Improving Firm Productivity: The Role of Energy Policies in Addressing Electricity Shortages in Sub-Saharan Africa

Abstract

Access to reliable electricity is a fundamental right and an essential catalyst for development and hope. Although the empirical literature on the impact of electricity shortages on firm productivity in developing countries is rich, studies on the evolution of this impact over time remain limited. This study examines the influence of energy policies on the relationship between electricity shortages and firm productivity using data from World Bank enterprise surveys. We used the Entropy Balancing method to compare World Bank surveys of firms in 30 African countries between (2006-2011) on the one hand and (2013-2023) on the other. Our results show that, despite significant advancements in energy supply, the negative impact of electricity shortages on firm productivity increases over time. Specifically, a 1% reduction in the duration of electricity shortages is associated with a 2.22 percentage point increase in productivity at this stage of electricity infrastructure improvement in Sub-Saharan Africa. Furthermore, our analysis indicates that countries that rely primarily on hydropower for electricity generation are more susceptible to electricity shortages than those that use other energy sources. Our results are robust to different estimation methods.

Keywords: electricity; shortage; productivity; energy policies.

JEL classification: D22; D24, O13, O14; L94

1. Introduction

In recent decades, the issue of electricity shortages has become a critical concern, particularly within the context of developing countries, due to their increasing frequency. An extensive body of literature has documented the social and economic costs of electricity shortages. These costs are particularly high at the firm level, because according to Waldfogel (1993) theory of deadweight loss, electricity shortages reduce the quantity traded below the efficient market equilibrium level[1].

As a result, given the high prevalence of blackouts in the Sub-Saharan Africa (SSA) region, firms in this area make a relatively modest contribution to Gross Domestic Product (GDP) compared to the rest of the world. In 2021, value added by manufacturing and service firms will average 12% and 47.2% of GDP in SSA, compared with 25% and 65.1% in East Asia and the Pacific, 16% and 65.1% in Latin America and the Caribbean, and 15% and 48.8% in South Asia (WDI, 2024)[2].

SSA is arguably an ideal region for assessing the impact of energy policies on firm's productivity. It has experienced significant economic growth, coupled with rapid electrification and the implementation of multiple energy policies in various countries. As a result, electrification rates have increased from less than 25.7% of the population in 2000 to about 37.9% of the population in 2012 and to about 51.4% of the population in 2022 (WDI, 2024)[3]. Between 2000 and 2012, SSA experienced spectacular growth. According to the International Monetary Fund (IMF), GDP in SSA countries grew at an average rate of between 5% and 7%, with many countries growing faster than China and India[4] . By 2013, twenty of the 48 SSA economies had entered the lower-middle income group, and two, Equatorial Guinea and Seychelles, were classified as 'non-OECD high-income countries'

[1] Deadweight loss theory describes a reduction in both producer and consumer surplus due to constraints imposed on production by external factors. Electricity shortages are one such external factor that can lead to deadweight loss and, as a result, lower business productivity.

[2] World Development Indicator consulted on 4 June 2024

[3] Consulted on 12 July 2024.

[4] Africa Rising: Time, 3 December 2012. P. 30-37.

(ILO, 2016). During this period, urban electrification rates in most SSA countries reached the 81% mark (WDI, 2024)[5].

However, despite significant investment in electricity infrastructure, the reliability of the electricity grid remains inadequate due to climate change (hydrological uncertainty), transmission and distribution losses and political instability in some countries (Salite, 2021; Soomro, 2024). Despite this seemingly impressive progress, the Global Competitiveness Index ranks the quality of electricity as the third most problematic factor for doing business in SSA (World Economic Forum, 2016). As a result, businesses experience an average of 13.35 power cuts per month (WBES, 2006-2023).

Thus, this study's ability to assess the effect of energy policies on firm productivity during two distinct periods allows us to compare the impact of electricity shortages on business productivity in the early and advanced stages of electricity supply development in sub-Saharan Africa. This dynamic approach provides new and complementary insights to previous research on this topic (Mensah, 2024; Elliott et al., 2021; Allcott et al., 2016).

According to data from the World Bank Enterprise Survey (WBES), entrepreneurs' perception of electricity shortages as a major constraint to the smooth running of their businesses in sub-Saharan Africa has increased over the years. This trend reflects the growing importance of power shortages among the challenges faced by entrepreneurs in the region. Specifically, WBES data from 30 Sub-Saharan African countries in the early stages of electricity infrastructure development (period 1: 2006-2011)[6] show that about 21% of entrepreneurs consider power outages to be a major constraint to their business, compared to 23% in the advanced stages of electricity infrastructure development (period 2: 2013-

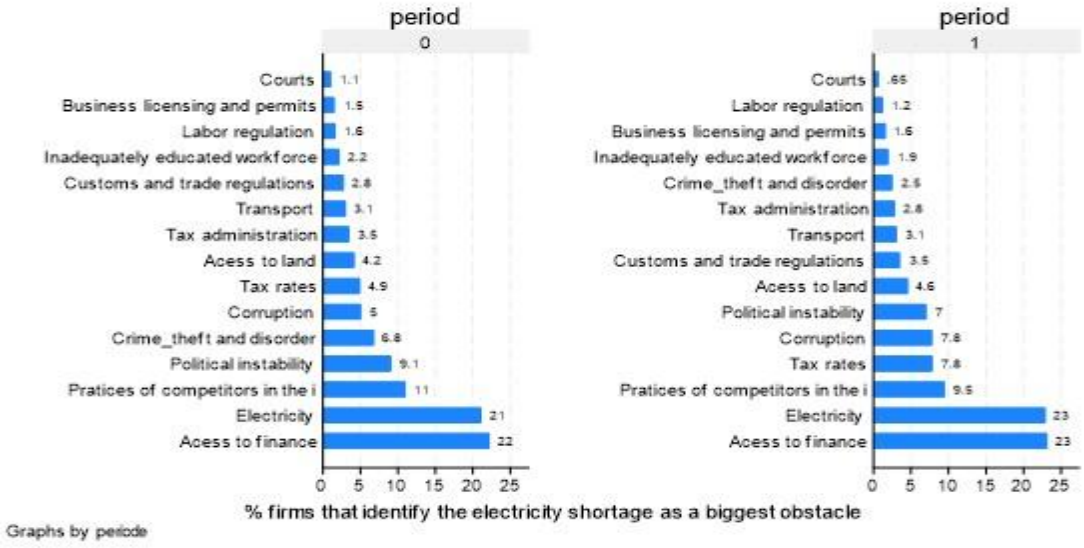
[5] Consulted on 12 July 2024.

[6] The study compares two periods, starting with the 2000s, because it was between 2000 and 2012 that economic growth in African countries almost doubled. It was also during the 2000s that most African countries experienced unprecedented energy crises. The choice of the second period is justified by the implementation of several programmes aimed at improving not only access to electricity but also the reliability of electricity in SSA. Countries and international organizations such as the African Development Bank (ADB) and the World Bank have implemented these programmes independently. The objective of this study is to assess the evolution of electricity reliability in terms of firm productivity. The data source is the World Bank's Enterprise Surveys, www.enterprisesurveys.org

2023) [7](Figure 1). This makes electricity the second most important constraint to doing business; the number one constraint is access to finance, cited by 22% of entrepreneurs.

In contrast, in period (2), 23% of entrepreneurs cited both electricity shortages and access to finance as significant obstacles to doing business. These figures support the argument put forward by Meles (2020) that in SSA countries, the reliability of electricity supply is secondary to problems of access to electricity in the region. This situation limits the potential benefits of access to electricity in the region and delays the achievement of Sustainable Development Goal (SDG) n°7, which focuses not only on access to electricity, but also on its reliability, in SSA by 2025 and 2030 respectively[8].

Figure 1: Percentage of business owners citing each element of the business environment as the main obstacle to doing business



Source: Authors based on the WBES 2006-2023.

Measuring the impact of electricity shortages on firms productivity, is part of production and cost theory. As an 'input-output' good, electricity plays a dual role in the production

[7] Data for the initial stage of electrical infrastructure are taken from the earliest year available for each country in our sample, while data for the advanced stage of electrical infrastructure are taken from the most recent year available for each country in our sample.

[8] See, https://sustainabledevelopment.un.org/sdg7

function: it contributes directly to firm production as an input and indirectly as a final product (Jones, 2011b). Its scarcity is therefore reflected in both the product and factor markets (Jones, 2011b). The consequences of this scarcity propagate through the economy via linkages and complementarities; they act as a tax on final output, reduce the optimal allocation of other intermediate products and result in declines in productivity (Jones, 2011a). Griffin and Gregory (1976) emphasize the link between electricity and productivity, which they describe as a complement to capital (machine tools) and a substitute for labor.

To assess the impact of electricity quality and quantity on productivity growth, Berndt (1983) used the quality-quantity factor demand model consistent with production and cost theory. The results of this study indicate that increasing the electrification rate has a positive impact on the productivity growth of firms in the United States and on their ability to reduce costs. Measuring the effect of electricity shortages on firm productivity is also consistent with organizational theory. Electricity shortage prompt firms to adapt their operations and organizational structures to cope with the constraints (Fisher-Vanden et al., 2015).

Much development literature emphasizes the critical importance of access to electricity in influencing key socioeconomic factors such as job opportunities, health, education and productivity (Shobande, 2023; Abbasi et al., 2022; Chhay & Yamazaki, 2021; Dinkleman, 2011). However, insufficient investment and research has been devoted to ensuring the reliability of the electricity supply. Existing studies on the consequences of electricity shortages have focused primarily on their impact on business productivity (Apeti and Ly, 2024; Nzepang & Mbebi, 2023; Abeberese et al., 2021; Hardy & McCasland, 2021), profitability (Cole et al., 2018; Hardy & McCasland, 2019) and employment (Mensah, 2024). An important yet often overlooked question is how the impact of electricity shortages on firm productivity evolves over time. Furthermore, does political energy influence this impact?

