Jobs! Electricity Shortages and Unemployment in Africa

Justice Tei Mensah*

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Abstract

This paper presents evidence on how the provision of unreliable electricity constrains expansion in the productive sectors of the economy and consequently leading to a reduction in the number of employment opportunities in Africa. Using GIS data on electricity transmission network in the continent, I compute an index that explores variations in technical losses in the electricity network as an instrument for electricity shortages. I combine this instrument with geo-referenced data from the Afrobarometer and Enterprise Survey datasets from over 20 African countries to causally estimate the impact of electricity shortages on employment and the mechanisms driving the impact. Results from the paper reveal that electricity shortages exert substantial negative impact on employment rates in Africa. The evidence also shows three channels by which electricity shortages affect labor market participation. First, on the extensive margin, electricity shortages constrain the creation of new businesses through its negative effect on entrepreneurship. Second, in the intensive margin, electricity shortages reduce output and productivity of existing firms, thereby causing them to reduce labor demand. Third, electricity shortages act as a distortion in the business climate thereby reducing the trade and export competitiveness of African firms.

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*Department of Economics, Swedish University of Agricultural Sciences, Uppsala-Sweden. Email:justice.tei.mensah@slu.se. This article has benefited from comments and discussions with Moussa Blimpo, Wilfried Kouamé, Franklin Amuakwa-Mensah, Théophile Bougna, Andrew Agyei-Holmes, Aimable Nsabimana and other anonymous researchers at the World Bank. The 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 of the Africa Region(AFRCE), World Bank under the project code P156903.The findings, interpretations, and conclusions expressed in this paper are entirely those of the author. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations or those of the Executive Directors of World Bank or the governments they represent.

1 Introduction

Electricity is considered one of the basic attributes of modern life. It is a key input for production of goods and services, as well as quality of life. The reality however is that, despite the fact that more than 600 million people in Africa lack access to electricity (IEA, 2015), the quality of supply to connected households and firms is precarious. Electricity outages have become a common feature in many African countries (Andersen and Dalgaard, 2013).

A large body of development literature has underscored the importance of electricity access on socioeconomic outcomes such as education, income, health and labor allocation (Dinkelman, 2011; Lipscomb et al., 2013). Yet little is known about the economic impact of poor quality supply of electricity services (Allcott et al., 2016; Chakravorty et al., 2014). Available studies on the impact of electricity shortages have largely focused on the extent to which outages affect firm productivity (Allcott et al., 2016). An important but often ignored question is the extent to which persistent electricity shortages affect job creation and consequently, the rising rate of unemployment in the developing world.

The main goal of this paper is to show evidence of how electricity shortages constrain job creation in the developing world through its negative impact on industry. Specifically, using recent and rich geo-referenced household and firm data together with GIS[1] data on electricity infrastructure, I estimate the causal impact of electricity shortages on employment in Africa, and document the mechanisms through which the supply inefficiencies affect job creation. This paper hypothesizes and tests three main channels through which persistent electricity shortages affect job creation and hence (un)employment. First, on the extensive margin, persistent electricity outages create distortions in the business climate and increase the expected cost of doing business. This may either discourage potential entrepreneurs in establishing businesses or relocate to areas (countries) with plausibly reliable supply of electricity. Second, in the intensive margin, since electricity is an integral

[1]Geographic Information System

input of production, shortages in supply exert adverse impact on firms' productivity and profit. At the margin, firms employ labor as long as the marginal product of labor is at least equal to wages; hence a falling marginal labor productivity resulting from electricity shortages will have negative effects on labor demand and employment. The third channel is through exports and trade competitiveness of firms. With electricity supply irregularities, firms will either have to rely on self-generated power or shutdown production. While reliance on self-generated power increases production cost due to the high cost of generation, shutting down production also implies lost production. Thus either way, electricity shortages reduce the competitiveness of firms in terms of pricing and their ability to meet supply schedules on time, particularly on external markets where they compete with firms from advanced economies with reliable access to power.

Causal estimation of the impact of infrastructure services such as the quality of electricity is often beset with the challenge of endogeniety. For instance, the distribution and intensity of electricity outages is non random across space and time. The presence of local economic, social and political factors may confound the relationship between outages and the outcome variables of interest. Hence, an OLS[2] estimation of the impact is likely to be biased. To overcome this challenge of identification, this paper uses an instrumental variable (IV) approach.

The empirical strategy of the paper is summarized as follows. First, I combine GIS data on electricity transmission network in Africa and location of electricity generation plants, with maps (shapefile) of the second administrative boundaries (districts) in the continent to compute the "relative distance[3]" along the transmission lines between the generation plants and centroids of each connected district. This index of "relative distance"– a measure of the relative closeness of a given district to the generation plant–is interacted with the aggregate technical losses in the electricity network (proxied by the transmission and

[2]Ordinary Least Squares

[3]it ranges between 0 and 1 with 0 for districts containing the generation plants and 1 for districts at the end of the transmission network

distribution losses as a percent of total electricity output) to create an index of technical losses for each district and used as an instrument for electricity shortages. The intuition behind this instrument is straight forward: every electricity network incur losses in transmission and distribution, and these losses are driven largely by the travel distance of electricity from the generator to the end-users (Brown and Sedano, 2004). The farther the distance, the higher the extent of losses and hence the lower the quality of electricity available to consumers (Brown and Sedano, 2004). Other proximate causes of technical losses include age of grid lines and maintenance of the grid infrastructure. This paper argues (with evidence) that these drivers of technical losses are exogenous to local conditions, and hence satisfies the exclusion restriction assumption.

I combine this instrument with data from the latest round of the Afrobarometer survey (2014/15) to estimate the causal impact of the quality of electricity provision in a community on the probability of employment in 21 African countries. I also examine the extent of heterogeniety in the impact by estimating the effect across gender, and skilled versus unskilled employment. Third, I rely on the Afrobarometer Survey, and Enterprise Survey data to analyze the mechanisms through which electricity outages affect firms on the intensive and extensive margins, as well as the impact on their export and trade competitiveness, again using the IV estimator. Alternative hypothesis tests are undertaken to validate the results herein.

The first part of the analysis presents evidence on the impact of electricity shortages[4] on employment rate. The results reveal that the persistence of electricity shortages explains a large variation in unemployment rates in African countries. Specifically, I find that electricity shortages reduce the probability that an individual is employed by between 35 and 41 percent depending on the measure of electricity shortages. These effects are substantial and far outweigh the job creation potentials of rural electrification as shown in Dinkelman (2011). Additionally, the evidence suggests that the effect falls largely on employment of

[4]in this paper electricity shortages and power outages are used interchangeably.

skilled workers. In other words, electricity shortages reduce the probability of skilled employment relative to non-skilled employment. The results also show evidence of gender gaps in employment induced by outages.

The second part presents evidence on the mechanisms through which electricity shortages affect employment. I find that electricity shortages exert a negative impact on entrepreneurship thereby constraining the creation of new businesses. For existing firms, electricity shortages impose a substantial negative impact on firm productivity, contributing to more than 2.3 percent reduction in total factor productivity of African firms. Firms respond to these productivity losses through job cuts particularly high-wage skilled employees. Another channel is trade and export competitiveness. Outages reduce the trade competitiveness of firms due to its high cost of production and productivity losses. Estimates from the paper suggest that outages reduce direct exports of African firms by 6 to 12 percent.

The contribution of this paper to the extant literature is threefold. First, I assemble data from both households and firms to demonstrate how the provision of unreliable electricity services in the developing world is a driving factor for the high unemployment rates therein. Unlike the existing studies (see for example Allcott et al., 2016; Chakravorty et al., 2014; Alam, 2013; Steinbuks and Foster, 2010; Fisher-Vanden et al., 2015; Reinikka and Svensson, 2002), this paper moves beyond quantification the level of impact of electricity shortages on firm productivity, to examine the implications on employment. Allcott et al. (2016) for instance offer evidence on the effects of electricity shortages on the performance of Indian firms. They show that electricity shortages reduce firm revenue by 5 to 10 percent albeit the productivity losses are marginal. In China, evidence from Fisher-Vanden et al. (2015) show that firms respond to electricity shortages by re-optimizing input use. Notably, the paper reveals that in spite of the high cost of outsourcing, Chinese manufacturing firms outsource their production in order to mitigate the high productivity losses associated with outages. What is absent so far, in the literature, is the labor market implication of these direct impact of outages on the industrial sector. Therefore, the results from this paper contribute significantly in filling this gap.

Second, to the best of my knowledge, this paper is the first to assemble cross country household and firm data to rigorously demonstrate the channels through which quality provision of infrastructural services like electricity can affect job creation and vice-versa. This study is similar in spirit with Hjort and Poulsen (2017) who by combining several household and firm datasets show that the gradual introduction of high-speed internet to Africa led to an appreciable increase in skilled job creation in the region.

Finally, this paper brings new knowledge to the strand of the literature on the impact of firm and business climate distortions (Garicano et al., 2016; Hsieh and Klenow, 2009; Restuccia and Rogerson, 2008). Restuccia and Rogerson (2008) for instance assert that distortions in the business environment affect productivity and resource allocation. As a result, efficient firms tend to produce too little and employ few workers. These distortions have also been shown to account for the productivity gaps between the advanced and developing economies (Hsieh and Klenow, 2009). Abeberese (2017) also shows evidence from India on how high energy cost creates firm level distortions thereby constraining the ability and incentives of firms to move into high productive energy intensive industries.

The remainder of this paper is structured as follows. Section 2 presents the theoretical underpinnings on the effects of electrification on employment and job creation. Details on data and construction of key variables are presented in Section 3. The identification strategy of the paper is outlined and discussed in Section 4, while results from the estimation are presented and discussed in Section 5. Robustness test are undertaken in Section 6. The paper concludes in Section 7 with a summary of the key findings and implications for policy.

