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Electricity Provision and Tax Mobilization in Africa

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Abstract

This paper provides evidence on how the provision of social infrastructure, such as reliable electricity, can be leveraged to increase taxation in developing countries, particularly in Sub-Saharan Africa. First, using comprehensive data from the latest round of the Afrobarometer survey, the paper uses the instrumental variable approach to estimate the effect of access to and reliability of electricity on the tax compliance attitudes of citizens in 36 countries in Sub-Saharan Africa. The evidence shows a significant positive effect of electrification on tax compliance attitudes, with potentially strong externalities. The analysis also finds that the reliability of supply is crucial in explaining the impact of electricity access on attitudes toward taxes. Second, the paper provides 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, toward the functioning of the state. Third, using data from the most recent World Bank Enterprise Surveys and under conservative assumptions, the paper estimates that countries in the region could in total generate additional tax revenues of more than $9.5 billion (4.3 percent of total tax revenue) per year solely by resolving issues related to electricity shortages. Put together, the paper concludes that the financial returns associated with public investments toward improving access to and reliability of electricity are substantial and could be harnessed to augment the financing gap in the sector.

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Electricity Provision and Tax Mobilization in Africa*

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1 Introduction

Inadequate access to electricity is a significant constraint to socioeconomic development in Sub-Saharan Africa (SSA). More than 600 million people in the region lack access to electricity (IEA, 2015). Even in areas connected to the grid, the quality of supply is unsatisfactory as households and firms often endure blackouts, with dire economic consequences (Forster and Steinbuks, 2009; Hardy and McCasland, 2017). Estimates suggest that electricity shortages cost African economies between 2 and 4 percent of gross domestic product (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 U.S government's "Power Africa"[2] programs – both of which seek to crowd-in 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. However, 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 to raise the needed capital to finance the required investments in the power sector.

Furthermore, the financial outlays required to provide universal electricity access are beyond the financial capability of 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 more than $50 billion per annum[3]. Compounding this challenge is the fact that while expansion in access is essential, the gains from electrification in the region can be fully realized only if 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 considerable 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 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 gov-

[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).

ernment'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 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 noteworthy to emphasize that the quality of social infrastructural services matters as well, especially in urban areas. Poor-quality service delivery, such as constant 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 suggests that public goods provision is at the heart of the social 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 toward 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 addresses two policy-relevant questions: To what extent does access to (reliable) electricity influence reported measures of tax compliance (morale) in SSA? And 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 their 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 comprehensive individual-level survey data from Round 6 (2014/2015) of the Afrobarometer survey matched with secondary data on national and subnational indicators, we estimate the effect of 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. Ordinary least squares (OLS) estimates of the relationship between electricity access and measures of tax compliance are plausibly biased due to the possibility of reverse causality. This limits the extent to which causal interpretations can be assigned. To overcome this challenge, we rely on the instrumental variable approach. Using geographic information system (GIS) data on the 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 in a district with less dense transmission network (Brown and Sedano, 2004; Chakravorty et al., 2014).

Based on 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 about the effect of electricity shortages on firm productivity and growth, and with the aid of firm-level data from the World Bank Enterprise Surveys, among other secondary data sources, we estimate the tax-revenue losses associated with unreliable power supply in 36 countries. The estimated revenue losses are 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 on electricity access and reliability on attitudes toward taxes. The impact is not restricted to household access to electricity but 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 attitudes toward taxes significantly. This underscores the importance and urgency of resolving the challenges of reliability in the electricity sector in Africa.

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

Further, we document national identity as an important mechanism through which electricity provision affects attitudes toward 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 are in turn 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 – more than $9.5 billion dollars (4.3 percent of total tax revenue) – in 36 African countries. The losses are highest in 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 financial 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 goods provision in Kenya, Uganda, and South Africa. We build on this literature by focusing on a specific (quasi) public good and providing an explicit 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 because 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 toward tax compliance. Our dual analysis of household and firm-level implications of increased electricity access provides 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 SSA should not be focused solely on grid expansion, but also on improving the quality of power supply.

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 SSA.

2.1 Taxation and the fiscal pact

Taxes are the lifeline of states. However, the costs of 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 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 public. From the perspective of taxpayers, there are strong incentives against paying taxes. Not only do taxes entail an effective "loss" of income, but they also constitute a contribution to the financing of public goods for which there are strong incentives to free-ride (Feld and Frey, 2007). States can only invest in so much 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 in the provision of public goods) determines the willingness of taxpayers to comply with the tax code voluntarily. 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 his or her likelihood to express support for tax evasion. In the same vein, Kasara (2007) finds that in Africa, farmers who are co-ethnics of presidents tend to be taxed at relatively higher rates

than those from different ethnicities, 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. Therefore, self-reported rates of national affinity are positively correlated with self-reported attitudes toward 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 affinities 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 preceding 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 levels) 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 evasion, and provide public goods) and legitimacy (the ability to elicit quasi-voluntary tax compliance by the public). The previous 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 tends to focus on the longer term. The stylized account is that the need for revenue to pay for interstate 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.