This study therefore differ from the existing literature in two respects, by proposing new data and using a matching-based approach (Entropy Balancing) to conduct the analysis. First, contrary to Elliot et al. (2021) who investigated the effect of energy policies on the

relationship between electricity shortages and firm productivity for a single country context (in Vietnam), we conduct our analysis on 30 African countries. We use the World Bank survey data to construct a two-period comparative analysis to accessing the effect of electricity shortages on firm productivity and evaluate the influence of political energy on this relationship. Second, in oder to address the lack of a balanced panel structure (survey data) and to extend previous findings on the limitations of instrumentation techniques related to hydroelectricity variables, as discussed by Apeti and Ly (2024)[9], we use an entropy balancing approach in our two-period comparative analysis. The primary advantage of this method lies in its capacity to reweight observations to produce a balanced dataset (Hainmueller, 2012). Additionally, it reduces biased estimates and addresses potential endogeneity issues (Hainmueller, 2012). Given that, we are dealing with unbalanced survey data and facing endogeneity challenges.

Broadly, our results show that, despite significant advancements in energy supply, the negative impact of electricity shortages on firm productivity is more important in the later period as firms increased their dependency on electricity. Specifically, a 1% reduction in the duration of electricity shortages is associated with a 2.22 percentage point increase in productivity at this stage of electricity infrastructure improvement in Sub-Saharan Africa. Additionally, we show that countries that rely primarily on hydropower for electricity generation are more susceptible to electricity shortages than those that use other energy sources.

The rest of the paper is organized as follows: section two presents the methodology and data; Section three presents the empirical results, and section four concludes the paper.

2. Methodology

Estimation technique

[9] Apeti and Ly (2024) use entropy balancing for data that is not comparable. However, our data is intended for comparative analysis.

A major methodological challenge to quantify the effect of electricity shortages on firm productivity is the identification of an exogenous variation in electricity supply. As Kouakou (2025) and Apeti et al. (2024) note, the intensity of power outages correlates with latent factors that simultaneously affect firm performance. Specific macro-institutional characteristics, such as the quality of sector regulation or the level of financial development, jointly determine both grid stability and firm productivity. Consequently, the occurrence of power outages is non-random, which generates an endogeneity problem from selection and simultaneity biases.

To address this issue, prior studies—such as (Mensah, 2024; Elliott et al., 2021; Allcott et al., 2016; Fisher-Vanden et al., 2015) have used the instrumental variables (IV) method as the best estimation approach. The hydroelectric instrument conditional on the flow of precipitation in the dams is the one adopted by these different studies. The objective of this instrument is to make fluctuations in electricity supply exogenous with respect to sales generation and other business results.

However, this instrument is only applicable in a limited number of countries, as not all have access to hydropower as their primary source of electricity generation. This is particularly relevant to our study, which covers 29 SSA countries, each with a different energy mix. Even if all countries of our sample use hydropower, the fact that the treatment exposure is not random may lead to poor estimates when using the instrumental variable approach, as highlighted by Canan et al. (2017) and Ertefaie et al. (2016), who show the relevance of the matching approach in the presence of this specific source.

Moreover, countries that rely primarily on hydropower tend to use fossil-fuel power plants to compensate for hydropower generation during low-flow periods (climate shocks), a practice that is increasingly common due to climate change. This could break the link between hydroelectricity production (the instrument) and electricity shortages (the outcome) (Apeti & Ly, 2024). Thus, the reliability of this type of instrument may be undermined.

This limitation of the instrument justifies the adoption of Entropy Balancing matching approach like Apeti and Ly (2024). The primary advantage of this method lies in its capacity to reweight observations to produce a balanced dataset (Hainmueller, 2012). Additionally, it

reduces biased estimates and addresses potential endogeneity issues (Hainmueller, 2012). Given that we are facing endogeneity challenges, Entropy Balancing is especially well-suited for this analysis, as it effectively mitigates bias.

Beyond basic reweighting, this framework strengthens causal inference because it secures near-exact balance on selected covariate moments. By completely bypasses propensity score estimation, this approach shields the treatment effect from the misspecification errors and erratic, post-hoc adjustments common in traditional methods like Inverse Probability of Treatment Weighting (IPTW) or propensity score matching (PSM) hybrids (Dehejia & Wahba, 2002; Chesnaye et al., 2022). Furthermore, entropy balancing eliminates the iterative tuning and repetitive balance checks required by stochastic matching. As a result, it yields significantly lower bias and root mean squared error than Mahalanobis distance or genetic matching (Hainmueller, 2012). As Kouakou (2025) highlights, this method also retains the entire sample to maximize statistical power rather than discard unmatched controls. Crucially for our empirical setup, the framework accommodates our data structure because it permits the seamless integration of fixed effects directly into the treatment effect estimation.

The empirical analysis of the study is based on the empirical model of Neuenkirch and Neumeier (2016), which is based on the idea that exposure to the electricity shortages represents a treatment. Firms exposed to the electricity shortages constitute the treatment group, while firms not exposed to the shortage constitute a potential control group. The average treatment effect on treated firms (ATT) is defined as follows:

$$\tau_{ATT} = E[y(1) \mid \mathrm{T} = 1] - E[y(0) \mid \mathrm{T} = 1] \quad (1)$$

$y(.)$ is the result variable (the TFP). T indicates whether a unit or company is exposed to a treatment or electricity shortage (T=1) or not (T=0). As a result $E[y(1) \mid \mathrm{T} = 1]$is the expected outcome after treatment and $E[y(0) \mid \mathrm{T} = 1]$ is the counterfactual outcome, i.e. the outcome that a unit exposed to the treatment would have obtained if it had not undergone the treatment. Since the counterfactual outcome is not observable, the use of an appropriate indicator (proxy) to identify the ATT is used in the study. If the treatment is randomly assigned, then the average outcome of the units not exposed to the treatment, , $E[y(0) \mid \mathrm{T} = 0]$,is an appropriate proxy. However, as the study pointed out earlier, exposure

to power shortage and therefore selection for treatment could be endogenous due to the potential confounding factors mentioned earlier.

The idea of matching-based estimators is to replicate randomisation with respect to treatment assignment. The unobserved counterfactual outcome is imputed by matching treated units with untreated units that are as similar as possible with respect to all observable characteristics, which: (i) are associated with selection into treatment (i.e. the probability of being exposed to shortage), and (ii) influence the outcome of interest. The realisations of the productivity gap measure for these matches are then used as an empirical approximation of the unobserved counterfactuals. Formally, the matching-based ATT estimate is defined as follows:

$$\tau_{ATT}(x) = E[y(1) \mid \mathrm{T} = 1, \mathrm{X} = \mathrm{x}] - E[y(0) \mid \mathrm{T} = 0, \mathrm{X} = \mathrm{x}] \quad (2)$$

Where x is a vector of relevant observable characteristics (see the description of company and country level control variables in subsection 3.1.1), $E[y(1) \mid \mathrm{T} = 1, \mathrm{X} = \mathrm{x}]$ is the expected outcome for the units receiving the treatment, and t $E[y(0) \mid \mathrm{T} = 0, \mathrm{X} = \mathrm{x}]$ the expected outcome for the best matches of the treated units.

Entropy balancing estimates the causal effect under the null hypothesis or the conditional independence hypothesis (CIA). The conditional independence hypothesis implies that selection into the treatment group is conditional only on a set of observed covariates. More specifically, it assumes that subject to covariate observation (after controlling for covariates), treatment allocation is independent of potential outcomes[10].

In this study, like Neuenkirch and Neumeier (2016) in analysing the effect of US sanctions on poverty gaps in target countries, and Apeti and Ly (2024) on the effect of power constraints on firm productivity, this study uses entropy balancing to select the matching of units exposed to the treatment and to estimate the ATT[11]. *Entropy balancing is a* two-stage method.

[10] In other words, the conditional independence hypothesis (CID) implies that after conditioning on observed covariates, there are no unobserved confounders that influence both treatment assignment and potential outcomes. This hypothesis is tested empirically in section.

[11] The papers by Apeti and Edoh (2023); Apeti (2023b), give more details.

First, weights are calculated and assigned to the non-treated units. These weights are chosen to satisfy pre-specified equilibrium constraints that imply a moment sample of observable characteristics, while remaining as close as possible to the uniform base weights. In the analysis, the equilibrium constraints require equal covariate means between the treatment and control groups, which ensures that the control group contains, on average, untreated units that are as similar as possible to the treatment units.

The weights obtained in the first step are then used in the regression analysis with the treatment indicator as the explanatory variable. This gives an estimate of the ATT. This is the conditional difference in the means of the outcome variable between the treatment group and the control group[12].

Briefly, the idea of entropy balancing is to compare the difference in productivity of firms exposed to the constraints of the electricity shortage with that of unexposed firms that are as similar as possible to the exposed firms. The average productivity difference between the exposed firms and the closest unexposed firms must be due to the treatment, i.e. exposure to the electricity shortage. In this sense, the empirical approach mimics a random experiment by balancing the treatment and control groups on the basis of observable characteristics.

The combination of matching and regression analysis means that entropy balancing has certain advantages over other treatment effect estimators. A particularly important advantage over regression-based approaches (including difference-in-difference estimation) and other propensity score-based matching methods is that entropy balancing is non-parametric, in the sense that it does not require specification of an empirical model for the outcome variable or selection into treatment. In addition, unlike regression-based analyses, there is no multicollinearity because the reweighting scheme orthogonalises the covariates to the treatment variable.

In addition, unlike other matching methods, entropy balancing ensures a high degree of covariate balance between the treatment and control groups, even in small samples. In 'conventional' matching methods, such as nearest neighbour matching or propensity score

[12] In the regression stage, the study also controls the covariates used in the first stage. This is equivalent to including control variables in a random experiment in order to increase the efficiency of the estimation.

matching, each treated unit is, in the simplest case, matched to the untreated unit that is closest in terms of the metric balancing score. As a result, the control group consists only of a subset of the units that do not receive the treatment (Hainmueler, 2012). In other words, in conventional matching methods, each untreated unit is given either a weight equal to 0 if it is not the best match for a treated unit, or a weight equal to 1 if it is the best match for a treated unit[13].

Then, by combining the reweighting scheme with a regression analysis, Entropy Balancing controls for both country fixed effects and year fixed effects in the second stage of the matching approach, i.e. the regression analysis[14]. The inclusion of country fixed effects is particularly useful to account for potential unobserved heterogeneity between firms in different countries and to control for the time invariance of country-specific conditions that could lead to differences in the productivity gap between firms.