2 Electrification and Job Creation: Theory

Technology shocks such as electrification affect economic outcomes in diverse ways. First, electricity affects the nature of home production (Lewis, 2014). Through appliance use, electricity increase labor productivity in home production such as cooking, washing, ironing, etc., thereby reducing total time spent on home activities and freeing up labor for participation in the labor market (Greenwood et al., 2005; Ramey and Francis, 2009; Coen-Pirani et al., 2010; Dinkelman, 2011; Lewis, 2014; Akpandjar and Kitchens, 2017). It also creates an endowment effect through the demand for market goods (iron, fans, fridges, etc) whose utilization has been made possible by the presence of electricity (Dinkelman, 2011). The need for income by households to 'effectively' demand these market goods pushes to supply more labor into the market (Dinkelman, 2011; Lewis, 2014).

Electrification also improves productivity of local economies. Extending electricity services to communities enables the adoption and utilization of modern technology (such as irrigation) to improve labor productivity (Assunção et al., 2014; Lewis and Severnini, 2014). For instance, electrification in farming communities can increase mechanization and enhance irrigation schemes to improve agricultural productivity (Assunção et al., 2014; Lewis and Severnini, 2014). Also, local (cottage) industries can switch from traditional technology to modern tools to boost productivity. The resultant increase in productivity will impact positively on employment and wages, *ceteris paribus*.

Further, electrification like most technology shocks creates opportunity for the creation of new business and induce structural change (Fried and Lagakos, 2017). Access to electricity can foster the creation of new jobs as it spurs prospective entrepreneurs to take advantage of the enabling conditions the infrastructure provision offers. For instance in many developing economies where the informal sector dominates, access to electricity can enable households to set up small firms that produce intermediate or final goods (and services) for the market. Additionally, appliance use and modernization of agriculture and local industries through the use of electricity can shift employment into high skilled non-agricultural employment, thereby reducing the share of labor employed in agriculture. The resultant boom in the non-agricultural sector increases demand for labor and thus reduce out-migration in electrified communities, while attracting labor from neighboring localities to participate in the booming economy (Fried and Lagakos, 2017).

Implicit in the above is the assumption that electricity services are stable and reliable. Irregularities in the supply of electricity is likely to undermine the impact of electrification outlined above. Unreliable supply of electricity exerts negative impacts on the productive and industrial sectors with potential negative implications on the labor market. Revenue and productivity losses to firms resulting from electricity shortages are non-trivial (Allcott et al., 2016). In response to electricity supply uncertainties, firms re-optimize production inputs by substituting materials for energy inputs or by outsourcing intermediate production to external firms (Fisher-Vanden et al., 2015). There are at least three mechanisms through which electricity shortages affect employment.

i. *Firm Entry and Exit*: Persistent shortages in the supply of electricity signal high production cost and uncertainties in business climate thereby reducing the incentive(s) of potential entrepreneurs in establishing businesses. Also, existing firms may either relocate to areas with reliable access to electricity or shutdown production to avoid investment losses[5]. Thus, pervasive outages constrain expansion in the industrial and service sectors thereby reducing labor demand and employment.

ii. *Productivity Losses*: Electricity shortages also impose productivity losses on firms (Allcott et al., 2016; Fisher-Vanden et al., 2015). Hence, at the margin, firms respond to these adverse productivity shocks by reducing variable cost through job cuts or reducing wages.

[5] Under the assumption of free mobility of labor and capital, firms may choose to relocate to areas with reliable supply. However, the cost of relocation is non-trivial.

iii. *Export and Trade Competitiveness*: Export is one of the channels through which technological change affect employment, as it enables productive firms to expand their revenue through sales on foreign markets (Verhoogen, 2008; Frías et al., 2009; Hjort and Poulsen, 2017). A negative technological shock such as electricity shortages will therefore affect employment through its negative impact on productivity and cost of production of exporting firms, thereby reducing their trade competitiveness.

This paper provides evidence on the effect of electricity shortages on employment and tests the above mechanisms in explaining the impact using household and firm data in Africa.

3 Data and Instrument Construction

This paper combines comprehensive datasets on households(individuals), firms and GIS data on electricity network to estimate the causal impact of electricity shortages on employment and the mechanisms driving the impact. Summary statistics of the data used in this paper are presented in Table 1. The following describes sources of the data used.

3.1 Afrobarometer Survey

The Afrobarometer survey is a nationally representative survey of public attitudes on democracy, governance, economic conditions, and access to basic social amenities in over 35 African countries. The survey uses a two-stage stratified sampling strategy and focuses on individuals above the age of 18. Data from the latest round (2014/2015) of the Afrobarometer series is used for the analysis. The dataset is georeferenced at the community making it possible to merge it with other datasets. Data from 21 countries are used in this paper[6]. Figure (1) shows the location of the survey communities used in the analysis.

I use data on employment status of individual(s), quality of electricity supply, socioeconomic attributes of the individual and their respective households, and community characteristics as well. The quality of electricity supply is measured from households' responses to the question "how often is the electricity actually available?". Here electricity supply is defined as reliable if a household receives electricity supply always and unreliable if otherwise. Using this data, I compute a measure of reliability in a community based on the share of electrified households in the primary sampling unit that have reliable access to electricity. Specifically, two main measures of reliability are computed: first, a dummy variable (outages in community) equal to 1 if more than 50 percent of connected households in the primary sampling unit (PSU) do not have access to reliable electricity; and second, the share of connected households without reliable access to electricity (outages in communty % HH).

3.2 Enterprise Survey

The World Bank Enterprise Survey (WBES) dataset is a global firm survey that undertakes face-to-face interviews with top managers and business owners in 139 countries. The survey collects data on myriad issues relating to firm attributes, access to infrastructure, constraints to doing business, competition, among others. The survey uses the two-stage stratified random sampling strategy. I use the global standardized version of the dataset which uses a standardized sampling strategy and questionnaire. All monetary data are converted into 2009 USD prices using the GDP deflator and exchange rates for the respective countries. The final dataset there is a repeated cross-section data of firms in 23 African countries surveyed between 2006 and 2016. To account for these time and

[6]including: Benin, Botswana, Burkina Faso, Burundi, Cote d'Ivoire, Ghana, Guinea, Kenya, Liberia, Malawi, Mozambique, Niger, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda, and Zimbabwe. The choice of these countries is informed purely by data availability and being a Sub-Saharan African country.

country variations in the dataset, year and country fixed effects are applied respectively in the estimation.

The dataset reports annual revenue and cost of inputs rather physical measures of outputs and inputs. Productivity in this paper is measured using two indicators: value added per worker and total factor productivity. Value added is computed as total sales revenue less the cost of raw materials and intermediate inputs (Hjort and Poulsen, 2017). Total factor productivity (TFP) computed as the residual from industry-specific OLS regression of the log of revenue on the log of capital, labor and material inputs[7].

Two measures of self-reported power outage intensity are explored in the firm analysis: First, outage frequency measured as the average number of times a firm experience power outages in a typical month. Second, the number of hours without electricity in a typical month, measured by the product of the frequency and average duration of outages in a typical month. Arguably, these self reported measures of outage intensity, are not without biases. However, administrative data on outage intensity are virtually non-existent in many African countries, thus making the self-reported measures as the best possible means of measuring outage intensity. Additionally, given the prevalence and regular nature of power cuts in the study area, the extent of bias associated with recall, if any, will be minimal, other things being equal.

To reduce the effect of outliers, I compute the mean and standard deviation of the log of each variable for each country and 2-digit industry classification. Observations for which the log transformed value exceeds three standard deviations from the mean are classified as outliers and returned as missing[8]. Finally, the GPS location of firms in the WBES dataset are not publicly available due to privacy concerns. To overcome this challenge, I geo-reference the city/towns in which firms in the dataset are located and match them to

[7]Arguably, TFP measures from Levinson-Petrin (Petrin et al., 2004) and Olley-Pakes (Olley and Pakes, 1996) are the preferred measures of productivity used in the literature. However, the lack of a panel data on firms constrains the computation of these measures.

[8]This follows the recommendations of the Enterprise Analysis Unit of the World Bank (see: World Bank, 2017a).

shapefiles of their respective second administrative regions, hereafter referred to as districts. Overall, firm data from 23 countries are used to show the mechanisms through which electricity shortages affect employment via its effect on industry[9].

3.3 Africa Infrastructure Diagnostic Database

The Africa Infrastructure Diagnostic Database (AICD) is a database that offers cross-country data on network infrastructure for nine major sectors: air transport, information and communication technologies, irrigation, ports, power, railways, roads, water and sanitation[10]. In this database, I utilize the georeferenced data on electricity transmission network[11] and the geo-location of electricity generation plants across the countries.

3.4 Instrument Construction

To causally estimate the impact of electricity outages on the set of outcome variables, I adopt an identification strategy that exploits spatial and temporal variations in technical losses in electricity transmission and distribution as an instrument for electricity shortages. Electricity, unlike other services, has a unique characteristic such that the amount generated before entering the transmission and distribution network always exceed the amount available for consumption. These are due to technical and non-technical losses. While non-technical or operational losses arise from theft, unmetered supply, and operational inefficiencies of the utilities, technical losses result mainly from technological, geographic and climatological factors. In most cases, the extent of technical losses depend largely on the geographic expanse of the transmission and distribution networks, quantity of electric current flowing through the network, and quality of the grid lines (Jiménez et al., 2014).

[9]They include: Angola, Benin, Botswana, Burkina Faso, Cameroon, Congo DR, Cote d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Madagascar, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Sudan, Sudan, Swaziland, Tanzania, Togo, and Zambia

[10]https://data.worldbank.org/data-catalog/africa-infrastructure

[11]see: https://energydata.info/dataset/africa-electricity-transmission-and-distribution-2017

Figure (2) presents a schema of a typical electricity network showing the various stages from generation plants through the transmission and distribution network until it reaches the final consumer.

In many Sub-Saharan African countries, underinvestment in grid network and the lack of systematic planning in the power sector has resulted in high technical (transmission and distribution) losses averaging 18 percent of electricity output (excluding South Africa) compared to the benchmark of 6-9 percent in high income countries (IEA, 2014; Avila et al., 2017). In countries like Togo, Namibia and Ghana, transmission and distribution losses (TDL) accounted for 72.5, 36 and 22.5 percent of total electricity output respectively in 2014 (World Bank, 2017b).