Some recent studies have 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 attitudes and practice regarding 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 to 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 SSA that has historically been plagued by perennial state weakness (Herbst, 2000). Our findings in this paper suggest that having a robust fiscal pact – buttressed by the reliable provision of (quasi) public goods and services – will be a crucial determinant of the region's realized levels of extractive capacity and joint 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 percent in 2012. Currently, more than 600 million people in the region are not connected to the grid, and without significant interventions, 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 percent, 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, Cabo Verde, Ghana, and Gabon, where on average at least 40 percent of rural populations are connected to the grid.

SSA countries will require significant investments in installed capacity and distribution to increase the rates of connectivity. To have the desired effects on economic performance,

[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).

some of these investments will have to be channeled toward guaranteeing reliable supply. The lack of reliable supply is a significant 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 an average of 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). Firm-level evidence corroborates the same trend. 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. These studies suggest potential positive economic impacts of increasing electricity access in SSA because of its effects on firm-level productivity. Increased productivity and employment, in turn, are likely to result in higher tax revenues for African governments. 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 only 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 critical variables for the analysis.

3.1 Empirical Strategy

The empirical analysis of this paper is structured in 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:

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

where y_{ijdc} is the outcome variable 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; X and Z are vectors of community and country characteristics; and ϵ_{ijdc} is the error term. Admittedly, estimation of the effects of electricity access and reliability on tax compliance attitudes and national identity require strong assumptions to assign causal interpretations. Factors such as simultaneity between electricity access and the outcome measures of tax compliance and national identity raise issues of endogeneity. The possibility of measurement errors in our measure of the tax compliance index poses an additional challenge to the identification of causal effects.

To address these concerns of identification, we adopt the instrumental variable (IV) approach, using the density of the 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 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 that converts 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, expan-

sion in grid network will not necessarily translate into 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 is 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 is violated, 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 the endpoint of the lines follows the least-cost approach, which is mostly determined by the topography of the landscape. Construction of a transmission network is capital intensive, and the cost increases with elevation. As a result, the placement of these lines is done to minimize cost. Another factor in the placement of transmission lines is the minimum distance. Every power network incurs losses in transmission and distribution, and these losses increase with distance from the generation plant. Therefore, in the spirit of cost (loss) minimization, placement of transmission lines arguably follows the 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 sub-regional power pools. Therefore, the possibility of local socioeconomic or political factors influencing the placement of transmission lines is minimal, other things being equal. 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_{dc} 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 loses

significant tax revenue due to the negative impact of power outages on firms' revenue and profits. Therefore, reducing or eliminating 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 reduce the profitability of existing firms, thereby reducing tax payments from these firms. On the extensive margin, electricity-supply irregularities constitute a distortion in the business environment and can constrain the establishment of new firms and hence stifle expansion of the tax net.

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 τ_j and θ_j represent, respectively, , the share of total tax payment(s) of existing firms lost due to the adverse 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 δ^t and t represent discount factor and years, respectively. $CITRev^*$ is the (potential) corporate income-tax revenue accruing to the state in the absence of power outages. Details on the steps and assumptions underlying the simulations of tax-revenue losses/gains are provided in the Appendix.

3.2 Data

The analysis relies heavily on data from the Afrobarometer and Enterprise Surveys data sets, complemented with data from secondary sources, including the Firm Informality Survey, Mo Ibrahim Index of 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

Afrobarometer is a research network that conducts surveys of public attitudes on democracy, governance, economic conditions, and related issues in African countries. The series currently contains data from 37 African countries collected during the period 1999-2015. Data from Round 6 (2014/2015) of the Afrobarometer series are used for the analysis. The

data set is georeferenced, covering 7,137 towns and villages in 31 countries in SSA, 62 percent of which are rural (BenYishay et al., 2017).

In this paper, we measure tax compliance using a tax morale index defined as an individual's expressed attitude toward 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. Explicitly, 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 larger values implying a 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[5], we observe a high possibility of tax compliance, with a mean tax morale index score of 0.62. Comparing rural and urban communities, we find marginal differences, with average index scores of 0.63 and 0.61, respectively. A similar pattern is observed for each component of the tax morale index, except trust in tax officials or administration, where less than half of the interviewees responded in the affirmative, indicating a 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 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 (herself) 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, schools, hospitals, paved roads, and reliable 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 these data, we compute an aggregate electricity-reliability index in the community as

[5]Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cabo Verde, Côte d'Ivoire, Gabon, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Swaziland, São Tomé and Príncipe, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe.