- **Data and description of variables at company level**

The study covers 28,924 manufacturing enterprises in 30 SSA countries from 2006 to 2023. However, in order to take into account the major changes in the energy situation in SSA since the 2000s, the data in the study are based on two time periods: the first period covers the oldest years for each country; the second period covers the most recent years for each country. The different databases were selected on the basis of their availability. The study takes into account both the oldest and the most recent years for each country in order to better assess the recent achievements in terms of electricity reliability. It also makes it easier to formulate targeted economic policies that take into account the current state of electricity supply by looking at recent progress and/or shortcomings.

At the country level, the study controls for bank concentration and economic growth. These variables come respectively from the Global Financial Development Database-World Bank and the World Development Indicators database respectively. Indeed, greater competition

[13] It should be noted that conventional matching approaches generally allow for replacement, meaning that an unprocessed unit can be used multiple times as a match. Thus, in general, conventional matching approaches allow weights equal to any non-negative integer. However, while matching with replacement improves matching quality in terms of covariate balance, it does so at the expense of efficiency, as the number of observations used to estimate the ATT decreases (Caliendo and Kopeinig, 2008).

[14] Region and income group fixed effects are also included in the econometric specification.

between banks (high bank concentration) is conducive to firm performance (Lee et *al*., 2020).

- **International comparability and treatment of outliers**

As all variables used to estimate productivity are collected in local currency units (LCUs), which are specific to the survey and the year, international comparability is necessary. This international comparability is achieved by converting all monetary data into a common currency year. To achieve this, all variables are first converted into US dollars (USD) using the nominal (period average) exchange rate of the World Development Indicators (WDI). The monetary data are then adjusted using the 2015 US Gross Domestic Product (GDP) deflator.

To minimize sensitivity to extreme values, outliers are removed from the analysis. Specifically, outliers in cost of sales, cost of labour and cost of capital are eliminated. Observations missing in any of the main variables of the production function (i.e. sales, labour and capital) are excluded. It should also be noted that in the case of negative value added (VA), logarithms cannot be defined and therefore these observations are not included in the analysis.

- **Measurement and description of variables**

Three types of variables are used in this study:

(i) The treatment variable, which is a dummy variable that takes the values 0 and 1. This variable characterizes the different levels of constraint caused by the shortage of electricity to which firms report being exposed. These levels are: shortages is not an obstacle; shortages is minor obstacle; shortages is moderate obstacle; shortage is biggest obstacles. One of the advantages of this measure is that it reflects the perception that firms have of the extent to which electricity shortages constrain their activities. This perception-based measure is important because firms' perceptions are one of the most important factors influencing their operational and investment decisions (Asiedu and Freeman, 2009).

(ii) Total Factor Productivity (TFP) is used in this study to measure productivity. It is defined as the share of output that is not explained by the quantity of inputs used[15] . This indicator was chosen because there is a broad consensus in the literature that differences in TFP explain most of the differences in income observed between countries (Klenow and Rodriguez-Clare, 1997 and Hall and Jones 1999). TFP, considered as the ability or capacity to produce more with less input, is one of the key elements of economic growth. Productivity is estimated on the basis of a Cobb-Douglass VA (Value Added) function. The form of the production function is shown below:

$$\mathrm{VA_i} = \mathrm{A_i} K_i^{\alpha_k} L_i^{\alpha_l} \qquad (3)$$

Where value added at company level $\mathrm{VA_i}$ is a function of capital $\mathrm{K_i}$ and labour $\mathrm{L_i}$[16]. The efficiency of firm production is measured by the term $\mathrm{VA_i}$which represents the share of output that is not directly attributed to the use of inputs. Equation (1) can be rewritten as follows:

$$l\,(VA_i = a_0 + a_k \log(K_i) + a_L \log(L_i) + \varepsilon_i \qquad (4)$$

$l(TFP_i)$[17]is estimated as the sum of the constant and the residual, as follows :$\log\log(TFP_i) = \hat{\alpha}0 + \varepsilon\hat{\imath}$ [18]. For this reason, TFP is the share of output that is not explained by the quantity of inputs used. In equation (1), TFP $\mathrm{A_i}$ is estimated separately for each industry. This estimation strategy avoids the assumption of a common production technology (where α_k and α_l) are identical within the sample. In addition, where possible, production elasticities with respect to capital and labour (i.e. and α_L) can vary according to the level of the revenue group in the corresponding economy. Finally, as in Halvorsen and Palmquist (1980), the country fixed effect and the year fixed effect are controlled through a dummy variable for each country and for each year. In order to estimate the above

[15] https://www.enterprisesurveys.org/en/enterprisesurveys, world Bank Group, Enterprise Analysis Unit. 2020. "firm-level Productivity Estimates".

[16] VA is captured by the difference between companies' annual sales and the total cost of production inputs; K is approximated by the replacement cost of appliances, vehicles and equipment; L is approximated by the total cost of labour.

[17] https://www.enterprisesurveys.org/en/enterprisesurveys, world Bank Group, Enterprise Analysis Unit. 2020. "firm-level Productivity Estimates".

[18] Where $log(\mathrm{VA_i}) = log(\mathrm{PTF_i})$

TFP, three approaches have been explored: the Ordinary Least Squares (OLS) method and the Levinson-Petrin (LP) productivity estimator. The main limitation of estimating productivity using the OLS method relates to the simultaneity problem: firms' input choices may be guided by productivity shocks (Marschak and Andrews, 1994). However, the LP estimator is considered to be a more robust estimator, as it overcomes the simultaneity between productivity shocks and inputs by using intermediate inputs as a proxy (Levinson and Petrin, 2003). Consequently, the main TFP measure of interest is the TFP estimated using the Levinson-Petrin approach, referred to as TFP_LP.

(iii) given that productivity varies with firm and economic characteristics (Syverson, 2011), a large number of control variables at the firm and country level are included in the regression:

Export status of the firm. Entering the export market helps the firm to strengthen its competitiveness (Cole et *al*., 2018). As an obligatory step in starting a business, the choice of legal form is essential to ensure not only the moral and legal durability of the firm, but also a high level of attractiveness and business performance. This legal form gives the company an identity, provides legal protection and can affect on the company's performance.

From this point of view, Asiedu et al (2021) suggest that the probability of facing and electricity shortage is lower for public firms with the largest shareholding. However, a high level of private shareholding in a firm could reveal significant levels of attractiveness or performance of the firm.

The practice of innovation activities has also been identified in several studies as an important factor in business productivity growth. Krugman (1988) distinguishes between technological innovation (product and process innovation) and non-technological innovation (organisational and marketing innovation). Power cuts have a greater impact on technological innovation because, according to Solow's (1956) neoclassical growth theory, technological progress is seen as a measure of total factor productivity. In view of these arguments, the innovation indicator used in this study is technological innovation.

The other firm-level variables that are likely to influence the direct relationship between electricity shortages and firm productivity are firm size, gender, access to credit and possession of an international certificate. Indeed, a positive relationship between firm size and TFP has been observed in the empirical literature on the manufacturing sector in general (Leung et al., 2008). We also include in the analysis the possession of a credit line from a formal institution as a control variable. The literature agrees that bank credit from formal institutions has a positive impact on firm productivity (Kafouros et al., 2022). We want to test whether this positive effect holds in the context of SSA firms.

Finally, Maestro and Pueyo and Maestre (2019) argue that women entrepreneurs face different challenges than men, not only in the way they use electrical energy, but also in the benefits they derive from it. Since the misallocation of production inputs, in this case electrical energy, contributes to lower firm productivity, women entrepreneurs and/or managers may face low productivity levels.

Table 1: Summary statistics on our main variables (period 1)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	Mean	Sd	Min	Max
Firm level controls					
Firm size	8,010	1.72	0.77	1.00	3.00
Private participation	8,010	86.88	31.71	0.00	100.00
Women owner	8,010	0.39	0.48	0.00	1.00
Innovation	8,010	0.15	0.35	0.00	1.00
Line credit	8,010	0.24	0.43	0.00	1.00
Longevity of firm	8,010	19.57	16.25	0.00	135.00
International certification	8,010	0.15	0.36	0.00	1.00
Products export production	8,010	5.449	16.84	0.00	100.00
Outage related variable					
Outages	8,010	0.818	0.386	0.00	1.00
Log outages frequency per month	8,010	2.07	1.09	0.00	5.48
Log outage intensity (hours per occurrence)	8,010	1.45	0.95	0.00	5.88
Country-level control					
GDP growth (annual %)	8,010	24.31	1.44	20.78	20.77
Bank concentration (%)	8,010	73.48	14.58	35.59	100.00

Performance related variable					
Log revenue-based (TFPR)	8,010	3.77	1.81	-5.16	17.82

Source: Authors

Table 1: Summary statistics on our main variables (period 2)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	Mean	Sd	Min	Max
Firm level controls					
Firm size	7,059	1.72	0.77	1.00	3.00
Private participation	7,059	76.09	39.63	0.00	100.00
Women owner	7,059	0.28	0.44	0.00	1.00
Innovation	7,059	0.35	0.48	0.00	1.00
Line credit	7,059	0.43	0.43	0.00	1.00
Longevity of firm	7,059	17.39	15.75	0.00	172.00
International certification	7,059	0.16	0.37	0.00	1.00
Outage related variable					
Outages	7,059	0.818	0.38	0.00	1.00
Log outages frequency per month	7,059	1.42	1.01	0.00	6.18
Log outage intensity (hours per occurrence)	7,059	2.06	1.07	0.00	7.60
Country-level control					
GDP growth (annual %)	7,059	24.36	1.40	24.23	27.07

Bank concentration (%)	7,059	61.28	17.93	32.52	100.00
Performance related variable					
Log revenue-based (TFPR)	7,059	3.76	2.21	-6.34	18.60

Source: Authors

3. Empirical results

3.1. Descriptive statistics

Tables (2) and (3) show the proportion of businesses affected by electricity shortages and the entrepreneur's perceptions of electricity shortages during the two study periods. They are constructed using the treatment variable "*electricity shortages* ".