The amount of electricity losses reflects the efficiency of the electricity network (Jiménez et al., 2014), and electricity outages are arguably symptoms of these inefficiencies. High technical losses for instance, implies a decay in the quality of electricity provision along the transmission network from generators to end points of the transmission and distribution lines. Thus, for a given amount of electricity generated, the cumulative loss in electricity increases with distance from the generation plant, other things being equal. This suggests that the variations in electricity losses across the electricity network is a good predictor of the distribution of power outages across the network.

To this end, I construct a localized measure of the technical losses in grid network as an instrument for electricity shortages using geodata on the electricity transmission network, location of generation plants, and cumulative technical losses. In contrast to transmission lines, the roll-out and maintenance of distribution lines are plausibly endogenous due to the influences of local economic, political and social conditions on grid extension and electricity access. For instance in many African countries, households, firms and local communities can pay for the cost of extending low-voltage distribution lines to unconnected households(communities) and/or maintenance of broken down distribution lines to ensure stable power supply. This is however, not the case for transmission lines whose construction and maintenance are largely determined by national and/or international policies often due to the capital intensive nature of such investment and also the quantum of power these lines carry. Therefore, the use of transmission lines can reasonably be justified to induce some exogenous variations. Further, geodata on distribution lines are relatively scant in most African countries thereby constraining their use. However, reliance on the transmission network implies that the instrument can be constructed at a relatively less granular geographic level such as districts rather than at a community level. This nonetheless, should not pose any significant challenge, as evidence from some household and individual data suggest low within community variation in outage intensity. As a result, I compute the instrument at the district level which happens to be the most feasible lowest administrative level in most African countries.

For each district j in country c at time t, I construct an instrument (Z) as the cumulative losses (TDL) in the electricity network weighted by the relative location of district j along the transmission network and expressed as

$$Z_{jct} = \alpha_j \times TDL_{ct} \tag{1}$$

where $\alpha_j \in [0, 1]$ is the relative location of district j along the transmission network. α_j is computed as the ratio between the least cost distance from the centroid of the district j to the generation plant and the total length of the transmission lines serving the district. The least cost distances between generators and the districts, represents how long electric power generated at these plants have to travel before reaching their respective destinations. Thus α_j is zero and one respectively for communities containing the generator(s) and the endpoint(s) of the transmission line(s). The intuition behind this instrument is that cumulative technical losses in electricity transmission increases with distance from generation plants, reducing the quality of supply and hence increasing the probability of power outages in areas at the endpoint of transmission lines relative to areas in the neighborhood of generation plants. To the extent that location of generation plants and TDL_{ct} are exogenous, Z_{jct} should induce exogenous variations in probability and intensity of power outages experienced in each district.

In computing the least cost distances between generation plants and districts, I use a digitized map of electricity transmission network in Africa from the AICD database, and shapefiles of Administrative boundaries in Africa from the Global Administrative Areas[12]. The AICD database provides the most comprehensive and up to date information on the geographic distribution of grid lines, as well as the location and status of power plants on the African continent. With the aid of the spatial data, the procedure used in generating the distances are summarized as follows. Technical details on the construction can be provided upon request.

First, I overlay the transmission lines and location of generation plants onto the district boundaries as shown in panel A of Figure (3). Second, using the network analyst tool in ARCGIS 10.2, I compute the Origin and Destination (OD) Cost Matrix between generators and centroids of districts under conservative assumptions on snapping and search tolerance levels. The results is an OD Cost Matrix of least cost distances (km) between 913 generation plants and 3902 districts, and the total length (km) of each transmission line. Panel B of Figure (3) shows the districts that were finally used in the analysis of this paper.

For districts traversed by multiple transmission lines, I compute three distance measures: minimum, mean and median distances to the generator. Even though the minimum distance is the preferred measure used in the computation of the instrument, I demonstrate in Section (6) that the choice of the distance measure does not matter for the results, as the results are qualitatively and quantitatively similar.

[12]http://www.gadm.org/country

4 Empirical Strategy

This section focuses on the methodological approach for analyzing the data. First, I outline and discuss the strategy used to causally identify the impact of electricity shortages on employment and the set of other outcome variables. Second, I present the baseline equation for analyzing the impact of electricity shortages on employment. The third part presents the estimation equation(s) for analyzing the mechanisms through which electricity shortages affect employment outcomes. In the last part of the section, I conduct exogeniety checks to further validate the instrument.

4.1 Identification Strategy

Empirical estimation of the causal impact of electricity outages on outcomes such as employment, firm productivity, etc, is often beset with methodological challenges. Notable among them is the issue of endogeniety resulting from the potential correlation between outage intensity and (observable and unobservable) factors that directly influence these outcomes. In other words, any assumption that variations in outage intensity are orthogonal to economic outcomes such as employment and firm productivity is unlikely to be valid. For instance, firm location, industry composition, and the prevailing economic and political conditions in a country can influence both outage intensity and the performance of firms. Also, regions with high unemployment and hence low income are more likely to suffer outages due to, among other things, a low willingness to pay for quality electricity services. Additionally, self reported measures of outage intensity are plausibly measured with error, hence the possibility of a downward bias (attenuation bias) in the impact from OLS estimation cannot be ignored (Allcott et al., 2016).

The identification strategy of this paper therefore, is to utilize the instrumental variable approach and exploit the spatial and time variation in technical losses along the electricity transmission network as an instrument for power outages. The motivation for this instrument is straight forward: every electricity network incurs technical losses in transmission and distribution, with the losses increasing with distance from the generation plants. Hence the quality of electricity supply along the transmission network reduces as you move farther away from the generation plant. Therefore being located in a district at the end point of the network will, other things being equal, imply a higher probability of experiencing electricity outages than being located in a district closer to the generation station. The construction of this instrument has been sufficiently discussed in Section 3.4.

The validity of this instrument hinges on two crucial criteria: First is the relevance condition, which basically requires the instrument to be correlated with the endogenous variable (outages). This is shown and discussed in the first stage results in Section 5.1.

The second condition, perhaps the most difficult to prove quantitatively, requires that the instrument affect the outcome variables only through outages. The instrument consists of the aggregate technical losses (% of total electricity output) in the electricity network of a country at a given time period and the relative distance between a generation plant and a given district. The roll-out of electricity transmission networks unlike distribution lines (mostly) follows a least-cost path between generation plants and endpoints, subject to geographic and economic conditions. In some cases, the lines extend across international boundaries as part of the network of sub-regional power pools (eg. The West and East African Power Pools). Also, the length of the transmission lines is largely influenced by the capacity and location of the generation plants which are plausibly exogenous. More so, location of generation plants are mainly determined by topographical and geological conditions, particularly for hydro, geothermal and coal fired generation plants which are the main sources of electricity generation in Sub-Saharan Africa (SSA). As a result, endogenous placement of transmission lines is possibly not a serious threat to the identification strategy particularly given that the paper focuses on reliability rather than access. To validate this claim, I show in Section 4.3.1, that the instrument is not correlated with pre-existing socioeconomic conditions in the districts. Thus conditional on having access to electricity, the relative location of a given district along the transmission network is plausibly exogenous.

Another argument is that even though the placement of generation plants are largely determined by topographical and environmental factors, the influence of political economy considerations cannot be ignored. For instance, although two locations may have similar conditions suitable for the construction of hydro-electric dams, political factors may favor one location over the other particularly subject to budgetary constraints. If these conditions persist over time, then the placement of generation plants may plausibly be non-random, thereby influencing the relative distance used in the construction of the instrument. This is sufficiently addressed and shown in Section 6, that the first stage IV results are robust to placement of generation plants.

Further, electricity consumption by transmission equipments such transformers, substations, and grid lines constitute a major source of technical losses. Hence aging equipments and grid lines tend to induce the amount of losses over time. It is therefore reasonable to assume that the drivers of technical losses are plausibly external to local conditions influencing the outcome variables of interest, at least at the district level. Another threat to the validity of the instrument arises if the extent of technical losses across countries is highly correlated with income, i.e. richer countries tend to have lower losses and vice versa. Again, in Section 4.3.1, I show that the level of technical losses in the electricity sector is not correlated with the income level of the country, at least within the dataset.

4.2 Electricity Shortages and Employment

Estimation of the impact of electricity shortages on employment is done using the Afrobarometer dataset (Round 5, 2014/15). Using the above identification strategy, I estimate the effect of electricity outages on employment using the two-stage least square (2SLS) IV approach, with the system of equations specified in (2) and (3):

$$EMPLOY_{injc} = \beta E_{njc} + \theta_1 A_{injc} + \alpha_1 X_{njc} + \alpha_2 M_c + \Lambda_t + \epsilon_{injc} \quad (2)$$

$$E_{njc} = \delta Z_{jc} + \theta_2 A_{injc} + \alpha_{11} X_{njc} + \alpha_{22} M_c + \Lambda_t + \mu_{injc} \quad (3)$$

Equation (2) is the second stage equation while IV first stage is represented by equation (3). $EMPLOY_{injc}$ is the employment status of individual i living in community n, district j, and country c ; E_{njc} is a measure of (average) electricity outage intensity in the community. Two measures of outage intensity are explored here: i. An indicator variable equal 1 if more than 50% of households (respondents) interviewed in the PSU receive poor quality electricity services[13] in the relevant period and 0 if otherwise. ii. The share of households who experience poor (quality) electricity services. The communal measure of outage intensity is preferred to household measure as the former captures, to a large extent, the general quality of electricity services in the community relative to the latter. More so, since most individuals are usually employed outside their home[14], a household measure of outage intensity may not suffice. A_{injc} is a vector of individual controls including age, gender and educational attainment.

The model includes additional controls to account for community and country-wide heterogeneity. X_{njc} is a vector of community controls including access to basic infrastructure such as pipe-borne water, school, road and hospital. These controls absorb differences in local economic conditions which may be key determinants of employment. M_c is a vector of country controls including income, population, natural resource dependence, and institutional and governance performance to account for cross-country variations in

[13]Poor quality electricity is defined as either having electricity occasionally, about half of the time or most of the time. Electricity supply is defined as of high quality if the household receives electricity all the time. In Section (6), we try alternative estimations by redefining our measure of electricity reliability to include households who receive electricity most of the time and always.

[14]even if individual is employed in household enterprises they may be located outside the households, eg in market or trading centers.

economic, social and political performance. Λ_t is a survey year fixed effect to account for temporal shocks during the survey period[15]. Z_{jc} is the measure of technical losses uses as the instrument. ϵ_{injc} and μ_{injc} represent respectively, the error terms for the second and first stage equations. Standard errors are clustered by primary sampling units. Sampling weights are applied as well.