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 score, the greater the extent of reliability in the community. Apart from school access, the data show significant gaps in access to infrastructure between urban and rural communities. For instance, the share of urban communities with access to grid electricity is almost twice the share of rural communities with grid access. Interestingly, however, reliability in electricity supply appears to be a significant 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, and asset ownership (TV and mobile phone) are also included in the analysis.

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 (herself) 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.

3.2.2 The Enterprise Surveys data

The analysis of tax-revenue gains uses data from the Enterprise Surveys, a data set on firm performance and their constraints to doing business. The data set is available for most countries in the region between 2002 and 2015. In this analysis, we focus on a section of the data set collected between 2006 and 2015, mainly because of the harmonization of the survey methodology since 2006. For each country in the data set, we focus on the latest round of the survey.

To obtain a measure of the impact of outages on firms' revenue, we compute the weighted average of the share of firm revenue lost due to power outages. Firms in the data set vary regarding sales, size, production, industry composition, and the extent of dependence on electricity for production activities, among other things. 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 a 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 predict the direct and indirect impacts of outages on their production and consequently, revenue. Hence, the effect of measure-

ment 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 endogeneity between outage intensity and firms' revenue. Mensah (2016) estimates the impact of outages on firms' revenue and productivity using the instrumental-variable approach with firm-level panel data from the Enterprise Surveys from several SSA countries between 2003 and 2015. To validate the 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) date 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 the willingness of informal firms to register and their reasons for not registering are obtained from the Firm Informality Surveys, which is a variant of the Enterprise Surveys data focusing solely on informal firms.

3.2.3 Supplementary Data Sources

We complement the above data sets with data on country-level indicators. In the analysis of the effects of electricity access and reliability on tax compliance and the potential mechanisms, country-level indicators such as total population, GDP at purchasing power parity (PPP), share of urban population, population density, value added of agriculture and service sectors as a share of GDP, and natural resources rents (% of GDP) from the World Development Indicators database; the Mo Ibrahim Index of African Governance (IIAG) from the Mo Ibrahim Africa Foundation; the Polity IV Index on Democracy; and the ethno-linguistic fragmentation score (Fearon, 2003). The 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. The 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 the 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 Surveys data with data on corporate income tax (CIT) revenue as a percentage of GDP from the Worldwide Gov-

ernment Revenue Database of the International Monetary Fund (IMF).[6]. The most recent data available for most of the countries considered in this paper are from 2012. As a result, we compute the average CIT revenue % GDP between 2010 and 2012. In a few countries with no data on tax revenue during this period, we use the most recently available data as a proxy. Also, we use the average real GDP between 2010 and 2015, from the World Development Indicators, as the baseline GDP. Combining these 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 percent 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[7]; electricity transmission network; and enumeration areas of the Afrobarometer survey.

First, we overlay the geocoordinates of the enumeration areas onto the administrative boundaries to match the survey areas to their respective districts based on their geolocation. 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 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 Afrobarometer to estimate the effects of electricity access and reliability on attitude toward tax compliance. We also examine the mechanisms driving this relationship by estimating the impact of electricity access on individuals' sense of national identity. Unfortunately, analyzing the relationship at the firm level is an empirical challenge since there are no available data set on firms' attitudes toward taxes. Nevertheless, the results from the household sector apply to firms as well, particularly given the

[6]https://www.imf.org/en/News/Articles/2015/09/14/01/49/pr15374
[7]http://www.gadm.org/about

fact that the former supplies labor force to the latter. Building upon 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 the household (individual) level, this section focuses solely on firms.

4.1 First-stage IV regression results

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

The Angrist and Pischke (AP) first-stage F test of weak instruments 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 the household and community levels. 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 household levels on tax compliance attitudes. Again, the results show a robust positive impact of access to reliable electricity on attitudes toward taxes.

Despite the importance of both access and reliability in explaining variations in tax compliance attitudes as shown in Table (4), we argue that reliability in particular plays a crucial role for sustainable economic growth and hence tax-revenue mobilization. As shown by Allcott et al. (2016b), reliability is a critical factor in 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 allows us to disentangle the relative importance of the various tiers of reliability

on tax compliance. We also split the sample into rural and urban residents 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 a sufficient number of instruments required to satisfy the "order condition" for identification (i.e. having at least as many instruments as endogenous variables). As a result, these estimates can be viewed as partial correlations.

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 a regular supply of electricity have favorable attitudes toward 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 electricity outages encourage negative public attitudes toward honoring their tax obligations. Thus, citizens may use non-payment of taxes as a form of protest against poor service delivery on the part of the state and utility companies. The results also show significant rural-urban differences regarding the effect of reliability on tax compliance. While reliability is a key determinant of attitudes toward taxes, the effect is significant and stronger for urban than rural households. These results provide suggestive evidence that reliability perhaps matters more for urban than rural households in explaining individuals' attitudes toward 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 morale index, as shown in Table 6. The results in columns 1-3, suggest that access to reliable electricity supply increases the probability of individuals accepting that: paying taxes is a civic responsibility, non-payment of taxes is a legitimate protest action, and government has the right to tax citizens to finance its activities. However, contrary to expectations, we find an adverse 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, expanding visible infrastructure such as electricity, without compromising on the quality of supply, can be a viable strategy to increase the tax base and government revenues.