The data suggest a slight downward trend in the proportion of businesses affected by electricity shortages. Specifically, the percentage of businesses experiencing electricity shortages decreased from 81.96% in period (1) to 81.67% in period (2), a fall of 0.29% points.

Indeed, during period (1), 6565 out of 8010 companies experienced electricity shortages, representing a percentage of 81.96% of companies. In addition, for 6017 companies, the shortage of electricity constitutes an obstacle in the exercise of their activities, representing 88.19% of companies. Among these companies, 14.96% consider the shortage of electricity as a minor obstacle, 15.31% as a moderate obstacle and 54.92% as a major obstacle in the exercise of their activity.

On the other hand, during period (2), 5,765 out of 7,059 companies experienced a shortage of electricity, or about 81.67% of companies. In addition, for 6065 companies, the shortage of electricity constitutes an obstacle in the exercise of their activities, or 86.07% of companies. For these companies, 20.63% consider the shortage of electricity as a minor obstacle, 18.01% as a moderate obstacle and 47.29% as a major obstacle in the exercise of their activity.

Finally, although electricity shortages is one of the main manifestations of constraints in the electricity sector, there are a number of other constraints, such as voltage drops, problems connecting to electricity networks and high electricity costs, which are not easily observable through survey data. Indeed, it is observed during the study periods that 11.81% of

companies in period (1), which consider electricity shortage as an obstacle, do not experience power outages, compared to 13.93% during period (2).

Similarly, 24.21% of period (1) versus 23.15% of period (2) of companies that consider electricity shortages as minor obstacles did not experience a power outage. 11.34% (period 1) and 12.51% (period 2) of companies that consider electricity shortages as moderate obstacles did not experience a power outage. 8.57% (period 1) and 10.46% (period 2) of companies that reported that electricity is the biggest challenge in carrying out their activities did not experience a power outage.

Tableau 2: Descriptive analysis of the treatment variable (period 1)

	No shortages	Shortages	Total	No shortages	Shortages	Total	No shortages	Shortages	Total
	Count			Row percentages			column Percentages		
Electricity shortages is an obstacle									
No	639	548	1,187	53.83%	46.17%	100%	44.22%	8.35%	14.82%
Yes	806	6,017	6,823	11.81%	88.19%	100%	55.78%	91.65%	85.18%
Total	1,445	6,565	8,010	18.04%	81.96%	100%	100%	100%	100%
Electricity shortages as a minor obstacle									
No	1,155	5,657	6,812	16.96%	83.04%	100%	79.93%	86.17%	85.04%
Yes	290	908	1,198	24.21%	75.79%	100%	20.07%	13.83%	14.96%
Total	1,445	6,565	8,010	18.04%	81.96%	100%	100%	100%	100%
Electricity shortages as a moderate obstacle									
No	1,306	5,478	6,784	19.25%	80.75%	100%	90.38%	83.44%	84.69%
Yes	139	1,087	1,226	11.34%	88.66%	100%	9.62%	16.56%	15.31%
Total	1,445	6,565	8,010	18.04%	81.96%	100%	100%	100%	100%
Electricity shortage as a very severe obstacle									
No	1,068	2,543	3,611	29.58%	70.42%	100%	73.91%	38.74%	45.08%
Yes	377	4,022	4,399	8.57%	91.43%	100%	26.09%	61.26%	54.92%
Total	1,445	6,565	8,010	18.04%	81.96%	100%	100%	100%	100%
N	1,445	6,565	8,010						

Source: Author's construction.

Tableau 3: Descriptive analysis of the treatment variable (period 2)

No shortage	Shortage	Total	No shortages	Shortage	Total	No shortages	Shortages	Total
Count			**Row percentages**			**column Percentage**		
Electricity shortage is an obstacle								
No	449	545	994	45.17%	54.83%	100%	34.70%	9.45%	14.08%
Yes	845	5,220	6,065	13.93%	86.07%	100%	65.30%	90.55%	85.92%
Total	1,294	5,765	7,059	18.33%	81.67%	100%	100%	100%	100%
Electricity shortage is a minor obstacle									
No	957	4,646	5,603	17.08%	82.92%	100%	73.96%	80.59%	79.37%
Yes	337	1,119	1,456	23.15%	76.85%	100%	26.04%	19.41%	20.63%
Total	1,294	5,765	7,059	18.33%	81.67%	100%	100%	100%	100%
Electricity shortage is a moderate obstacle									
No	1,135	4,653	5,788	19.61%	80.39%	100%	87.71%	80.71%	81.99%
Yes	159	1,112	1,271	12.51%	87.49%	100%	12.29%	19.29%	18.01%
Total	1,294	5,765	7,059	18.33%	81.67%	100%	100%	100%	100%
Electricity shortage is a very severe obstacle									
No	945	2,776	3,721	25.40%	74.60%	100%	73.03%	48.15%	52.71%
Yes	349	2,989	3,338	10.46%	89.54%	100%	26.97%	51.85%	47.29%
Total	1,294	5,765	7,059	18.33%	81.67%	100%	100%	100%	100%
N	1,294	5,765	7,059						

Source: Author's construction.

However, over the two periods of the study, the evolution of electricity shortages shows disparities depending on the characteristics of the companies and the country in which the company operates.

Tables A.4 and A.5, presented in the appendix, show the disparities in the incidence of electricity shortages according to the characteristics of the companies and the characteristics of the countries in which they are located.

Thus, during period (1), the companies most exposed to the electricity shortage are companies run by women, those that own a generator, those that have exporter status and those that innovate. Furthermore, during period (2), the trend reverses downward among exporting companies. From the point of view of size characteristics, the proportion of small companies decreased during period (2). In addition, large and medium-sized companies saw their proportions increase. For each category of companies, both during period (1) and during period (2), the frequency of the electricity shortage is greater than 75%. This percentage suggests the extent of the electricity shortages during these two periods.

The data suggest a positive correlation between the level of innovation of companies and their exposure to the electricity shortage. This correlation seems to increase over time. Indeed, the most innovative companies are also those that are most confronted with the problems of electricity shortage. Thus, only 15.67% of companies innovated during period (1). Among them, a large majority, or 88.92%, faced the electricity shortage. While in period (2), the innovation rate doubled, reaching 37.03% of companies, the proportion of companies facing the electricity shortage slightly decreased by 5.45 points. These figures suggest that over the years, companies innovate to counter the harmful effects of the electricity shortage.

Statistics suggest that companies are gradually adopting the backup generator. Thus, among the 45.28% of companies that have a generator during period (1), 92.86% are facing the electricity shortage. While in period (2), the proportion of companies that adopt the backup generator increased by 14.12 points to reach 87.77% of companies suffering from the electricity shortage.

Women-led businesses are more exposed to electricity shortages and this exposure increases over time. Of the 22.89% women in the sample in period (1), more than three-quarters

(80.33%) of them face electricity shortages. This trend increased during period (2), where 81.13% of the 25.60% of women-led businesses face electricity shortages. These figures show that, despite the growing share of women-led businesses, their exposure to electricity shortages has continued to increase over the years.

Table (1.5) shows the sample means for all matching covariates, divided into two groups: the treatment group and the control group[19].

Table 4: Descriptive Statistics

	(1)	(2)	(1) - (2)	(4)	(5)	(4) - (5)
	Shortages	No shortages	Difference	Shortages	No shortages	Difference
Size	1,572	1,505	0, 067***	1,712	1,609	0, 229***
Private property	0,900	0,874	0,025***	0,830	0,770	0,060**
Certificate	0,158	0,169	-0,011***	0,160	0,119	0,041*
Export	4,952	3,443	-1,491***	0,180	0,213	-0,033***
Credit access	0,175	0,173	-0,002***	0,240	0,154	0,086***
Woman	0,246	0,242	0,003***	0,262	0,248	0,014***
Innovation	0,165	0,094	0,071***	0,377	0,338	0,039*
GDP	24,438	24,463	-0,025***	24,367	24,194	0,173*
Bank concentration	4,252	4,309	-0,057***	4,050	4,102	-0,052***
Weigted observation	6565	1445		5765	1294	

Source: Author based on data from WBES (2006, 2023). Note: This table shows the sample means of all matching covariates, divides into two groups: observations of firms facing outages or the treatment group (column1 and 4) and observation of firms facing outages or the treatment group (column 5 and 6). Columns (3 and 4) show the standardized differences in means between these two groups with the corresponding level of significance in each case. The analysis of the corresponding level of significance in each case. The analysis of the results for all the relevant observable characteristics reveal that firms facing outages drastically compared to firms not facing outages.

Analyzing the results for all relevant observable characteristics reveals that firms facing electricity shortages differ radically and operate in very different environments from those that do not. Moreover, these differences vary depending on the study period. Indeed, we find that firms facing electricity shortages are, on average, smaller than others. Similarly, these firms exposed to electricity shortages are, on average, headed by women, compared to those not exposed to it. It should also be noted that over time, the average proportion of women-headed firms exposed to electricity shortages increases.

[19] Columns 1 and 4 present the treatment variable; columns 5 and 6 the treatment groups; and columns 3 and 4 the standardized mean differences between the two groups for the two periods.

It is also observed that firms exposed to electricity shortages are, on average, more innovative than those that are not. Moreover, these firms have, on average, a greater proportion of credit lines in formal institutions. Over time, the average proportion of firms facing electricity shortages and holding a credit line in a formal institution increases.

It is also found that, during the first period, firms not exposed to the electricity shortage exported on average less than those facing it, but this trend reversed during the second period. In addition, it is noted that firms not exposed to the electricity shortage held on average a smaller share of international certificates.

Finally, it is noted that the companies most frequently faced with electricity service constraints are generally owned by private actors.

Furthermore, the economic and political environment in which these firms exposed to the electricity shortage operate differs from that of firms that do not experience power outages. Economic growth is lower and financial development through bank concentration is also slower. These descriptive results illustrate the importance of selecting an appropriate control group and justify the use of the matching approach to calculate the treatment effect. Otherwise, the effect of the electricity shortage on firm productivity could be misestimated.