The main parameter of interest,β, measures the causal effect of electricity shortages on the outcome variable. Therefore conditional on the instrument validity, $\hat{\beta}_{IV}$ recovers the Local Average Treatment Effect (LATE) of electricity shortages on the outcome variables.

4.3 Mechanisms

Next, to identify the mechanisms through which electricity shortages affect employment, I rely on firm level data from the WBES. Consequently, the IV approach is used to estimate equations (4) and (5):

$$Y_{kjdct} = \beta E_{kjdct} + \psi_j + \eta_c + \Lambda_{dt} + \epsilon_{kjdct} \quad (4)$$

$$E_{kjdct} = \delta Z_{jct} + \psi_j + \eta_c + \Lambda_{dt} + \mu_{kjdct} \quad (5)$$

where Y_{kjdct} is the outcome variable for firm k in district j, industry d, country c at time t; E_{kjdct} represents the power outage intensity experienced by the firm.

The estimation includes district fixed effects[16],ψ_j, to control for unobserved time invariant differences across districts; industry-year fixed effects, Λ_{dt}, to absorb common shocks in the 2-digit industry in a given year; and country fixed effects ,η_c, to account for cross-country time invariant differences. Results for clustering by districts are also presented in

[15]The Afrobarometer data used in this study was collected between 2014 and 2015, hence $\Lambda_t = 1$ for households surveyed in 2015 and 0 if otherwise. Also, the cross-sectional nature of the data implies that the instrument is correlated with the district fixed effect, hence the omission of the latter in the model.

[16]unlike the Afrobarometer data, the Enterprise Survey dataset used in this paper is a repeated cross-section from 2006 to 2015. This allows us to sufficiently utilize district and country fixed effects.

the Appendix. Survey sampling weights are also applied in the estimation.

4.3.1 Exogeniety Checks

A key identifying assumption of the IV strategy outlined above is that technical losses, Z_{jct}, are uncorrelated with other determinants of the outcome variable(s). This assumption is invalidated if for instance, the roll-out and/or maintenance of transmission lines are determined by some underlying pre-existing social, economic and political conditions.

To address this concern, I present exogeniety checks for the instrument at the district level. Table (2) shows results from a regression of the instrument and relative distance from district centroids to generation plants on population density, and income at the district level, measured (in 2005) before the study period[17]. The choice of these variables are purely based on data availability. A Correlation between the instrument or the relative distance between districts and generation plants, and the socioeconomic variables will suggest that the instrument is unlikely to fulfill the exclusion restriction criteria.

According to the results, there is no statistically significant correlation between the instrument and these pre-existing socioeconomic conditions. Further, the results show no correlation with relative distance from district centroids to the generation plants. These evidence go to buttress the argument that the placement of generation plants and transmission lines are plausibly exogenous, and hence validate the identifying assumptions in the paper.

Next, I demonstrate that any concern that technical losses are correlated with income of the countries in the study is plausibly invalid. Figure (4) shows the relationship between aggregate technical losses and income per capita from a regression of the TDL on income per capita, electrification rates and institutional quality (proxied by the CPIA ratings[18]) of

[17] the earliest version of the Enterprise Survey data used in this paper is 2006

[18] Country Policy and Institutional Assessment(CPIA) is a rating of countries by the World Bank "against a set of 16 criteria grouped in four clusters: economic management, structural policies, policies for social inclusion and equity, and public sector management and institutions See http://data.worldbank.org/data-catalog/CPIA

the countries in the dataset during the study period. Again, the results show no evidence of a (cross-country) correlation between income and the level of technical losses. This further boosts the credibility of the identifying assumptions of the paper.

5 Results

This section presents the analysis and results of the paper. To begin with, I present results from the IV first stage regression and assess the strength of the instrument. The second part presents results on the effect of electricity outages on employment, and how the impact varies across heterogeneous groups. This analysis is undertaken using the Afrobarometer dataset. In the third part of the section, I present evidence on the mechanisms through which outages affect labor market outcomes, specifically focusing on the intensive and extensive margins, and trade competitiveness using the household and firm data from the Afrobarometer and WBES datasets.

5.1 First Stage Results

Table 3 presents results of the first stage regressions. Columns 1 and 2 shows the first stage results from the estimation of the effect of outages on employment using the Afrobarometer survey, while Columns 3-6 presents the first stage regression from the firm level analysis using the enterprise survey dataset.

In Columns 1 and 2, the results show a strong positive correlation between technical losses and the respective measures of outage intensity in community. A percentage increase in the instrument is associated with a 0.7 percent increase in the probability of outages (Column 1). Using the average relative distance index (α_j) of 0.81, this results imply that a percentage increase in TDL is associated with a 0.6 percent increase in the probability of experiencing outages in a community[19].

[19] $0.81\times 0.007=0.006$

Similarly, in Columns 3-6, the results show a strong and significant positive correlation between technical losses and outage intensity experienced by firms. Columns 4 and 6 are estimated without controlling for industry-year fixed effects, whereas Columns 3 and 5 are estimated with the inclusion of industry-year fixed effects to allow for correlations among firms in the same 2-digit industry in a given year. The results remain robust as the estimated coefficients are quantitatively and qualitatively similar, showing a strong positive correlation between technical losses in the electricity network and outage intensity. Specifically, a percentage increase in the instrument is associated with a 1.8% percent increase in the probability of outages (Column 3). Again, using the mean relative distance index, this suggests that percentage increase in TDL is associated with a 1.5 percent increase in the intensity of outages[20]. The strength of the instrument is high as the first stage F-statistic (Fstat) exceeds the minimum threshold of 10 in all specifications.

5.2 Electricity Shortages and Employment

Table (4) presents the results from the IV estimation of the effect electricity outages on employment of individuals using the Afrobarometer Survey. The table also presents the reduced-form and OLS estimates. Two outcome variables are evaluated: employment and employment in non-agricultural sector.

The results suggest that living in a community with unreliable power supply reduces the probability of being employed by 35 percent (Column 1), while a 1 percent increase in the share of households with unreliable power supply in the community results in a 41 percent decrease in the probability of employment. From a sample mean of 64.5 percent, these estimates correspond to a 54 percent (.346/.645) and 64 percent (.414/.645) increase in the probability of being unemployed respectively. The results are consistent and even more robust when the sample is restricted to employment in non-agricultural sector. In-

[20] $0.81 \times 0.018 = 0.015$

dividuals living in a community with unreliable power supply are 55 percent less likely to be employed in non-agriculture related employment (Column 3).

The magnitude of the estimated impact of electricity shortages on employment appears relatively high. To the extent that the magnitude increases in the restricted sample of employment in non-agric sectors highlights the importance of electricity reliability on job creation in the region. Could the results be driven by outlier countries with possibly well functioning industrial sector that is heavily dependent on electricity or countries with intense outages? Two possible candidates are South Africa and Nigeria. South Africa is the most developed country in SSA with arguably a relatively high energy intensive industrial sector. Hence, the labor market implications of electricity shortages may be high relative to other countries, thereby overestimating the impact. Nigeria despite having the largest economy in Africa, is noted for its high prevalence of blackouts. As a result, its inclusion may drive the impact estimates upwards. To verify the relative importance of these countries in possibly over-estimating the impact, I re-estimate the model while excluding them alternatively. The results are shown in Table (11) in the Appendix. In Columns 1-4, where South Africa is excluded, the results do not lend support to this claim as the coefficient estimates remain qualitatively and quantitatively similar to the baseline estimates in Table (4). However, the results in Columns 5-8 where Nigeria is excluded, are slightly lower than the baseline results in Table (4). Nonetheless, the results remain robustly negative and significant.

Overall, the results indicate that electricity shortages have a substantial negative impact on employment rates in Africa. Thus, electricity shortages are significant drivers of unemployment in the region.

5.2.1 Are there Gender Differences?

A relevant extension of the analysis of the impact of electricity shortages on employment relates to whether the impact induces gender gaps in employment. If employment patterns are distributed along gender dimensions then it is reasonable to expect the impact of electricity shortages to exhibit gender biases. For instance, if employment in energy intensive industries are male dominated, then other things being equal, males are more likely to be affected by power crises relative to females, although the overall general equilibrium implications of outages cannot be overemphasized.

In Table (5), I explore the sensitivity of the results to the gender of the individual by estimating separate regressions for the male and female sub-samples. The results reveal substantially negative impact on the female employment, with a probability ranging 50 and 59 percent, while the effect on male employment is insignificant. However, in terms of non-farm employment, the results show strong and significant impact on employment of both male and females, albeit the effect on the latter is higher than the former. Thus in terms of the effect size, the results consistently shows a larger impact on female employment relative to male employment. The gender differences are consistent with the literature that shows that electrification in developing countries have a high impact on labor market participation of females than males (Dinkelman, 2011).

5.2.2 Electricity Shortages and Skilled Employment

Further, I examine how reliability of electricity affects the distribution of skilled and unskilled jobs in the region. Three categories are considered: highly skilled, medium skilled and unskilled occupations based on ISCO classifications[21].

[21]Highly Skilled (ISCO level 4): Artisan or skilled manual worker (e.g., trades like electrician, mechanic, machinist or skilled manufacturing worker), Upper-level professional (e.g., banker/finance, doctor, lawyer, engineer, accountant, professor, senior-level government officer), Mid-level professional (e.g., teacher, nurse, mid-level government; Medium Skilled: Retail/Shop, Trader/hawker/vendor, Agriculture/farming/fishing/forestry, Clerical or secretarial; Unskilled: Housewife/homemaker, Unskilled manual worker (e.g., cleaner, laborer, domestic help, unskilled manufacturing worker)

The results in Table (6) reveal that the effect of electricity shortages fall largely on employment rates in highly skilled jobs. Living in a community with poor electricity supply reduces the likelihood of having a high-skilled job by 27 percent (Column 1). There is however no effect on employment of medium and unskilled labor. A possible reason behind this result is that the negative effect of electricity shortages on productivity/profitability affect negatively firms' demand for highly skilled high-wage employees to ensure survival (Hardy and McCasland, 2017).