In the final part of this section, we examine the effects of electricity access and reliability on tax compliance attitudes conditional on public- vs. private-sector employment of the individual. The results (Table 7) show striking differences in the impact between the two categories. The results for the public sector are not significant and appear less robust, as the first-stage F test of instrument strength is in most cases very low. Also, our data set is dominated (about 7 to 1) by private-sector over public-sector employees. The

results for private-sector employees show a significant and positive impact of electricity access and reliability irrespective of the level of measure, i.e. communities or households. 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 toward taxes. A key question is to what extent the provision of reliable electricity generates spillovers on the attitudes of households or individuals who lack private access to these quasi-public goods. In other words, are there possible externalities in the impact of the provision of reliable electricity on tax compliance?

To answer this question, we extend the analysis to individuals who reside in communities with access to electricity but do not themselves have access to electricity in their homes. Thus, we estimate the effect of communal access to electricity on tax compliance attitudes of individuals in unconnected households. We compare these 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. However, we find a negative spillover effect for access to water. The outcome of a positive spillover effect of electricity access is indicative of the salient attributes that come along with grid connection. Intuitively, the results suggest that expanding access to electricity to communities can foster positive attitudes in the minds of citizens toward honoring their tax obligations.

4.4 Mechanisms

In this section, we argue and provide evidence for 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 central premise is that the provision of social infrastructural services like electricity tends 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 are 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 progress made in democratic governance (Polity IV), support for opposition parties, and the share of the country's population who are natives of the president's ethnic group. These factors are key political and economic considerations that operate in different dimensions to influence an individual's sense of identity with the state vis-a-vis his/her ethnic group. Thus we interact these measures with our variable of interest, access to electricity in the community.

In the results (Table 9), we find a 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 promotes ethnic identity at the expense of national identity. Therefore, electrification programs to communities with strong ethnic ties with the president of the country are 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 positive, albeit at a reduced level of impact due to the negative ethnic-induced impact. The interaction between being a sympathizer of the opposition party and access to electricity is not statistically significant. This suggests that extending electricity access to sympathizers of opposition parties does not in any way influence their level of association with the national course. Again, we do not find any differences in the effects of electrification on the 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 morale index using 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 tax compliance. The results remain robust as the estimates are quantitatively and qualitatively similar to the primary 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 supply deficiencies and inefficiencies in the power sector will create a sense of goodwill among citizens of African countries to honor their tax obligations.

In this section, we present evidence on the potential gains in tax revenue accruing from

the business sector following complete elimination of outages and 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 current challenges in the power sector of respective countries remain unresolved.

To begin with, we compare simulation results based on two measures of outage impact to enable us to 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 (NIG), Ghana (GHA), and the Democratic Republic of Congo (COD), where the self-reported losses/gains are larger. A possible reason for an over-estimation of the self-reported impact estimates in some countries may be a heavy reliance of firms in these countries on electricity generators due to the frequent outages they experience. For example, data from the Enterprise Surveys reveal that 79 percent of firms in Nigeria rely on generators for electricity during power holidays. As stated before, however, for the most part the estimates of tax losses/gains are similar. Thus, 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 U.S. (2010) dollars.

Results on the average annual loss in tax revenue due to outages reveal that South Africa, Angola, Nigeria, Ghana, and Kenya record the highest losses – more than $300 million per annum. Nigeria and South Africa are the most prominent economies in SSA, with large industrial sectors, so one would expect the absolute impact of unreliable power supply on firms' performance and consequently their tax payments to be high. Expressing these losses as percentages of total tax revenues, Angola (15.1%), Republic of Congo (8.9%), Nigeria (6.8%), Gabon (6.3%), and Mali (5.1%) are the top five losers (Figure 6). Cumulatively, the estimated losses in the study countries are in excess of $9.5 billion (4.3 % of total tax revenue). These losses represent tax-revenue gains that could be mobilized, other things being equal, if power outages in these countries could be eliminated. Considering the massive deficits in government revenue across countries in the region, the importance of tax-revenue savings from an improvement in the quality of electricity supply cannot be overemphasized. The enormity of potential 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 analyzes the fiscal implications of improving reliability in electricity supply in Sub-Saharan Africa.