Table (1.6) below compares the sample means of all corresponding covariates in the treatment group (columns 1 and 4) and the synthetic control group obtained via the entroping balancing method. Columns (3) and (6) show the standardized difference of means. Comparing the average observable characteristics of the treatment group with those of the control group reveals the effectiveness of entropy balancing. All covariates are perfectly balanced and no significant statistical differences remain. Therefore, we can say that the control groups in the subsequent empirical analysis are composed of relevant counterfactuals for the sample of firms facing the electricity shortage.

Table 5: Covariate balancing

	(1)	(2)	(1) - (2)	(4)	(5)	(4) - (5)
	Shortages	No shortages	Difference	Shortages	No shortages	Difference
Size	1,572	1,572	0, 000	1,712	1,712	0, 000
Private participation	0,900	0,900	0,000	0,830	0,830	0,000
Certificate	0,158	0,158	-0,000	0,160	0,160	0,000
Export	4,952	4,952	-0,000	0,180	0,180	-0,000
Access to credit	0,175	0,175	-0,000	0,240	0,240	0,000
Woman owner	0,392	0,392	0,000	0,262	0,262	0,000
Innovation	0,165	0,165	0,000	0,377	0,377	0,000
GDP	24,438	24,438	-0,000	24,367	24,367	0,00
Bank concentration	4,252	4,252	-0,000	4,050	4,050	-0,000
Weigted observations	6565	6565		5765	5765	

Source: This table compares the sample means of all matching covariates in the treatment group (column 1 and 4) and the synthetic control group obtained via Entropy Balancing (5 column 6). Columns 3 and 4 show the standardized differences in means with the corresponding significance level in each case. The comparison of the average realizations of the observable characteristics of the treatùent group xith those of synthetic control group reveals the effectiveness of Entropy Balancing. All covariates are perfectly balanced and no statistically significant differences remain.

3.1. Treatment effects

To ensure the relevance of the results and based on the treatment effects for endogenous treatments, an endogeneity test is performed to verify compliance with the conditional independence hypothesis (Wooldridge, 2010). To check the endogeneity of the treatment assignment, the "control function" approach is required; this approach does not affect the relevance of the chosen instruments (Cameron and Trivedi, 2022)[20].

The hypothesis (H0) of the test is as follows: unobservable elements related to treatment and outcomes are not correlated. Rejection of the null hypothesis indicates endogeneity. The results of the endogeneity test show: at period (0) a chi2 (2) =0.50 and a Prob > chi2=0.5844); at period (1) a chi2(2) =1.07 and a Prob > chi2=0.5436). Therefore, the hypothesis (H0) cannot be rejected. These results confirm the validity of the entropy

[20] The instrument used is the sector of activity in which the company operates. This method controls for endogeneity by including the residuals from the treatment assignment model as regressors in the potential outcome models. The 'control function' approach is used through the estimation of endogenous treatment effects, which estimates the correlation between unobservable treatment assignment variables and potential outcome models. Next, the Wald test is performed to determine whether the estimated correlations between the treatment assignment models and the potential outcome models are non-zero.

balancing estimates, which represent the consistent effects of the treatment on the treated firms (ATT).

The results in Tables (4 and 5) indicate that the electricity shortages negatively affect exposed firms, as we observe a negative and significant coefficient associated with the electricity shortage dummy variable of 0.132 and 0.220 respectively, i.e. 1.4 percentage points or 9% of unconditional average productivity (column 1, Table 4). 2.37 percentage points or 10% of unconditional average productivity (column 1, Table 5). This first result consistent with those found in much of the literature (Elliott et *al*., 2021; Cole et *al*., 2018; Abdisa, 2018)[21]. However, it is interesting to note an increase in the coefficient of 0.088 between period 1 and period 2. This trend highlights the need to intensify efforts to improve electricity supply.

This result can be explained by the fact that companies have become more dependent on the reliability of electrical energy over time. This dependence on electricity can be explained by the growing demand for electricity by firms due to the automation of production processes and the use of the Internet to communicate within the firm and with suppliers and customers. This finding is consistent with that of Elliott et al (2021) on a set of Vietnamese firms between 2005 and 2015. Firm characteristics also have an impact on firm productivity. In particular, the results show that innovation increases firms' TFP over time. This result is consistent with the findings of Karimu et al. (2018).

[21] Negative and statically significant results at both periods (0) and (1) of the study.

Table 6: First period of the effect of electricity shortages on firm productivity (using the Entroping Balancing)

VARIABLES	(1) LTFP_LP	(2) LTFP_LP	(3) LTFP_LP	(4) LTFP_LP	(5) LTFP_LP
Shortages	-0.132*				
	(-1.862)				
Shortage not an obstacle	-	-0.00876			
	-	(-0.133)			
Shortages minor obstacle			-0.0396		
			(-0.524)		
Shortages moderate obstacle				-0.0855	
				(-0.900)	
Shortages a major obstacle					-0.135*
					(-1.859)
Medium-sized companies	0.384***	0.373***	0.373***	0.374***	0.372***
	(6.070)	(5.836)	(5.806)	(5.821)	(5.810)
Large companies	0.764***	0.758***	0.758***	0.758***	0.758***
	(7.226)	(7.151)	(7.120)	(7.136)	(7.158)
International certification	0.299***	0.290***	0.290***	0.289***	0.286***
	(3.375)	(3.244)	(3.260)	(3.253)	(3.214)
Formal institution credit	0.142*	0.135*	0.135*	0.135*	0.134*
	(1.786)	(1.693)	(1.688)	(1.688)	(1.683)
Woman	-0.0423	-0.0283	-0.0300	-0.0284	-0.0297
	(-0.558)	(-0.363)	(-0.390)	(-0.365)	(-0.382)
Innovation	0.224**	0.228**	0.228**	0.227**	0.228**
	(2.500)	(2.557)	(2.557)	(2.543)	(2.557)
Individual property	-0.0845	-0.0764	-0.0786	-0.0774	-0.0786
	(-0.907)	(-0.817)	(-0.835)	(-0.826)	(-0.837)
Exports production	0.0194	0.0241	0.0230	0.0242	0.0190
	(0.206)	(0.256)	(0.244)	(0.257)	(0.201)
Gross domestic product	-3.492**	-3.484**	-3.504**	-3.464**	-3.382**
	(-2.215)	(-2.199)	(-2.207)	(-2.173)	(-2.133)
Bank concentration	5.472***	5.440***	5.480***	5.415***	5.362***
	(3.156)	(3.126)	(3.136)	(3.089)	(3.079)
Constant	11.93***	64.08**	65.20**	63.47**	12.11***
	(0.924)	(28.59)	(28.59)	(28.60)	(0.918)
Country fixed effect	Yes	Yes	Yes	Yes	Yes
Fixed effect year	Yes	Yes	Yes	Yes	Yes
R-Carré	0.4605	0,4597	0.4599	0.4597	0.4602
Prob>F	0,0000	0,0000	0,0000	0,0000	0,0000
Observation	8 010	8 010	8 010	8 010	8 010

Source: Author based on WBES data (2006, 2023). Note: robust t-statistics are in brackets, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Table 7: Second period of the effect of electricity shortages on firm productivity (using the Entroping balancing)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP
Shortages	-0.220**	-			
	(-2.333)	-			
Shortage not an obstacle	-	-0.0616			
	-	(-0.726)			
Shortages minor obstacle	-	-	-0.0866		
	-	-	(-0.757)		
Shortages moderate obstacle	-	-		-0.0875	
	-	-		(-0.818)	
Shortages a major obstacle	-	-			-0.511***
	-	-			(-3.196)
Medium-sized company	0.123**	0.128	0.104	0.111	0.129
	(1.985)	(1.335)	(1.053)	(1.126)	(1.361)
Large companies	0.326***	0.505***	0.344***	0.353***	0.504***
	(4.326)	(4.408)	(2.865)	(2.934)	(4.405)
International certification	0.364***	0.0411	0.261**	0.262**	0.0445
	(4.930)	(0.335)	(2.160)	(2.149)	(0.362)
Credit in a formal institution	0.107*	0.00261	-0.00701	-0.00612	0.00587
	(1.743)	(0.0245)	(-0.0665)	(-0.0581)	(0.0550)
Female manager and/or shareholder	-0.251***	-0.00768	-0.206**	-0.205**	-0.00696
	(-4.179)	(-0.0825)	(-2.142)	(-2.156)	(-0.0748)
Innovation	0.114**	0.00306	0.185**	0.181**	0.00389
	(2.012)	(0.0319)	(2.046)	(2.034)	(0.0409)
Individual property	-0.503***	-0.396***	-0.651***	-0.650***	-0.406***
	(-6.922)	(-3.366)	(-5.488)	(-5.471)	(-3.475)
Exports production	0.336***	0.479***	0.452***	0.453***	0.481***
	(4.239)	(4.002)	(3.651)	(3.676)	(4.018)
Gross domestic product	0.0415*	0.765***	0.0675*	0.0659**	0.766***
	(1.758)	(9.012)	(1.840)	(2.057)	(9.035)
Bank concentration rate	-0.0788	-12.93***	0.0111	0.0134	-13.00***
	(-0.868)	(-13.26)	(0.0716)	(0.0865)	(-13.35)
Constant	3.551***	40.89***	40.99***	40.59***	41.27***
	(0.798)	(4.544)	(4.536)	(4.545)	(4.526)
Country fixed effect	Yes	Yes	Yes	Yes	Yes
Fixed effect year	Yes	Yes	Yes	Yes	Yes
R-Carré	13,90	0,1847	0,0352	0,0351	0,1857
Prob>F	0,0000	0,0000	0,0000	0,0000	0,0000
Observations	7 059	7 059	7 059	7 059	7 059

Source: Author based on WBES data (2006, 2023). Note: robust t-statistics are in brackets, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Furthermore, firms' TFP increases with the possession of an international certificate. We find that the magnitude of the impact of holding an international certificate is generally highly statistically significant and increases over time (0.290 in period (1) and 0.364 in period (2)). With respect to firm size, the regression results indicate a scale effect on productivity over time. In addition, having a credit line with a formal institution has a positive and significant impact on the TFP of SSA firms.

In terms of gender, the econometric estimates show that the TFP of female-owned enterprises is more affected by electricity shortages than that of their male counterparts. This result can be explained by the fact that male-owned enterprises are better connected to the electricity grid than their female counterparts.