5.3 Mechanisms

This section presents evidence on the channels through which electricity shortages affect employment in Africa. Three channels are hypothesized: extensive margin, intensive margin and trade and competitiveness of the industrial sector. On the extensive margin, distortions in the business environment like electricity shortages have the potential to discourage potential entrepreneurs to establish new enterprises due to the perceived constraints to doing business. In the intensive margin, electricity shortages reduce firm productivity profitability. Hence at the margin, existing firms may either reduce their labor demand or reduce wages other things being equal. The third channel is trade and competitiveness of existing firms. To be competitive on international markets, firms particularly those engaged in processing, will need reliable electricity to be able to run production lines efficiently as reliance on self-generated electricity with its attendant cost increases production cost thereby translating into high output prices. This affects the competitiveness of firms in particularly in external markets given that they compete with firms from other plausibly favorable business climate. As shown by Verhoogen (2008) and Melitz (2003), within each industry, the most productive firms are able to enter into export markets and such firms in turn affect the labor market through wages and labor demand. Thus any shock to productivity is likely to affect the export competitiveness of firms in the industry and hence the ability of firms to venture into the export markets.

5.3.1 Entrepreneurship and Job Creation

To what extent do distortions in the business environment resulting from persistent outages affect entrepreneurial abilities or willingness of (prospective) entrepreneurs in establishing businesses or enterprises that will eventually create jobs? In this section, I present evidence on the effect of electricity shortages on the probability of individuals in the region becoming self-employed. Admittedly, entrepreneurship is multifaceted and self-employment is just one dimension. However, there is a dearth of data on the entrepreneurial activities in many African countries, hence the use of self-employment status as an indicator of entrepreneurial activities suffices as a good proxy.

Using data from the Afrobarometer Survey, Table (7) presents estimates of the impact of electricity shortages on the probability of becoming self-employed. In Columns 1 and 2, the results suggest that electricity shortages reduce the probability of self-employment by between 32 and 47 percent. In Columns 3 and 4, I estimate the effect on self-employment in the non-agricultural sectors. Again the effect remains negative with relatively larger magnitude. Thus as expected, the effect of unreliable supply of electricity on entrepreneurial activities in the electricity intensive sectors (i.e. non-agricultural activities) is high relative to agricultural related activities. Columns 5 and 6 presents similar estimations where the share of respondents in the PSU that are self-employed is used as the outcome variable. Again, the results show a robust and significantly negative impact of electricity shortages on self-employment.

Combined, the estimates herein provide suggestive evidence of the effect of electricity shortages on employment at the extensive margin, by reducing the probability of new businesses created to absorb the increasing supply of labor in the economy.

5.3.2 Firm Productivity and Labor Demand

To analyze the effect of electricity shortages on performance of existing firms and the implications on their labor demand, I rely extensively on data from the enterprise survey. Specifically, I evaluate the effect of outages on output and productivity . Second, I examine the firm responses to outage intensity in terms of labor demand. Here, outage is measured at the firm level using two main indicators: log of the number of times a firm experiences blackout in a typical month ($ln(Outages)$) and the log of total duration of blackouts during a typical month ($ln(Outages \times Duration)$).

Table (8) presents results of the firm level impact of electricity shortages. The results show significant negative impact on both output and productivity of firms in the continent. A percentage increase in the frequency and total duration of outages reduces firm value added by 3.3 percent (Column 1) and 1.9 percent (Column 2) respectively. Columns 3-6 presents estimates of the impact on firm productivity using two indicators: value added per worker and total factor productivity (TFP). Again, the results reveal strong and significant negative impact of electricity shortages on productivity of firms in the region. For every percentage increase in the frequency and total duration of outages experienced by a firm, total factor productivity declines by 3.5 and 2.3 percent respectively.

Arguably, these estimates can be regarded as lower bound estimates of the total effect of outages given the fact that some firms in the dataset rely on self-generation during periods of blackouts to mitigate the impact of outages. Disentangling the extent of attenuation in the impact by self-generation is however an empirical challenge as the decision to self-generate and the degree of self-generation are endogenous. Nonetheless, the evidence herein unambiguously highlight the challenges of African firms[22] in operating in a business environment with unreliable access to power.

Given the above negative effect of electricity shortages on productivity, what are the

[22] The term "African firms" as used in this paper, refers to firms operating in Africa, without any connotation to the nationality of its owners or country of origin.

implications on labor demand by African firms? Table (9) presents results on the effect of electricity shortages on employment by firms. The results provide suggestive evidence that firms respond to the negative impact of outages on productivity through job losses, i.e. reducing their demand for labor. In Columns (1) and (2), the results suggest that a 1 percent increase in the frequency and total duration of outages reduces the number of firm employees by 1.1 and 0.6 percent respectively. In Columns 3-6, I evaluate the relative effect on employment of permanent and temporary workers. While no effect on employment of temporary workers is observed, the effect on employment of permanent workers are qualitatively and quantitatively similar to the results on total firm employment. This can be largely attributed to the relatively low number of temporary employees by the firms in the dataset, accounting for nearly 15 percent of total firm employment.

Further, I evaluate the differences in the impact on the demand for skilled versus unskilled labor. The results in Columns (7) and (8) reveal strong negative impact of electricity shortages on firms' employment of skilled labor. Even though, a negative effect is also observed for the impact on unskilled jobs at the firm, the effect is relatively weak. Thus results suggest that when confronted with intense outages, firms respond by reducing labor demand, particularly those involved in skilled and permanent positions. Available evidence from the relatively scant literature on the effects of electricity shortages on firm productivity and labor demand, lends support to the findings of this paper (Allcott et al., 2016; Hardy and McCasland, 2017). Allcott et al. (2016) for instance provide evidence of significant revenue and productivity losses resulting from electricity shortages in India. Also using data on small garment firms in Ghana, Hardy and McCasland (2017) shows that effect of electricity shortages on firm revenue and profitability is non-trivial. Hardy and McCasland (2017) further shows that firms respond to these shortages by reducing production hours without any allocation to non-outage days, and more importantly substituting high-wage employees for low-wage employees.

5.3.3 Exports and Trade Competitiveness

The third mechanism is the effect of electricity shortages on trade (export) competitiveness of firms. In Table (10), I estimate the effect of electricity shortages on firms' export and trade competitiveness, using the share of sales in international and domestic markets. Two measures of exports are considered: direct exports which refers to the share of the firms' sale of output in foreign markets, and indirect exports composed of the share of sales from output sold to domestic third party firms who export the produce.

The results in Columns (1) and (2), suggest that electricity shortages reduces direct exports of firms by between 6 and 12 percent. No impact on indirect exports is observed. On the contrary, the effect is positive for sales in domestic market. Thus the evidence herein, suggest that electricity shortages constrain the trade competitiveness of African firms to participate effectively in exports, with direct and indirect consequences on the job creation potential of these firms.

6 Robustness Checks

In this section, I present alternative arguments and estimations to confirm the robustness of the estimates above.

First, the main analysis in the paper relies on household data from 21 countries and firm level data in 23 countries. A potential concern is that countries in the two datasets are heterogeneous and hence results from the two dataset may not consistently apply for the all the countries combined. To rule out the plausibility of this claim, I restrict the data to countries[23] in the two datasets and re-estimate the model(s). The results in Table 12 of the Appendix show consistency in the impact of electricity shortages, as estimates of the impact of electricity shortages on employment (total and non-agricultural employment)

[23]there are 10 countries in both datasets, including: Benin, Botswana, Burkina Faso, Ghana, Guinea, Mozambique, Nigeria, Senegal, Swaziland, and Tanzania

and skilled occupations are qualitatively and quantitatively similar to the results in Tables 4 and 6. Hence, as shown by the results, the choice of the countries in both datasets does not really matter in explaining the impact of electricity shortages on employment.

So far the standard errors in the analysis of household level impact were clustered at the level of the primary sampling units (PSU), while the firm level estimations were clustered by district-year. To test the sensitivity of the standard errors to the level of clustering, I re-estimate the model(s) while clustering at the district level. Once again, the results shown in Tables 13 and 14, are consistent with the results in the baseline (Tables 4 and 8).

Furthermore, the baseline analysis using the Afrobarometer data defines reliability as having electricity supply always, while households who receive electricity occasionally, about 50% of the time, and most of the time are regarded as experiencing electricity outages. Concerns are that, given the normative nature of this measure, responses on receiving electricity always and most of the time, may be qualitatively similar, and thus raising issues about the ability of the baseline measure of reliability in capturing the true impact. As a result, I revise the measure of reliability to include having access always and most of the time, while occasionally and 50% of the time to represent electricity outages. The results in Table 15 in the Appendix are qualitatively similar to the estimates in Tables 4 and 6 where the baseline measure of reliability is used. However, the impact of the new measure are quantitatively lower than the baseline measure, underscoring the importance of reliable electricity provision (i.e., having electricity always) on job creation.

To what extent does the placement of generation plants affect the instrument and its correlation with outages? As stated in Section 4.1, a non-random placement of generation plants can affect the relative distance weights used in the computation of the instrument, and thus bias the correlation between the instrument and the measure of power outages. To this end, I examine the robustness of the first stage IV results by excluding districts in the proximity of the generation plants. This is done by estimating the IV regression using the specification in Column 3 of Table 4 while imposing thresholds on the distance[24] to the generation plants. The results in Table 16 of the Appendix show that the correlation between the instrument and electricity outages remain robust at varying distance thresholds.

The final assessment of the analysis is on the computation of the instrument. In the baseline, the instrument is constructed using TDL weighted by the ratio of the minimum distance between district centroids and the electricity generation plants along the transmission network, to the total length of the transmission line traversing the district. A potential threat to the validity of the instrument is that in districts traversed by multiple transmission lines, the minimum distance may not be representative of the relative distance between a district and their respective generation plants. As a result, I compute an alternative instrument using the average distance between the district and the generation plants along all the transmission lines. In Table 17 in the Appendix, I show that the strength of the instrument remains robust as the first stage F statistics is considerably high. The second stage impacts are also consistent with the baseline results. These results in this section gives credence to the baseline analysis.