Complementing data from the Afrobarometer survey with other relevant data sources, we find a robust 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 toward taxation in SSA. Additionally, we find strong positive spillover effects of reliable access to electricity. Extending grid connection to a community induces positive attitudes among residents toward 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 their effect on national identity. Access to electricity improves citizens' sense of "belonging" to the state as opposed to ethnic groups, and therefore increases willingness to contribute resources (taxes) for the efficient functioning of the state.

Finally, the paper examines the fiscal implications of improving reliability in electricity supply by estimating tax-revenue gains from a complete elimination of power outages. Simulations on tax-revenue losses/gains reveal that countries in the region can generate more than $9.5 billion (4.5 percent of total tax revenue) every year by resolving reliability constraints in the electricity sector.

Policy prescriptions stemming from this analysis include the following: First, expanding access to electricity, particularly in rural communities, can produce significant economic and fiscal benefits for the country. Second, while efforts at expanding grid access are important, improving reliability in supply should be given equal attention, as outages have the potential to undermine the impact of electricity access through their negative impact on household welfare and firm performance. Citizens may therefore have less incentives to pay taxes, as they view such actions as a form of protest against government's inability to provide reliable electricity. Third, the elimination of power outages has the potential to generate significant tax revenues that can, in turn, be used to refinance investments in the electricity sector.