Our results also show that the TFP of firms decreases when the firm is majority owned by private actors. A plausible explanation is that private firms tend to employ family members for the most part, without taking account of their skills.

TFP is positively correlated with GDP and bank concentration. TFP decreases with GDP in the first period, and increases with GDP in the second period. This could be explained by the increase in the growth rate of African countries over time. In addition, the concentration ratio of banks increases corporate TFP in the first period. However, it is statically insignificant in the second period of the study. This result can be explained by the fact that the increase in bank concentration facilitates firms' access to credit and encourages investment. Specifically, the concentration rate of banks increases the TFP of firms by 5.472 points in the first period of the study.

3.3. Robustness analysis

We test the robustness of our results using of the Ordinary Least Squares (OLS) estimator in Tables (6) and (7), to ensure that our results are not strongly influenced or biased by the entropy equilibrium estimator. Obviously, we have small differences in magnitudes for some of the coefficients estimated through the OLS method, due to measurement error, and bais caused by business-friendly environment factors (Neuenkirch and Neumeier, 2016 and Allcott et *al.*, 2016), but they remain qualitatively unchanged[22]. Like the entropy equilibrium, the OLS estimator also allows us to see the negative and gradual effect of the electricity shortages on the TFP of firms in SSA over the two study periods.

[22] The omission of environmental factors that support business activity can increase energy demand and further disrupt energy supply demand. This type of bais pushes the negative impact of the electricity shortage towards zero.

Table 8: First period of the effect of electricity shortages on firm productivity (using of least squares regressions, without entropy balancing re-weighting scheme)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP
Shortages	-0.174***				
	(-2.841)				
Shortage not an obstacle		0.0456			
		(0.945)			
Shortages minor obstacle			-0.0357		
			(-0.643)		
Shortages moderate obstacle				-0.0363	
				(-0.924)	
Shortages a major obstacle					-0.199***
					(-3.472)
Medium-sized company	0.250***	0.389***	0.390***	0.391***	0.249***
	(4.892)	(8.890)	(8.963)	(8.991)	(4.872)
Large companies	0.389***	0.754***	0.757***	0.758***	0.401***
	(4.949)	(11.92)	(12.02)	(12.03)	(5.105)
International certification	0.178***	0.228***	0.228***	0.229***	0.167***
	(2.761)	(4.400)	(4.411)	(4.440)	(2.577)
Formal institution credit	0.0461	0.140***	0.141***	0.142***	0.0437
	(0.807)	(3.085)	(3.118)	(3.136)	(0.766)
Woman	-0.151***	0.00396	0.00314	0.00357	-0.142***
	(-3.804)	(0.109)	(0.0870)	(0.0986)	(-3.588)
Innovation	0.180***	0.151**	0.153**	0.153**	0.194***
	(2.763)	(2.528)	(2.557)	(2.564)	(2.978)
Private property	-0.230***	-0.114*	-0.113*	-0.113*	-0.224***
	(-2.954)	(-1.742)	(-1.722)	(-1.717)	(-2.888)
Exports production	0.0623	0.109*	0.110*	0.109*	0.0659
	(1.057)	(1.913)	(1.932)	(1.925)	(1.119)
Gross domestic product	-0.171***	-3.287**	-3.351**	-3.367**	-0.170***
	(-14.86)	(-2.194)	(-2.235)	(-2.245)	(-14.82)
Bank concentration	-0.976***	4.945***	5.025***	5.037***	-0.977***
	(-9.196)	(2.987)	(3.034)	(3.040)	(-9.227)
Constant	12.36***	59.51**	7.832***	61.02**	12.35***
	(0.617)	(27.44)	(0.764)	(27.47)	(0.617)
Country fixed effect	Yes	Yes	Yes	Yes	Yes
Fixed effect year	Yes	Yes	Yes	Yes	Yes
R-Carré	0.384	0.091	0.384	0.091	0.384
Prob>F	0.000	0.000	0.000	0.000	0.000
Observations	8 010	8 010	8 010	8 010	8 010

Source: Author based on WBES data (2006, 2023). Note: robust t-statistics are in brackets, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Table 9: Second period of the effect of electricity shortages on firm productivity (by using least squares regressions, without entropy balancing re-weighting scheme)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP
Shortages	-0.00112*				
	(-1.645)				
Shortage not an obstacle		-0.123			
		(-1.627)			
Shortages minor obstacle			-0.0186		
			(-0.309)		
Shortages moderate obstacle				-0.0124	
				(-0.231)	
Shortages a major obstacle					-0.203***
					(-2.790)
Medium-sized company	0.112*	0.110*	0.108*	0.108*	0.109*
	(1.913)	(1.893)	(1.862)	(1.860)	(1.877)
Large companies	0.475***	0.473***	0.473***	0.473***	0.474***
	(6.733)	(6.705)	(6.700)	(6.693)	(6.715)
International certification	0.178**	0.174**	0.176**	0.176**	0.175**
	(2.565)	(2.503)	(2.533)	(2.534)	(2.525)
Formal institution credit	0.0793	0.0716	0.0694	0.0692	0.0697
	(1.328)	(1.201)	(1.163)	(1.159)	(1.168)
Woman	-0.00619	-0.00803	-0.00966	-0.00978	-0.00932
	(-0.110)	(-0.143)	(-0.172)	(-0.174)	(-0.166)
Innovation	0.0135	0.0116	0.00794	0.00757	0.00767
	(0.242)	(0.207)	(0.142)	(0.135)	(0.138)
Private property	-0.224***	-0.226***	-0.232***	-0.232***	-0.232***
	(-3.163)	(-3.175)	(-3.264)	(-3.259)	(-3.274)
Exports production	0.354***	0.362***	0.360***	0.360***	0.360***
	(4.718)	(4.786)	(4.765)	(4.764)	(4.769)
Gross domestic product	0.885***	0.890***	0.890***	0.890***	0.888***
	(13.86)	(14.01)	(14.02)	(14.01)	(14.00)
Bank concentration	-11.20***	-11.20***	-11.16***	-11.16***	-11.20***
	(-16.30)	(-16.50)	(-16.35)	(-16.35)	(-16.48)
Constant	30.51***	30.08***	-6.889***	29.95***	30.13***
	(3.374)	(3.363)	(1.032)	(3.374)	(3.360)
Country fixed effect	Yes	Yes	Yes	Yes	Yes
Fixed effect year	Yes	Yes	Yes	Yes	Yes
R-Carré	0.209	0.208	0.207	0.207	0.208
Prob>F	0.000	0.000	0.000	0.000	0.000
Comments	7 059	7 059	7 059	7 059	7 059

Source: Author based on WBES data (2006, 2023). Note: robust t-statistics are in brackets, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

The World Bank study suggests grouping by industry when each industry has at least 500 observations[23] . Otherwise, the appropriate grouping is by economy or by country, as we have done so far. However, in order to assess the sensitivity of our results, we have repeated our regressions using a grouping by industry (see tables 1.12 and 1.13), even though we

[23] World Bank Group, Enterprise Analysis Unit 2017. "Firm-level Productivity Estimates.

have fewer than 500 observations for some industries in our sample. Thus, although we have some small variations in the significance of certain coefficients, in the standard errors and in terms of the magnitude of the coefficients, the results remain practically the same as our initial results with the grouping by country.

Table 10: Effect of electricity shortages on the TFP of firms with the grouping of normative errors at the level of industrial sectors period (0).

VARIABLES	(1) LTFP_LP	(2) LTFP_LP	(3) LTFP_LP	(4) LTFP_LP	(5) LTFP_LP
Shortages	-0.541***				
	(-2.651)				
Shortage not an obstacle		-0.208			
		(1-.060)			
Shortages minor obstacle			-0.274		
			(-1.558)		
Shortages moderate obstacle				-0.00837	
				(-0.0545)	
Shortages a major obstacle					-0.556***
					(-2.985)
Medium-sized company	0.656***	0.608***	0.614***	0.615***	0.615***
	(3.816)	(3.550)	(3.571)	(3.575)	(3.581)
Large companies	0.543**	0.513**	0.509**	0.511**	0.511**
	(2.209)	(2.085)	(2.061)	(2.072)	(2.072)
International certification	0.155	0.108	0.105	0.108	0.109
	(0.767)	(0.533)	(0.519)	(0.532)	(0.535)
Formal institutional credit	-0.201	-0.223	-0.228	-0.227	-0.227
	(-1.130)	(-1.247)	(-1.282)	(-1.274)	(-1.269)
Woman	-0.230	-0.166	-0.159	-0.168	-0.167
	(-1.447)	(-1.035)	(-0.989)	(-1.046)	(-1.038)
Innovation	0.430	0.439	0.426	0.432	0.431
	(1.542)	(1.561)	(1.516)	(1.535)	(1.533)
Private property	-0.143	-0.104	-0.110	-0.114	-0.115
	(-0.637)	(-0.453)	(-0.480)	(-0.497)	(-0.502)
Exports production	-0.181	-0.155	-0.155	-0.158	-0.157
	(-0.777)	(-0.662)	(-0.662)	(-0.673)	(-0.670)
Gross Domestic Product	8.843**	8.856**	9.251**	9.067**	9.065**
	(2.135)	(2.126)	(2.201)	(2.146)	(2.160)
Bank concentration	-15.99***	-16.05***	-16.58***	-16.30***	-16.31***
	(-3.559)	(-3.625)	(-3.705)	(-3.626)	(-3.658)
Country fixed effect	Yes	Yes	Yes	Yes	Yes
Fixed effect year	Yes	Yes	Yes	Yes	Yes
R-Carré	0.270	0.267	0.266	0.266	0.266
Prob>F	0,000	0.000	0.000	0.000	0.000
observations	7 580	7 580	7 580	7 580	7 580

Source: Author based on WBES data (2006, 2023). Note: robust t-statistics are in brackets, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Table 11: Effect of the electricity shortage on the TFP of firms with the grouping of normative errors at the level of industrial sectors period (1).