7 Conclusion

This paper provides a systematic analysis of the impact of electricity shortages on patterns of unemployment in Africa using a comprehensive set of household and firm data from over 20 countries. Additionally, the paper presents strong evidence on the mechanisms driving the impact of electricity shortages on employment. Also, I perform several robustness tests and show that the results are robust to alternative assumptions and specifications.

[24]The estimations are done by restricting the sample to districts beyond 10, 20, 30, 40, and 50 kilometers from a generation plant.

The estimates suggest that electricity shortages reduce the likelihood of an individual being employed by between 35 and 41 percent. This negative impact are largely concentrated in high-skilled high wage employment in non-agricultural sectors. In terms of the mechanisms through which electricity shortages affect employment, the findings of the paper documents three main channels. First, electricity shortages create distortions in the business climate thereby reducing the incentives of entrepreneurs in establishing new business, hence reducing job creation. Second, electricity shortages exert substantial negative impact on productivity of African firms. Firms respond to these losses through layoff of labor. Third, electricity shortages reduces the trade and export competitiveness of African firms through its impact on production cost and disruption in production schedules.

The findings of this paper have important implications for policy. The results provide suggestive evidence that resolving the challenges in the electricity sector is an important channel towards expanding the industrial sector as it will increase entrepreneurship and job creation. Again, access to reliable electricity is crucial for improving productivity of existing firms and increasing their export competitiveness. These will eventually increase the number of employment opportunities in the region and ultimately reduce the teaming mass of unemployment in many African economies.

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Figures

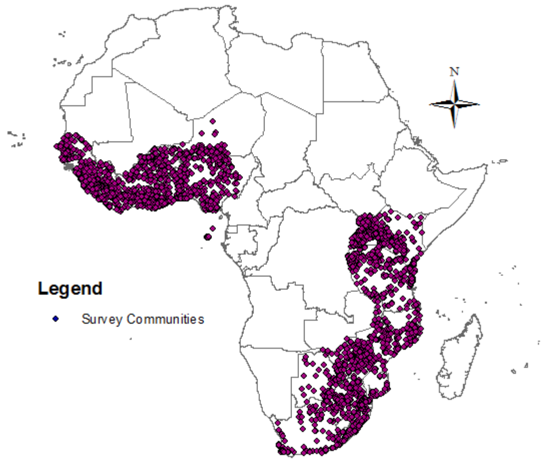

Figure 1: Afrobarometer Survey Communities Used in the Analysis

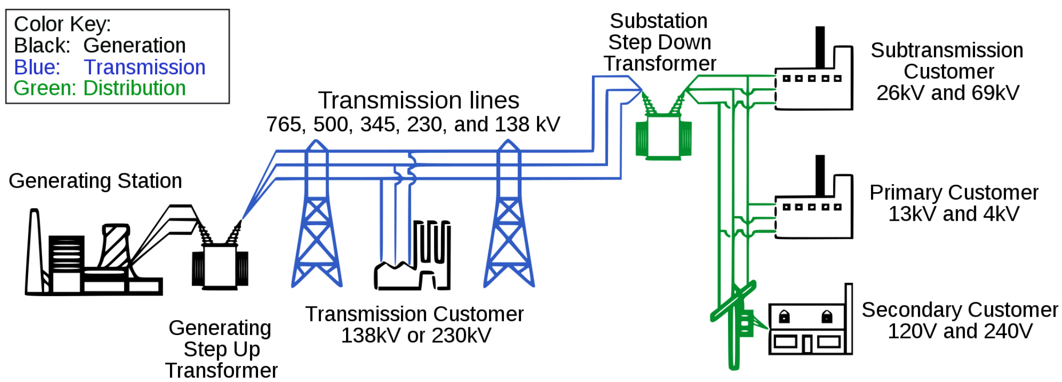

Figure 2: Schema of Electricity Grid Network

Source: Mienergiasolar[25]

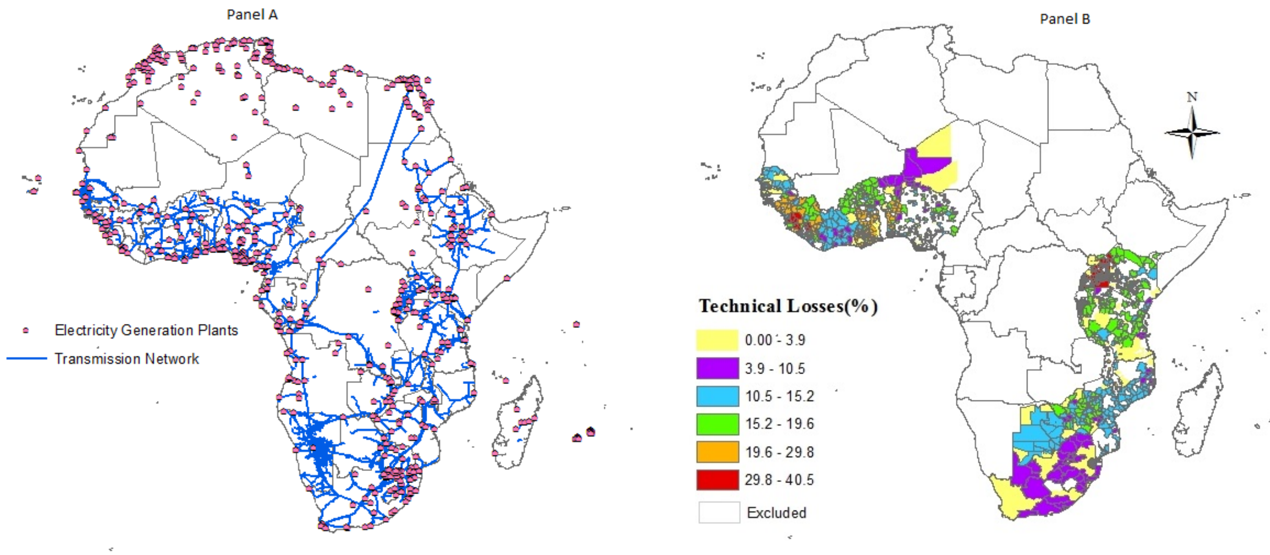

Figure 3: Electricity Transmission Network, and Technical Losses in the Network by District

Notes: Technical Losses by district is computed using the total transmission and distribution losses% of total electricity production weighted by the relative distance between the district centroid and the generation plant along the transmission network.

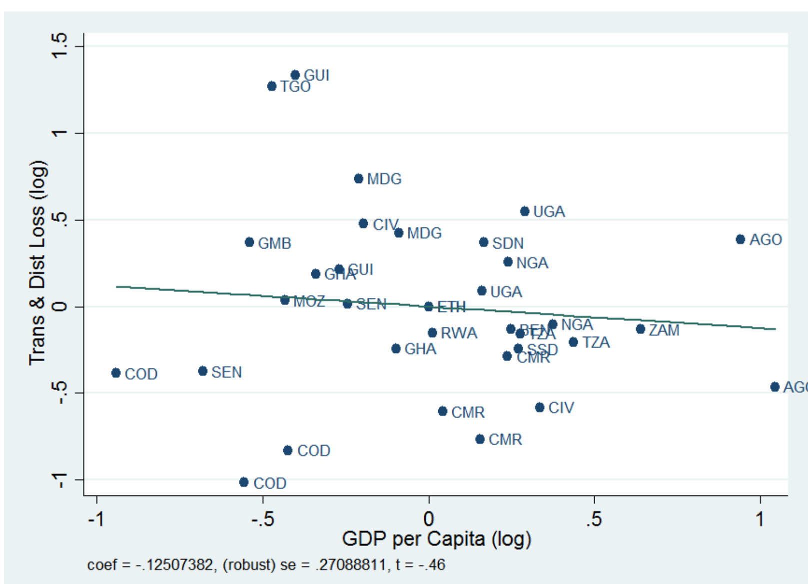

Figure 4: Income and Transmission & Distribution Losses

Tables

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max	Obs
A: Household Analysis					
Employment	0.621	0.485	0	1	22301
Employment in Non-Agric	0.452	0.498	0	1	22301
Unskilled Empl	0.135	0.341	0	1	13038
Medium Skilled Empl	0.563	0.496	0	1	13038
High Skilled Empl	0.293	0.455	0	1	13038
Self-Employed	0.633	0.482	0	1	17676
Self-Employed (% PSU)	0.623	0.356	0	1	33540
Age	37.019	14.366	18	99	35579
No Education	0.158	0.365	0	1	35730
Informal Education	0.052	0.221	0	1	35730
Primary Education	0.297	0.457	0	1	35730
Secondary Education	0.361	0.48	0	1	35730
Tertiary Education	0.133	0.339	0	1	35730
Female	0.504	0.5	0	1	35826
Outages in Community(0/1)	0.744	0.437	0	1	19743
Outages in Community (% HH)	0.748	0.295	0	1	19743
Technical Losses(%)	16.702	9.124	0	40.5	32396
Piped water system in PSU	0.529	0.499	0	1	35826
School in PSU	0.857	0.35	0	1	35826
Hospital/Clinic in PSU	0.549	0.498	0	1	35826
Paved Roads in PSU	0.515	0.5	0	1	35826
Urban	0.388	0.487	0	1	35826
GDP per capita (log)	7.771	0.838	6.599	9.638	35826
Pop Density (log)	4.266	0.888	1.365	6.043	34702
Natural Resources Rents (% of GDP)	12.439	7.078	2.425	29.694	35826
Mo Ibrahim Overall Score	55.109	9.068	40.431	74.247	35826
B: Firm Analysis					
Value Added (log)	10.785	2.529	-3.466	22.872	3458
Value Added per Worker (log)	7.825	1.982	-7.742	20.387	3433
TFP	0.00	1.072	-8.643	12.612	3400
Outages (log)	2.112	0.907	0	5.707	8467
Outage × Duration (log)	3.251	1.46	0	6.581	8016
# of Employees (log)	2.874	1.079	0	8.936	12028
# of Permanent Employees (log)	2.808	1.064	0	8.936	12023
# of Temporary Employees (log)	0.466	0.911	0	8.517	12009
# of Skilled Employees (log)	2.283	1.146	0	7.523	4569
# of Unskilled Employees (log)	1.341	1.362	0	7.601	4593
Direct Export (% of Sales)	0.037	0.155	0	1	11994
Indirect Export (% of Sales)	0.025	0.117	0	1	11999
National sales (% of Sales)	0.938	0.2	0	1	12035
Technical Losses	16.97	15.482	0	74	12012

Notes: Summary statistics are unweighted

Table 2: Are Pre-existing Conditions Correlated with the Instrument?