Figures

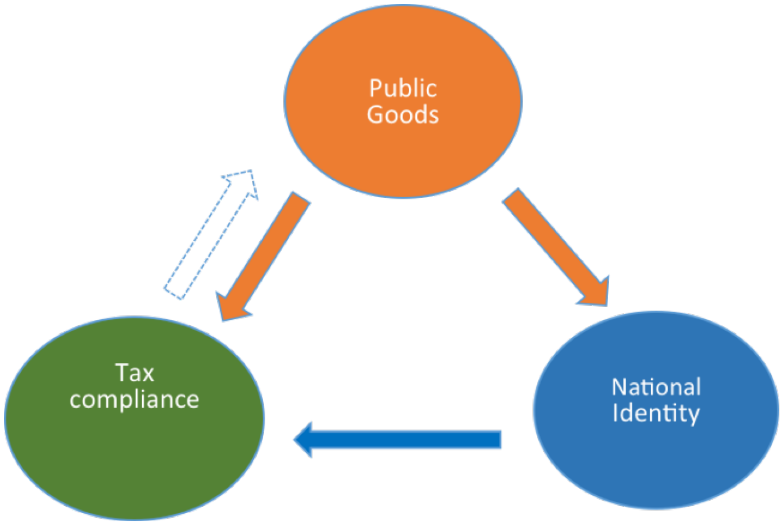

Figure 1: The Virtuous cycle of taxes, public goods, and national identity

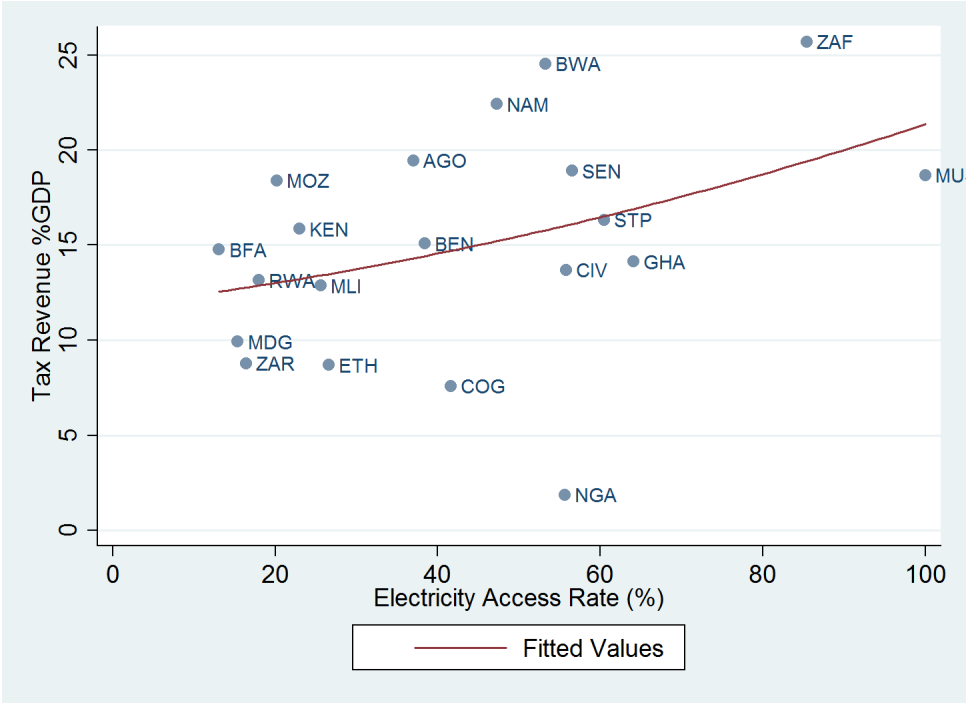

Figure 2: Electricity access and tax-revenue mobilization

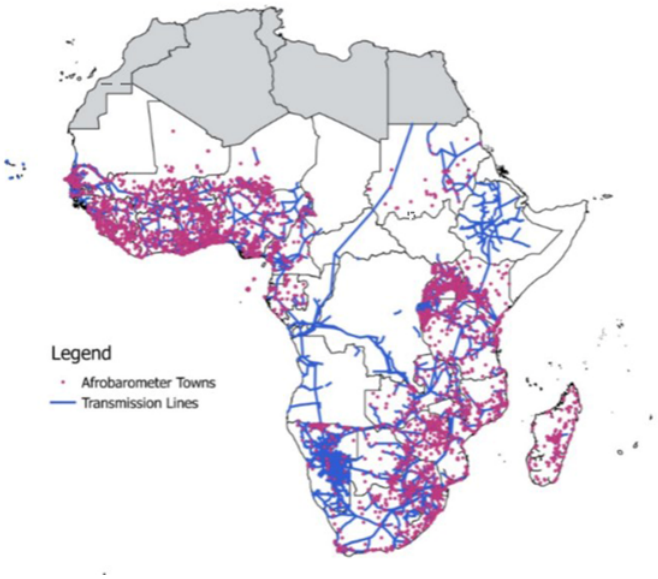

Figure 3: Afrobarometer survey locations

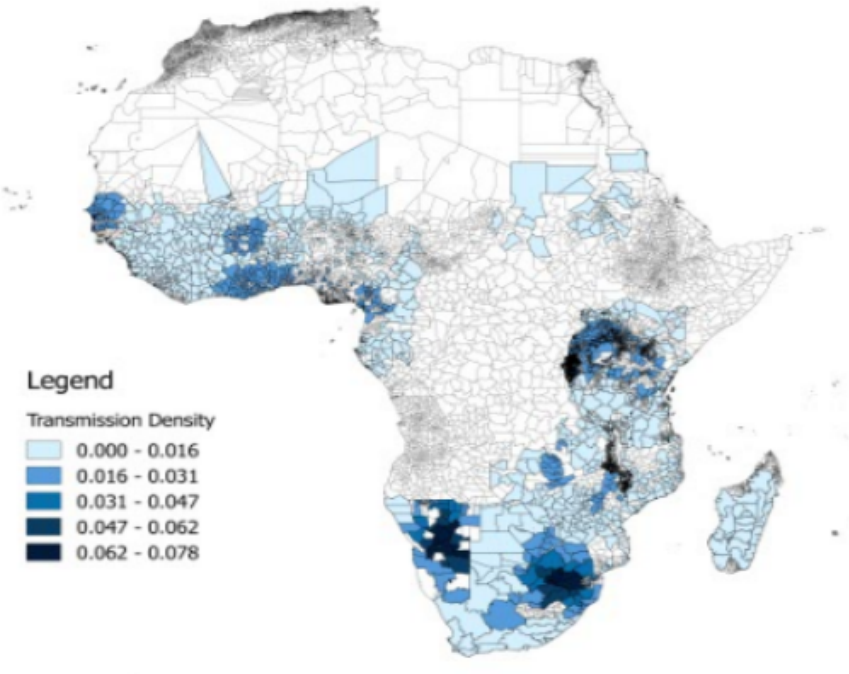

Figure 4: Variations in electricity transmission density

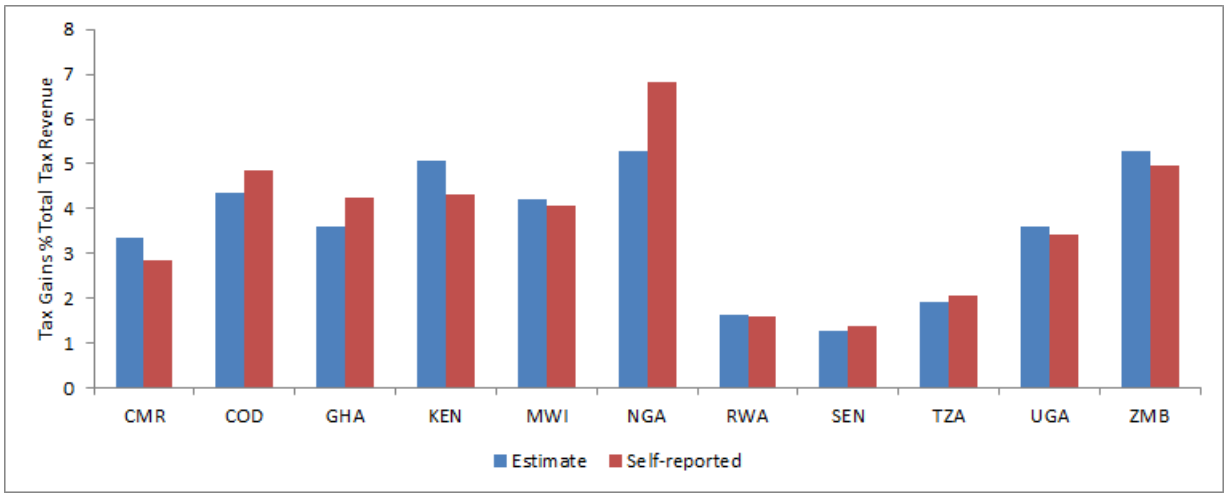

Figure 5: Comparison of average annual tax revenue losses due to power outages

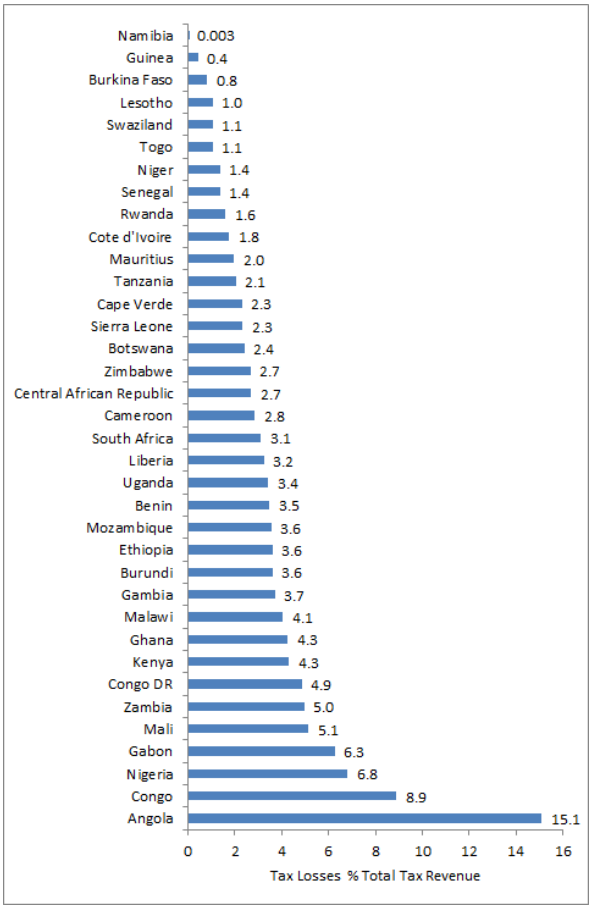

Figure 6: Average annual tax revenue losses due to power outages

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
Household Size	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. F-stat 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. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and 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 PSU level. F-stat 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. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and ethno-linguistic fragmentation score.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 5: Differential impact electricity access and reliability on tax compliance

	(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

Notes: Robust standard errors in parenthesis and clustered at the PSU level. Estimations are done using OLS. The survey sampled across 7,137 communities/towns (4,435 in rural areas, 2,702 in urban areas). The independent variable of interest is the availability and reliability of electricity for those who are connected. Responses ranged from 1 to 5, where 5 represents 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. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and ethno-linguistic fragmentation score. The dependent variable is tax morale. The index on tax morale is an average of responses on whether the respondent agrees that people must pay taxes, sees refusing to pay taxes as a legitimate protest action, thinks the government should have the right to collect taxes, and trusts tax officials or administration.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 6: Differential impact of electricity access on components of 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