	(1)	(2)	(3)	(4)	(5)
VARIABLES	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP	LTFP_LP
Shortages	-0.415*				
	(-1.857)				
Shortage not an obstacle		-0.363			
		(-1.436)			
Shortages minor obstacle			-0.302		
			(-1.620)		
Shortages moderate obstacle				-0.266	
				(-1.379)	
Shortages a major obstacle					-0.461**
					(-2.001)
Medium-sized company	0.0319	0.0506	0.0607	0.0506	-0.161
	(0.159)	(0.253)	(0.300)	(0.253)	(-0.775)
Large companies	0.530*	0.538*	0.553**	0.538*	0.211
	(1.897)	(1.927)	(1.973)	(1.917)	(0.705)
International certification	-0.476	-0.504	-0.485	-0.477	-0.0913
	(-1.462)	(-1.537)	(-1.482)	(-1.456)	(-0.276)
Formal institutional credit	-0.164	-0.174	-0.170	-0.168	0.243
	(-0.700)	(-0.740)	(-0.722)	(-0.716)	(0.996)
Woman	-0.469**	-0.450**	-0.457**	-0.465**	-0.368*
	(-2.372)	(-2.278)	(-2.314)	(-2.355)	(-1.733)
Innovation	0.305	0.339*	0.320	0.307	0.658***
	(1.478)	(1.646)	(1.555)	(1.489)	(3.235)
Private property	-0.166	-0.146	-0.171	-0.188	-0.330
	(-0.676)	(-0.594)	(-0.695)	(-0.767)	(-1.347)
Exports production	0.466	0.498*	0.486*	0.468	0.846***
	(1.605)	(1.725)	(1.685)	(1.612)	(2.826)
Gross Domestic Product	0.939***	0.932***	0.952***	0.951***	0.410***
	(6.548)	(6.395)	(6.579)	(6.589)	(4.811)
Bank concentration	-3.175**	-3.756**	-3.184**	-3.312**	-2.381***
	(-2.004)	(-2.429)	(-2.071)	(-2.127)	(-6.563)
Country fixed effect	Yes	Yes	Yes	Yes	Yes
Fixed effect year	Yes	Yes	Yes	Yes	Yes
R-Carré					
Prob>F	0.000	0.000	0.000	0.000	0.000
Observations	6 646	6 646	6 646	6 646	6 646

Source: Author based on WBES data (2006, 2023). Note: robust t-statistics are in brackets, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

3.4. Controlling heterogeneity

We also examined the evolution of our results according to the sources of electricity production in the countries where the firms operate. Tables 8 and 9 show the results for the two study periods[24]. The results show that the negative impact of electricity shortages is

[24] This section distinguishes between two samples of countries according to their electricity generation mix. The first sample (1st column of Table 10) is made up of countries for which hydropower represents at least 50% of their installed generation capacity. The second sample is made up of countries where at least 50% of

0.061 percentage points higher in the second period for countries that use hydroelectricity as their main source of electricity generation than for countries that use other sources of electricity generation. Furthermore, the impact of the electricity shortages is the same before implementation of political energy, when all sources of electricity generation are taken into account. This result can be explained by the fact that the impact of climate change (drying up of rivers) is less before implementation of political energy than after.

Table 12: Effect of the electricity shortage on firm productivity by electricity generation source (period 1).

	(Hydroelectricity)	(other source of production)

their installed generation capacity comes from other sources, such as fossil fuels, nuclear, solar, wind, geothermal and biomass.

VARIABLES	LTFP_LP	LTFP_LP
Shortages	-0.132*	-0.132*
	(-1.862)	(-1.862)
Medium-sized company	0.384***	0.384***
	(6.070)	(6.070)
Large companies	0.764***	0.764***
	(7.226)	(7.226)
International certification	0.299***	0.299***
	(3.375)	(3.375)
Formal institution credit	0.142*	0.142*
	(1.786)	(1.786)
Woman	-0.0423	-0.0423
	(-0.558)	(-0.558)
Innovation	0.224**	0.224**
	(2.500)	(2.500)
Private property	-0.0845	-0.0845
	(-0.907)	(-0.907)
Exports production	0.0194	0.0194
	(0.206)	(0.206)
Gross domestic product	-3.492**	-3.492**
	(-2.215)	(-2.215)
Bank concentration	5.472***	5.472***
	(3.156)	(3.156)
Country fixed effect	Yes	Yes
Fixed effect year	Yes	Yes
R-Carré	0.461	0.461
Prob > F	0.000	0.000
observations	8 010	8 010

Source: Author based on WBES data (2006, 2023). Note: Robust t-statistics in parentheses, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

Table 13: Effect of the electricity shortage on firm productivity by electricity generation source (period 2).

	(Hydroelectricity)	(other source of production)
VARIABLES	LTFP_LP	LTFP_LP
Shortages	-0.183*	-0.122**
	(-1.943)	(-2.007)
Medium-sized company	0.168***	0.487***
	(3.752)	(6.000)
Large compagny	0.508***	0.801***
	(8.459)	(7.470)
International certification	0.236***	0.259***
	(4.188)	(2.741)
Formal institution credit	0.0750	0.139
	(1.535)	(1.524)
Woman	-0.00488	-0.0163
	(-0.116)	(-0.167)
Innovation	0.0403	0.141
	(0.867)	(1.157)
Private property	-0.201***	-0.0457
	(-3.271)	(-0.411)
Exports production	0.334***	-0.175*
	(5.221)	(-1.700)
Gross domestic product	0.453	-1.753***
	(0.918)	(-5.968)
Bank concentration	-3.299***	3.837***
	(-2.996)	(5.820)
Constance	-4.364***	-4.364***
	(-3.444)	(-3.444)
Country fixed effect	Yes	Yes
Fixed effect year	Yes	Yes
R-Carré	0,197	0,516
Prob>F	0.000	0.000
Observations	7 059	7 059

Source: Author based on WBES data (2006, 2023). Note: Robust t-statistics in parentheses, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

4. Conclusion

Despite persistent electricity shortages in many Sub-Saharan African economies, which can negatively affect firm performance, there is a significant research gap regarding the influence of energy policies on the relationship between electricity shortages and firms productivity. In particular, there is a lack of understanding of how the effects of electricity shortages on firm productivity evolve over time. This study compares World Bank Enterprise Survey data from two different time periods to explore how energy policies

affect firm productivity, by analysing the temporal evolution of the impact of electricity shortages on productivity in Sub-Saharan Africa.

This analysis leads to two main conclusions.

First, the impact of electricity shortages on firm productivity increases progressively over time. The estimates show a 0.088 increase in the coefficient between before and after the implementation of political energy, suggesting that improving the reliability of the electricity supply remains a persistent challenge in SSA despite the numerous programmes implemented by governments and international agencies. The impact of electricity shortages on firm productivity increases over time. Furthermore, a gendered approach reveals that women-owned enterprises are disproportionately affected by electricity shortages.

Second, the negative impact of electricity shortages is more pronounced after the implementation of political energy, with a difference of 0.061 percentage points for countries using hydroelectricity compared to those using other sources. Conversely, the impact of electricity shortages is consistent in period (1) when different sources of electricity production are considered. Based on these findings, we make recommendations for governments to implement to improve the reliability of the electricity supply.

The first recommendation is to increase investment in the production of electricity from solar, biomass and wind sources, depending on the potential of the regions, and to use incentive policies to encourage industrial entrepreneurs to invest in renewable energies.

The second recommendation is to create MAGZI (Industrial Estate Development and Management Mission) clusters around major hydropower infrastructure investment projects. Specifically, the aim is to develop other infrastructure projects such as transport and telecommunications infrastructure around hydroelectric infrastructure investment projects, which would create a king of "*silicon valley*" and would therefore be attractive areas for investors. These industrial agglomerations will reduce the cost of transporting electrical energy and consequently reduce losses in the transmission and distribution of electrical energy. Investments in hydroelectric infrastructure are very costly and require partnerships, which so far have only been partnerships between foreign subsidiaries specialising in the construction of hydroelectric dams. The creation of MAGZI zones

around these projects would lead some industrial entrepreneurs to become shareholders in power generation companies. These partnerships will significantly reduce losses in the distribution and transmission of electricity.

The third and final recommendation is to encourage research and innovation into methods of generating electricity from renewable energy sources such as wind, biomass and solar power. In concrete terms, this means implementing training programmes directly linked to industry, so that seminars and forums can be held jointly in firms and on university campuses.

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Period 1			Period 2		
Countries	Year	Outage duration	Countries		Outage duration
Angola	2006	24.85	Angola	2013	15.06
Benin	2009	3.89	Benin	2016	3.28
Botswana	2006	2.95	Botswana	2023	2.80
Burkina Faso	2006	1.41	Burkina Faso	2013	2.51
Cameroon	2009	2.81	Cameroon	2016	10.46
Chad	2009	6.82	Chad	2018	4.50
Congo, Dem. Rep.	2010	6.61	Congo, Dem. Rep.	2013	5.62
Congo, Rep	2006	2.98	Congo, Rep	2013	51.77
Ivory Coast	2008	5.23	Ivory Coast	2016	3.00
Eswatini	2006	2.00	Eswatini	2016	4.60

Ethiopia	2011	7.76	**Ethiopia**	2015	11.23
Gambia	2006	5.82	**Gambia**	2018	5.32
Ghana	2007	12.57	**Ghana**	2013	5.67
Guinea	2006	7.21	**Guinea**	2016	1.01
Kenya	2007	5.13	**Kenya**	2018	6.18
Madagascar	2009	1.16	**Madagascar**	2022	2.87
Malawi	2009	2.68	**Malawi**	2014	3.17
Mauritania	2006	2.82	**Mauritania**	2014	1.09
Mozambique	2007	4.39	**Mozambique**	2018	1.45
Namibia	2006	3.10	**Namibia**	2014	1.01
Niger	2009	1.87	**Niger**	2017	2.24
Nigeria	2007	9.28	**Nigeria**	2014	7.86
Rwanda	2011	2.92	**Rwanda**	2023	0.20
Senegal	2007	7.60	**Senegal**	2014	0.86
Sierra Leone	2008		**Sierra Leone**	2023	8.62
South Africa	2007	4.50	**South Africa**	2020	1.95
Togo	2009	4.57	**Togo**	2023	2.72
Uganda	2006	10.93	**Uganda**	2013	3.82
Zambia	2007	2.29	**Zambia**	2020	8.65
Zimbabwe	2011	4.93	**Zimbabwe**	2016	3.97
Total		5.55	**Total**		6.12

Appendix

Table A1: Distribution of the outage duration by country and period.