	(1)	(2)	(3)	(4)
	Technical Loss		Relative Distance to Gen. Plant	
Pop Density	-0.131		-0.001	
	(0.301)		(0.003)	
Income		-0.243		-0.004
		(0.427)		(0.004)
Obs	1444	1444	1314	1314

Notes: Robust standard errors in parentheses clustered at country level. Pop Density is measured as the number of people living per square kilometer. Income is proxied by the stable nightlights intensity in the district. Population density and Income level are measured in 2005. All independent variables are measured in logs. Country fixed effects are applied. Observations correspond to districts covered in the Afrobarometer Survey used in the analysis.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 3: First Stage IV Regression

	(1)	(2)	(3)	(4)	(5)	(6)
	Afrobarometer		Enterprise Survey			
	Outages in Comm (0/1)	Outages in Comm(% HH)	ln(Outages)		ln(Outages $\times$ Duration)	
Technical Loss	0.007	0.005	0.018	0.016	0.033	0.029
	(0.001)***	(0.001)***	(0.002)***	(0.001)***	(0.008)***	(0.002)***
Unit of Analysis	Individuals		Firms			
Fstat	32.46	40.59	59.85	395.29	18.17	194.32
Obs	11831	11831	2467	2527	2366	2421

Notes: Robust standard errors in parentheses. In Columns 1-2, standard errors at primary sampling unit (PSU) level. In Columns 3-6, standard errors clustered at district-year level. Fstat is the IV First Stage F test of instrument strength. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. lnOutages is the log of the frequency of outages experienced by a firm in a typical month. ln(Outagee$\times$Duration) is the product of the frequency and the average duration of a typical outage in a typical month. All regressions account for controls which are explained in their respective IV second stage equations. Columns 3 and 5 include industry-year fixed effects, while Columns 4 and 6 do not include industry-year fixed effects.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 4: Electricity Shortages and Employment

	(1)	(2)	(3)	(4)
	Employment (0/1)		Employment in Non-Agric (0/1)	
			IV	
Outages in Community (0/1)	-0.346		-0.551	
	(0.149)**		(0.167)***	
Outages in Community (% HH)		-0.414		-0.571
		(0.178)**		(0.165)***
			Reduced Form	
Technical Loss	-0.002	-0.002	-0.004	-0.004
	(0.001)**	(0.001)**	(0.001)***	(0.001)***
			OLS	
Outages in Community(0/1)	0.003		0.009	
	(0.015)		(0.015)	
Outages in Community(% HH)		-0.012		-0.058
		(0.022)		(0.023)**
Fstat	32.464	40.593	32.464	42.174
Obs	11831	11831	11831	11831
Mean of Outcome Var	0.645	0.645	0.559	0.559

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 5: Electricity Shortages and Employment by Gender

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Employment (1/0)				Employment in Non-Agric (0/1)			
	Female		Male		Female		Male	
Outages in Community(0/1)	-0.502		-0.213		-0.714		-0.422	
	(0.205)**		(0.161)		(0.231)***		(0.185)**	
Outages in Community(% HH)		-0.594		-0.258		-0.844		-0.511
		(0.236)**		(0.196)		(0.257)***		(0.224)**
Fstat	27.315	34.280	33.335	43.143	27.315	34.280	33.335	43.143
Obs	5603	5603	6228	6228	5603	5603	6228	6228
Mean of Outcome Variable	0.602	0.602	0.684	0.684	0.531	0.531	0.583	0.583

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 6: Electricity Shortages and Skilled Employment

	(1)	(2)	(3)	(4)	(5)	(6)
	High Skill		Medium Skill		Unskilled	
			IV			
Outages in Community(0/1)	-0.271		0.184		0.054	
	(0.118)**		(0.112)		(0.084)	
Outages in Community(% HH)		-0.357		0.242		0.071
		(0.156)**		(0.148)		(0.110)
			Reduced-Form			
Technical Loss	-0.002	-0.002	0.002	0.002	0.000	0.000
	(0.001)**	(0.001)**	(0.001)	(0.001)	(0.001)	(0.001)
			OLS			
Outages in Community(0/1)	-0.034		0.052		-0.018	
	(0.016)**		(0.018)***		(0.014)	
Outages in Community(% HH)		-0.057		0.094		-0.037
		(0.025)**		(0.029)***		(0.021)*
Fstat	31.396	39.784	31.396	39.784	31.396	39.784
Obs	7133	7133	7133	7133	7133	7133
Mean of Outcome Var	0.365	0.365	0.486	0.486	0.143	0.143

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. “Outages in Community(0/1)” is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. “Outages in Community(% HH)” is the share of connected households in the PSU without reliable access to electricity.. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance. Highly skilled, medium skilled and unskilled occupations are defined based on ISCO classifications.Highly Skilled (ISCO level 4): Artisan or skilled manual worker (e.g., trades like electrician, mechanic, machinist or skilled manufacturing worker), Upper-level professional (e.g., banker/finance, doctor, lawyer, engineer, accountant, professor, senior-level government officer), Mid-level professional (e.g., teacher, nurse, mid-level government; Medium Skilled: Retail/Shop, Trader/hawker/vendor, Agriculture/farming/fishing/forestry, Clerical or secretarial; Unskilled: Housewife/homemaker, Unskilled manual worker (e.g., cleaner, laborer, domestic help, unskilled manufacturing worker).
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 7: Electricity Shortages and Entrepreneurship

	(1)	(2)	(3)	(4)	(5)	(6)
	All		Non-Agric			
	Self Employed (0/1)		Self Employed (0/1)		Self Empl. (% in PSU)	
	IV					
Outages in Community(0/1)	-0.321		-0.440		-0.500	
	(0.160)**		(0.176)**		(0.154)***	
Outages in Community(% HH)		-0.465		-0.639		-0.740
		(0.241)*		(0.266)**		(0.234)***
	Reduced-Form					
Technical Loss	-0.002	-0.002	-0.003	-0.003	-0.004	-0.004
	(0.001)**	(0.001)**	(0.001)***	(0.001)***	(0.001)***	(0.001)***
	OLS					
Outages in Community(0/1)	0.009		0.026		0.019	
	(0.017)		(0.016)		(0.011)	
Outages in Community(% HH)		0.028		0.032		0.024
		(0.027)		(0.026)		(0.027)
Fstat	20.346	19.633	20.346	19.633	30.549	31.028
Obs	9261	9261	9261	9261	2214	2214
Mean Dep. Var.	0.553	0.553	0.291	0.291	0.303	0.303

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. “Outages in Community(0/1)” is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. “Outages in Community(% HH)” is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, natural resource rent % of GDP, MO Ibrahim Index on governance. Columns 5 and 6 are estimated at the community level, without individual controls.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 8: Electricity Shortages and Firm Performance

	(1)	(2)	(3)	(4)	(5)	(6)
	Output		Productivity			
	ln(Value Added)		ln(Value Added per Worker)		ln(TFP)	
	IV					
ln(Outages)	-3.341		-2.749		-3.529	
	(0.556)***		(0.652)***		(0.483)***	
ln(Outages×Duration)		-1.872		-1.505		-2.327
		(0.464)***		(0.493)***		(0.418)***
	Reduced-Form					
Technical Loss	-0.061	-0.062	-0.049	-0.049	-0.064	-0.064
	(0.004)***	(0.005)***	(0.006)***	(0.006)***	(0.008)***	(0.008)***
	OLS					
ln(Outages)	0.219		0.156		-0.018	
	(0.118)*		(0.086)*		(0.049)	
ln(Outages×Duration)		-0.039		-0.010		-0.051
		(0.066)		(0.042)		(0.041)
Fstat	59.851	18.166	58.486	17.959	34.881	12.451
Obs	2467	2366	2448	2349	2469	2364

Notes: Robust standard errors in parentheses clustered at district-year level. Fstat is the IV First Stage F test of instrument strength. ln(Outages) is the log of the frequency of outages in the typical month. ln(Outagee×Duration) is the product of the frequency and the average duration of a typical outage in a typical month. TFP refers to Total Factor Productivity.Value added is computed as total sales less the cost of raw materials and intermediate inputs. All estimates include district, country and industry-year fixed effects.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 9: Firms Response to Electricity Shortages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	ln(# Empl)		ln(Perm Empl)		ln(Temp Empl)		ln(Skilled Empl)		ln(Unskilled Emp)	
	IV									
ln(Outages)	-1.057		-1.057		-0.034		-0.352		-0.671	
	(0.411)**		(0.417)**		(0.184)		(0.077)***		(0.462)	
ln(Outages×Duration)		-0.580		-0.580		-0.013		-0.236		-0.418
		(0.093)***		(0.093)***		(0.100)		(0.076)***		(0.212)*
	Reduced-Form									
Technical Loss	-0.016	-0.016	-0.016	-0.016	-0.001	-0.000	-0.007	-0.008	-0.013	-0.014
	(0.005)***	(0.005)***	(0.005)***	(0.005)***	(0.003)	(0.003)	(0.002)***	(0.002)***	(0.009)	(0.010)
	OLS									
ln(Outages)	0.015		0.010		0.032		0.058		0.012	
	(0.041)		(0.037)		(0.036)		(0.050)		(0.043)	
ln(Outages×Duration)		-0.007		-0.009		0.006		0.018		-0.065
		(0.030)		(0.028)		(0.021)		(0.034)		(0.026)**
Fstat	24.992	15.161	24.841	15.022	24.814	15.010	67.138	22.015	65.769	22.267
Obs	6593	6176	6588	6172	6584	6168	3248	3089	3326	3156

