi \sum_{i=1}^{n} \tau(1-\gamma)\pi_i^* \tag{7.7}$$

where $0 < \phi \leq 1$ and $n$ represent respectively, the tax compliance rate and total number of firms in the country. Tax compliance rate measures the rate at which tax payers in an economy comply with the tax rules (i.e. in terms of actually paying all the taxes due them). From equation (7.7) the total tax revenue losses resulting from the negative impact of blackouts on the universe of firms in the economy is given as

$$TL = \phi \sum_{i=1}^{n} \tau(\gamma)\pi_i^* \tag{7.8}$$

In this framework, the impact of outages on firm profit, $\gamma$, is assumed to consist of direct and indirect impacts[7]. On the one hand, outages reduce profitability directly through its negative impact on output and/or increasing cost of production. On the other hand, electricity shortages often engender uncertainties in the business environment. As a result, firms may cut back on their investments in expansion, and/or operate below their optimal capacity levels, thereby limiting their ability to realize their full profit potentials.

[7]Hence, $\gamma = \alpha_1 + \alpha_2$, where $\alpha_1$ and $\alpha_2$ represent respectively, the direct and indirect impacts.

Alternatively, equation (7.8) can be expressed as

$$TL = \gamma \times CITRev^{*} \tag{7.9}$$

where $CITRev^{*}$ is the potential CIT revenue accruing to the state in the absence of power outages, other things being equal.

### 7.0.2 Tax Gains from New Firms

The provision of reliable electricity will, other things being equal, create a convenient business ambiance for the establishment of new firms, which will ultimately have positive fiscal implications. Additionally, some existing firms evade taxes by deliberately avoiding business registration. The motivations for tax evasion include among others, protest actions against government for the poor infrastructural quality. Therefore, the provision of reliable electricity will, other things being equal, motivate such business owners to formalize their businesses, thus making it possible for government to tax these firms. In essence, we argue that the provision of reliable electricity will expand the tax base through the above channels. To express this more formally, under the assumption of a constant tax compliance rate and in the absence of other market distortions, the tax revenues gains from the creation of new firms and registration of existing firms can be expressed as

$$AddTax = \theta \times CITRev^{*} \tag{7.10}$$

where $\theta$ is the percentage increase in the tax base as a result of reliable electricity provision, computed as the sum of the share of newly established firms and formalization of old firms as a result of access to reliable electricity.

### 7.0.3 Aggregate Tax Gains

From the above, other things being equal, the potential tax revenue gains from fixing reliability issues in the electricity sector is equal to the sum of the forgone tax losses (equation (7.9)), and the gains from new firms registered (equation (7.10) and expressed as

$$TTAX = (\theta + \gamma) \times CITRev^{*} \tag{7.11}$$

Using this expression, we simulate the tax revenue losses in 36 SSA countries over a two year period. Thus for each country $j$, we estimate the present value of the potential tax revenue gains as follows

$$TTAX_j = \sum_{t=1}^{2} \delta^t((\tau_j + \theta_j) \times CITRev^{*}_{jt}) \tag{7.12}$$

where $\delta^t$ and $t$ represent discount factor and years respectively.

## 7.1 Data Measurement and Assumptions

The determination of the potential tax revenue from firms in the absence of power outages, $CITR^{*}$, is an empirical challenge. This is particularly the case for SSA, as most countries in the region have over the years experienced recurrent power crises, albeit with varying degrees of intensity across space and time. We attempt to overcome this challenge by using the average CIT tax revenues over a three year period[8] as a proxy for the potential CIT tax revenue. Admittedly, this does not fully address the issues associated with the measure. Nonetheless, this approach is beneficial in two ways: first, we are able to smooth out seasonal variations in the performance of the economies which has strong correlation with tax revenues; second, given the variations in the outage intensity and impact over time, averaging the tax revenue offers an alternative approach in minimizing the bias in the use of the past CIT tax revenues as a counterfactual.

[8]This is the most recent data available for the countries in the study (i.e., 2010-2012)

We proxy the indirect impact of blackouts on firm profitability with the impact of blackouts on capacity utilization of firms. Other things being equal, access to uninterrupted access to electricity induces firms to operate at optimal capacity thereby maximizing profit. Estimations using the enterprise survey data suggest that access reliable electricity boost capacity utilization by 2.2%. Further, using data from the Firm Informality Dataset (a sequel to the Enterprise Survey data), we proxy the effect of reliable electricity on the tax base by estimating the effect of access to reliable electricity on the willingness of informal firms registering their businesses and the probability of firms avoiding taxes.

The following are key assumptions underlying the simulation of the potential tax revenue gains reliable supply of electricity. 1). Outage intensity in the respective countries remain as in the status quo over the 2 year forecast period; 2). Tax revenues and real GDP grow at the same rate. In other words, an expansion in economic activities will generate tax revenues particularly from the business sector. In line with that, we use country specific forecast of real GDP growth (2016-2017) by the IMF and World Bank[9]. Finally, we assume a baseline discount rate of 10% as used in Steinbuks and Foster (2010), and Trimble et al. (2016)

[9]The two data sources have forecast for 2016 and 2017. So we take the geometric average for 2016-2017 for each data source (i.e. world bank and imf). This yields two different mean forecast. Now since these correspond to concurrent period, a geometric average of the two is not appropriate, so instead we take the arithmetic mean of the two because the two estimates are independent of each other.

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