Notes: Robust standard errors in parenthesis and clustered at the PSU level. Estimations are done using OLS. The survey sampled across 7,137 communities/towns (4,435 in rural area, 2,702 in urban areas). Dependent variables are dummy variables used to construct the tax morale index: whether the respondent agrees that people must pay taxes, sees refusing to pay taxes as a legitimate protest action, thinks the government should have the right to collect taxes, and trusts tax officials/administration. All regressions in the table control for individual/household-, community-, and country-level variables. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and 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 PSU level. F-stat is the IV first-stage F test of instrument strength. All regressions in the table control for individual/household-, community-, and country-level variables. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and 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 PSU level. F-stat is the IV first-stage F test of instrument strength. All regressions in the table control for individual/household-, community-, and country-level variables. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and 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)
	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 PSU level. Estimations are done using OLS. The survey sampled across 7,137 communities/towns (4,435 in rural areas, 2,702 in urban areas). The dependent variable is the response to the question whether respondents identify more with their ethnic group or their country. Responses are ordered in the following way: 1. identify only with their ethnic group; 2. identify more with their ethnic group than their country; 3. Identify with both equally; 4. identify more with the country than the ethnic group; 5. identify only with the country. All regressions in the table control for individual/household-, community-, and country-level variables. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and 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 PSU level. F-stat is the IV first-stage F test of instrument strength. All regressions in the table control for individual/household-, community-, and country-level variables. Individual/household-level variables include the respondent's gender, age, education, quality of housing, employment status, size of the household, and ownership of a TV or mobile phone. Community-level variables include the presence of piped-water systems, paved roads, schools, and hospitals. Country-level variables include total population, GDP PPP, share of the urban population, population density, value added of agriculture and service as a share of GDP, total natural-resources rents (% of GDP), IIAG score, and ethno-linguistic fragmentation score.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Appendix