Notes: Robust standard errors in parentheses clustered at district-year level. Fstat is the IV First Stage F test of instrument strength. ln(Outages) is the log of the frequency of outages in the typical month. ln(Outagee×Duration) is the product of the frequency and the average duration of a typical outage in a typical month. ln(# Empl) is the log of the total number of employees hired by the firm. ln(Perm Empl) is the log of the total number of full time permanent employees hired by the firm. ln(Temp Empl) is the log of the total number of temporary employees of the firm. ln(Skilled Empl) is the number of skilled production workers of the firm. ln(Unskilled Empl) is the number of unskilled production workers of the firm. All estimates include district, country and industry-year fixed effects.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 10: Export and Trade Competitiveness

	(1)	(2)	(3)	(4)	(5)	(6)
	Direct Export (% Sales)		Indirect Export (% Sales)		National Sales (% Sales)	
	IV					
ln(Outages)	-0.118		-0.015		0.139	
	(0.033)***		(0.029)		(0.057)**	
ln(Outages×Duration)		-0.063		-0.009		0.076
		(0.010)***		(0.015)		(0.021)***
	Reduced-form					
Technical Loss	-0.002	-0.002	-0.000	-0.000	0.002	0.002
	(0.000)***	(0.000)***	(0.000)	(0.000)	(0.001)***	(0.001)***
	OLS					
ln(Outages)	-0.007		0.004		0.003	
	(0.004)*		(0.003)		(0.005)	
ln(Outages×Duration)		0.003		0.003		-0.005
		(0.004)		(0.002)		(0.004)
Fstat	26.633	15.566	27.068	15.560	29.462	15.697
Obs	6566	6153	6568	6154	6573	6158
Mean of Dep. Var.	0.043	0.041	0.029	0.028	0.929	0.931

Notes: Robust standard errors in parentheses clustered at district-year level. Fstat is the IV First Stage F test of instrument strength. ln(Outages) is the log of the frequency of outages in the typical month. ln(Outagee×Duration) is the product of the frequency and the average duration of a typical outage in a typical month. Indirect exports are firm output sold domestically to third party firms that exports products. All estimates include district, country and industry-year fixed effects.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

8 Appendix

Table 11: Electricity Shortages and Employment: Excluding South Africa and Nigeria

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Exc. South Africa				Exc. Nigeria			
	Employment (0/1)		Employment in Non-Agric(0/1)		Employment (0/1)		Employment in Non-Agric(0/1)	
	IV							
Outages in Com (0/1)	-0.367		-0.568		-0.260		-0.463	
	(0.151)**		(0.170)***		(0.135)*		(0.148)***	
Outages in Com (% HH)		-0.440		-0.579		-0.287		-0.445
		(0.179)**		(0.164)***		(0.148)*		(0.137)***
	Reduced Form							
Technical Loss	-0.002	-0.002	-0.004	-0.004	-0.002	-0.002	-0.003	-0.003
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)**	(0.001)**	(0.001)***	(0.001)***
	OLS							
Outages in Com (0/1)	-0.002		0.001		0.003		0.008	
	(0.015)		(0.016)		(0.014)		(0.015)	
Outages in Com (% HH)		-0.012		-0.066		-0.019		-0.074
		(0.023)		(0.025)***		(0.022)		(0.023)***
Fstat	31.644	39.899	31.644	43.037	35.214	52.886	35.214	55.469
Obs	10874	10874	10874	10874	10254	10254	10254	10254
Mean of Outcome Var	0.650	0.650	0.557	0.557	0.637	0.637	0.548	0.548

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 12: Electricity Shortages, Employment and Skilled Occupations: For Afrobarometer and Enterprise Survey Countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Employment Status				Skilled Occupation					
	Employment (0/1)		Employment in Non-Agric (0/1)		High Skilled (0/1)		Medium Skilled(0/1)		Unskilled(0/1)	
Outages in Community(0/1)	-0.539		-0.788		-0.245		0.166		0.049	
	(0.216)**		(0.273)***		(0.113)**		(0.107)		(0.075)	
Outages in Community(% HH)		-0.539		-0.550		-0.245		0.166		0.049
		(0.216)**		(0.144)***		(0.113)**		(0.107)		(0.075)
Fstat	13.163	13.163	13.163	33.320	28.168	28.168	28.168	28.168	28.168	28.168
Obs	6932	6932	6932	6932	7133	7133	7133	7133	7133	7133
Mean of Dep. Var	0.659	0.659	0.561	0.561	0.365	0.365	0.486	0.486	0.143	0.143

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. Here reliability is defined as having electricity all the time or most of the time. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 13: Alternative Estimations: Clustering at District Level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Employment Status				Skilled Occupation					
	Employment (0/1)		Employment in Non-Agric (0/1)		High Skilled (0/1)		Medium Skilled(0/1)		Unskilled(0/1)	
Outages in Community(0/1)	-0.346		-0.551		-0.271		0.184		0.054	
	(0.205)*		(0.212)***		(0.146)*		(0.116)		(0.110)	
Outages in Community(% HH)		-0.414		-0.571		-0.357		0.242		0.071
		(0.239)*		(0.204)***		(0.190)*		(0.160)		(0.143)
Fstat	11.647	15.065	11.647	13.800	12.271	16.171	12.271	16.171	12.271	16.171
Obs	11831	11831	11831	11831	7133	7133	7133	7133	7133	7133
Mean of Dep. Var	0.645	0.645	0.559	0.559	0.365	0.365	0.486	0.486	0.143	0.143

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. Here reliability is defined as having electricity all the time or most of the time. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 14: Robustness Check: Clustering at District Level

	(1)	(2)	(3)	(4)	(5)	(6)
	Output		Productivity			
	ln(Value Added)		ln(Value Added per Worker)		ln(TFP)	
	IV					
ln(Outages)	-3.341		-2.749		-3.529	
	(0.691)***		(0.804)***		(0.586)***	
ln(Outages×Duration)		-1.872		-1.505		-2.327
		(0.582)***		(0.611)**		(0.473)***
	Reduced-Form					
Technical Loss	-0.061	-0.062	-0.049	-0.049	-0.064	-0.064
	(0.005)***	(0.006)***	(0.007)***	(0.008)***	(0.009)***	(0.010)***
	OLS					
ln(Outages)	0.219		0.156		-0.018	
	(0.131)		(0.100)		(0.056)	
ln(Outages×Duration)		-0.039		-0.010		-0.051
		(0.069)		(0.044)		(0.037)
Fstat	43.643	11.795	42.206	11.523	26.661	9.572
Obs	2467	2366	2448	2349	2469	2364

Notes: Robust standard errors in parentheses clustered at district level. Fstat is the IV First Stage F test of instrument strength. ln(Outages) is the log of the frequency of outages in the typical month. ln(Outagee×Duration) is the product of the frequency and the average duration of a typical outage in a typical month. TFP refers to Total Factor Productivity.Value added is computed as total sales less the cost of raw materials and intermediate inputs. All estimates include district, country and industry-year fixed effects.
* Significant at 10 percent level
** Significant at 5 percent level
*** Significant at 1 percent level

Table 15: Estimations from Alternative Measures of Electricity Shortages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Employment Status				Skilled Occupation					
	Employment (0/1)		Employment in Non-Agric (0/1)		High Skilled (0/1)		Medium Skilled(0/1)		Unskilled(0/1)	
Outages in Community(0/1)	-0.269		-0.428		-0.245		0.166		0.049	
	(0.127)**		(0.142)***		(0.113)**		(0.107)		(0.075)	
Outages in Community(% HH)		-0.269		-0.396		-0.245		0.166		0.049
		(0.127)**		(0.135)***		(0.113)**		(0.107)		(0.075)
Fstat	19.251	19.251	19.251	24.231	28.168	28.168	28.168	28.168	28.168	28.168
Obs	11831	11831	11831	11831	7133	7133	7133.000	7133	7133	7133
Mean of Dep. Var	0.645	0.645	0.559	0.559	0.365	0.365	0.486	0.486	0.143	0.143

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. Here reliability is defined as having electricity all the time or most of the time. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 16: Placement of Generation Plants and First Stage Results

	(1)	(2)	(3)	(4)	(5)
	Dependent Variable: Outages in Community (0/1)				
	≥10 km	≥20 km	≥30 km	≥40 km	≥50 km
Technical Loss	0.006	0.006	0.006	0.007	0.006
	(0.001)***	(0.002)***	(0.002)***	(0.003)**	(0.003)**
Fstat	18.446	11.915	9.155	6.325	4.455
Obs	9722	8321	7587	6722	6052

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. The results correspond to the first stage IV regression of "Employment in Non-Agric (0/1)" on "Outages in Community(0/1)" while excluding districts close to generation plants using 10, 20, 30, 40 and 50 kilometer thresholds. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance. All regressions individual, community and country controls, as well as survey year fixed effect.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Table 17: Effects of Electricity Shortages Using Alternative Instruments

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Employment Status				Skilled Occupation					
	Employment (0/1)		Employment in Non-Agric (0/1)		High Skilled (0/1)		Medium Skilled(0/1)		Unskilled(0/1)	
Outages in Community (0/1)	-0.248		-0.302		-0.322		0.207		0.084	
	(0.107)**		(0.107)***		(0.105)***		(0.101)**		(0.072)	
Outages in Community (% HH)		-0.308		-0.424		-0.420		0.269		0.109
		(0.134)**		(0.121)***		(0.135)***		(0.132)**		(0.092)
Fstat	64.144	80.955	64.144	75.488	46.125	64.182	46.125	64.182	46.125	64.182
Obs	11869	11869	11869	11869	7156	7156	7156	7156	7156	7156
Mean of Dep. Var	0.645	0.645	0.559	0.559	0.365	0.365	0.486	0.486	0.143	0.143

Notes: Robust standard errors in parentheses clustered at primary sampling unit (PSU) level. Fstat is the IV First Stage F test of instrument strength. "Outages in Community(0/1)" is defined as 1 if more than 50% of connected households in the PSU do not have access to reliable electricity, and 0 if otherwise. "Outages in Community(% HH)" is the share of connected households in the PSU without reliable access to electricity. All regressions individual, community and country controls, as well as survey year fixed effect. Individual Controls: educational attainment, gender and log of age; Community Controls: access to pipe-borne water, school, hospital and road; Country controls: Logs of GDP per capita and population density, MO Ibrahim Index on governance. The instrument used here is defined as the average of all the transmission lines traversing the districting divided by the mean length of all the transmission lines times the total technical losses in the electricity network in the country.

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level