Methodology for computing tax-revenue gains from reliable supply of electricity

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

5.0.1 *Tax Savings from Existing Firms*

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

$$Tax_i = \tau \pi_i^* \tag{5.5}$$

where Tax_i is the amount of profit tax paid by firm i, τ is the tax rate, π_i^* is the profit level of the firm in the absence of constraints such as outages.

Outages reduce firm profitability due to their 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 γ as the impact of outages on firm profits, we can express the total tax payment of the firm during periods of intense outages as

$$Tax_i = \tau(1-\gamma)\pi_i^* \tag{5.6}$$

where $0 < \gamma \leq 1$. Therefore, from equation (5.6), the reduction in taxes paid by the firm as a result of outages is equivalent to the term $\tau\gamma\pi_i^*$. This suggests that the level of γ, 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

$$TaxRev = \phi \sum_{i=1}^{n} \tau(1-\gamma)\pi_i^* \tag{5.7}$$

where $0 < \phi \leq 1$ and n represent, respectively, the tax compliance rate and total number of firms in the country. The tax compliance rate measures the rate at which taxpayers in an economy comply with the tax rules (i.e. in terms of actually paying all the taxes due them). From equation (5.7) the total tax revenue losses resulting from the negative impact of blackouts on the universe of firms in the economy is given as

$$TL = \phi \sum_{i=1}^{n} \tau(\gamma)\pi_i^* \tag{5.8}$$

In this framework, the impact of outages on firm profit, γ, is assumed to consist of direct and indirect impacts[8]. On the one hand, outages reduce profitability directly through their 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.

Alternatively, equation (5.8) can be expressed as

$$TL = \gamma \times CITRev^* \tag{5.9}$$

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

5.0.2 *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. Motivations for tax evasion include, among others, protest actions against the government for 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 the 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

[8]Hence, $\gamma = \alpha_1 + \alpha_2$, where α_1 and α_2 represent respectively, the direct and indirect impacts.

compliance rate and in the absence of other market distortions, tax-revenue gains from the creation of new firms and registration of existing firms can be expressed as

$$AddTax = \theta \times CITRev^{*} \tag{5.10}$$

where θ is the percentage increase in the tax base because of reliable electricity provision, computed as the sum of the share of newly established firms and formalization of old firms because of access to reliable electricity.

5.0.3 *Aggregate Tax Gains*

From the above, other things being equal, the potential tax revenue gain from fixing reliability issues in the electricity sector is equal to the sum of the forgone tax losses (equation 5.9), and the gains from new firms registered (equation 5.10) and expressed as

$$TTAX = (\theta + \gamma) \times CITRev^{*} \tag{5.11}$$

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

$$TTAX_j = \sum_{t=1}^{2} \delta^t((\tau_j + \theta_j) \times CITRev^{*}_{jt}) \tag{5.12}$$

where δ^t and t represent discount factor and years respectively.

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 [9] as a proxy for the potential CIT tax revenue. Admittedly, this does not adequately address the issues associated with the measure. Nonetheless, this approach is beneficial in two ways: First, we can smooth out seasonal variations in the performance of the economies, which has a strong correlation with tax revenues; second, given the variations in outage intensity and impact over time,

[9] These are the most recent data available for the countries in the study (i.e., 2010-2012)..

averaging the tax revenue offers an alternative approach in minimizing the bias in the use of the past CIT tax revenues as a counterfactual.

We proxy the indirect impact of outages on firm profitability with the impact of blackouts on capacity utilization of firms. Other things being equal, uninterrupted access to electricity induces firms to operate at optimal capacity, thereby maximizing profit. Estimations using the Enterprise Surveys data suggest that access to reliable electricity boosts capacity utilization by 2.2 percent. Further, using data from the Firm Informality Dataset (a sequel to the Enterprise Surveys 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 to register their businesses and the probability of firms avoiding taxes.

The following are fundamental assumptions underlying the simulation of the potential tax-revenue gains due to reliable supply of electricity: 1) Outage intensity in the respective countries remains as in the status quo over the two-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 mainly from the business sector. In line with that, we use country-specific forecasts of real GDP growth (2016-2017) by the IMF and World Bank. Finally, we assume a baseline discount rate of 10 percent as used in Steinbuks and Foster (2010), and Trimble et al. (2016).

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