Period					
Period 1			Period 2		
Countries	Year	Outage duration	Countries	year	Outage duration
Angola	2006	24.85	Angola	2010	15.06
Benin	2009	3.89	Benin	2016	3.28
Botswana	2006	2.95	Botswana	2023	2.80
Burkina Faso	2006	1.41	Burkina Faso	2009	2.51
Cameroon	2009	2.81	Cameroon	2016	10.46
Chad	2009	6.82	Chad	2018	4.50
Congo, Dem. Rep.	2010	6.61	Congo, Dem. Rep.	2013	5.62
Congo, Rep	2006	2.98	Congo, Rep	2008	51.77
Ivory Coast	2008	5.23	Ivory Coast	2016	3.00
Eswatini	2006	2.00	Eswatini	2016	4.60
Ethiopia	2011	7.76	Ethiopia	2015	11.23
Gambia	2006	5.82	Gambia	2018	5.32
Ghana	2007	12.57	Ghana	2013	5.67
Guinea	2006	7.21	Guinea	2016	1.01
Kenya	2007	5.13	Kenya	2018	6.18
Madagascar	2009	1.16	Madagascar	2022	2.87
Malawi	2009	2.68	Malawi	2014	3.17
Mauritania	2006	2.82	Mauritania	2014	1.09
Mozambique	2007	4.39	Mozambique	2018	1.45
Namibia	2006	3.10	Namibia	2014	1.01
Niger	2009	1.87	Niger	2017	2.24
Nigeria	2007	9.28	Nigeria	2014	7.86
Rwanda	2011	2.92	Rwanda	2023	0.20
Senegal	2007	7.60	Senegal	2014	0.86
Sierra Leone	2008		Sierra Leone	2023	8.62
South Africa	2007	4.50	South Africa	2020	1.95
Togo	2009	4.57	Togo	2023	2.72
Uganda	2006	10.93	Uganda	2013	3.82
Zambia	2007	2.29	Zambia	2020	8.65
Zimbabwe	2011	4.93	Zimbabwe	2016	3.97
Total		5.55	Total		6.12

Source: Authors based on the WBES 2006-2023**.**

Table A2: Summary statistic on our main variable for period 0 and period 1.

	Period 1 (N=8010)				Period 2 (N=7059)			
Variable	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD.**	**Min**	**Max**
Countries	29				30			
Firms level data								
Electricity supply								
Duration cut;(hour per month)	7.04	11.87	0.00	360	4.92	17.24	0.00	486
Frequency of power cuts per month	11.82	14.03	0.00	240	14.84	51.85	0.00	200
Power obstacle	0.85	0.36	0.00	1.00	0.86	0.35	0.00	1.00
Power no obstacle	0.15	0.35	0.00	1.00	0.14	0.35	0.00	1.00
Power minor obstacle	0.15	0.36	0.00	1.00	0.21	0.40	0.00	1.00
Power moderate obstacle	0.15	0.36	0.00	1.00	0.18	0.38	0.00	1.00
Power major obstacle	0.55	0.50	0.00	1.00	0.47	0.50	0.00	1.00
Firm characteristics								
Small size (1-19 employees)	0.59	0.49	0.00	1.00	0.19	0.39	0	1
Medium size (20-49 employees)	0.26	0.44	0.00	1.00	0.44	0.50	0	1
Large size (50-100 employees)	0.15	0.35	0.00	1.00	0.27	0.45	0	1
Large size (101 or more)	0.08	0.28	0.00	1.00	0.10	0.29	0	1
Certificate international	0.16	0.37	0.00	1.00	0.15	0.36	0	1.00
Female owned (1=yes)	0.38	0.48	0.00	1.00	0.26	0.44	0.00	1.00
Innovation (1=yes)	0,16	0.36	0.00	1.00	0.37	0.48	0.00	1.00
Line credit institution	0.003	0.06	0.00	1.00	0.23	0.42	0.00	1.00
Firm performance								
Total factor productivity (log)	3.80	1.83	0.00	17.82	3.91	2.21	0	20.33
Business environment								
GDP (log current USD)	24.40	1.47	20.77	27.08	24.33	1.44	21.24	27.07
bank concentration rate	4.17	0.85	0.29	3.48	4.06	0.30	3.48	4.61

Source: Authors based on the WBES 2006-2023.

Table A3: Summary statistics on the treatment variables period 1

Counting			Percentage online				Percentage in column		
The electricity shortage is an obstacle									
No	639	548	1 187	53,83%	46,17%	100%	44,22%	8,35%	14,82%
Yes	806	6 017	6 823	11,81%	88,19%	100%	55,78%	91,65%	85,18%
Total	1 445	6 565	8 010	18,04%	81,96%	100%	100%	100%	100%
The electricity shortage is a minor obstacle									
No	1 155	5 657	6 812	16,96%	83,04%	100%	79,93%	86,17%	85,04%
Yes	290	908	1 198	24,21%	75,79%	100%	20,07%	13,83%	14,96%
Total	1 445	6 565	8 010	18,04%	81,96%	100%	100%	100%	100%
The electricity shortage is a moderate obstacle									
No	1 306	5 478	6 784	19,25%	80,75%	100%	90,38%	83,44%	84,69%
Yes	139	1 087	1 226	11,34%	88,66%	100%	9,62%	16,56%	15,31%
Total	1 445	6 565	8 010	18,04%	81,96%	100%	100%	100%	100%
The electricity shortage is a very serious obstacle									
No	1 068	2 543	3 611	29,58%	70,42%	100%	73,91%	38,74%	45,08%
Yes	377	4 022	4 399	8,57%	91,43%	100%	26,09%	61,26%	54,92%
Total	1 445	6 565	8 010	18,04%	81,96%	100%	100%	100%	100%
Observation	1 445	6 565	8 010						

Source: Authors based on the WBES 2006-2023.

Table A4: Summary statistics on the treatment variables period 2.

Counting			Percentage online				Percentage in column		
The electricity shortage is an obstacle									
No	449	545	994	45,17%	54,83%	100%	34,70%	9,45%	14,08%
Yes	845	5 220	6 065	13,93%	86,07%	100%	65,30%	90,55%	85,92%
Total	1 294	5 765	7 059	18,33%	81,67%	100%	100%	100%	100%
The electricity shortage is a minor obstacle									
No	957	4 646	5 603	17,08%	82,92%	100%	73,96%	80,59%	79,37%
Yes	337	1 119	1 456	23,15%	76,85%	100%	26,04%	19,41%	20,63%
Total	1 294	5 765	7 059	18,33%	81,67%	100%	100%	100%	100%
The electricity shortage is a moderate obstacle									
No	1 135	4 653	5 788	19,61%	80,39%	100%	87,71%	80,71%	81,99%
Yes	159	1 112	1 271	12,51%	87,49%	100%	12,29%	19,29%	18,01%
Total	1 294	5 765	7 059	18,33%	81,67%	100%	100%	100%	100%
The electricity shortage is a very serious obstacle									
No	945	2 776	3 721	25,40%	74,60%	100%	73,03%	48,15%	52,71%
Yes	349	2 989	3 338	10,46%	89,54%	100%	26,97%	51,85%	47,29%
Total	1 294	5 765	7 059	18,33%	81,67%	100%	100%	100%	100%
Observation	1 294	5 765	7 059						

Source: Authors based on the WBES 2006-2023

Table A5: Summary statistics on our main categorical variables period 1

	No outage	outage	total	No outage	outage	total	No outage	outage	Total
	Count			Row percentages			Column percentages		
Firm size									
Small (<20)	903	3 853	4 756	18.99	81.01	100	62.49	58.69	59.38
Medium (20-99)	358	1 715	2 073	17.27	82.73	100	24.78	26.12	25.88
Large (>100)	184	997	1 181	15.58	84.42	100	12.73	15.19	14.74
Total	1 445	6 565	8 010	18.04	81.96	100	100	100	100
Innovation									
No	1 306	5 449	6 755	19.33	80.67	100	90.38	83.00	84.33
Yes	139	1 116	1 255	11.08	88.92	100	9.62	17.00	15.67
Total	1 445	6 565	8 010	18.04	81.96	100	100	100	100
Generator									
No	781	2 085	2 866	27.25	72.75	100	60.36	36.17	40.60
Yes	513	3 680	3 680	12.23	87.77	100	39.64	63.83	59.40
Total	1 445	6 565	8 010	18.33	81.67	100	100	100	100
Women									
No	1 046	3 946	4 992	20.95	79.05	100	72.39	60.11	62.32
Yes	399	2 619	3 018	13.22	86.78	100	29.61	39.89	37.68
Total	1 445	6 565	8 010	18.04	81.96	100	27.61	39.89	37.68
Export									
No	1 266	5 669	6 935	18.26	81.74	100	87.61	86.35	86.58
Yes	179	896	1 075	16.35	83.35	100	12.39	13.65	13.42
Total	1 445	6 565	8 010	18.04	81.96	100	100	100	100

Source: Authors based on the WBES 2006-2023.

Table A6: Summary statistics on our main categorical variables period 2

	No outage	outage	total	No outage	outage	total	No outage	outage	Total
	Count			Row percentages			Column percentages		
Firm size									
Small (<20)	711	2 800	3 511	20.25%	79.75%	100%	54.95%	48.57%	49.74%
Meduim (20-99)	370	1 816	2 186	16.93%	83.07%	100%	28.59%	31.50%	30.97%
Large (>100)	213	1 149	1 362	16.64%	84.36%	100%	16.46%	19.93%	19.29%
Total	1 294	5 765	7 059	18.33%	81.67%	100%	100%	100%	100%
innovation									
No	862	3 583	4 445	19.39%	80.61%	100%	66.62%	62.15%	62.97%
Yes	432	2 182	2 614	16.53%	83.47%	100%	33.38%	37.85%	37.03%
Total	1 294	5 765	7 059	18.33%	81.67%	100%	100%	100%	100%
Generator									
No	781	2 085	2 866	27.25%	72.75%	100%	60.36%	36.17%	40.60%
Yes	513	3 680	4 193	12.23%	87.77%	100%	39.64%	63.83%	59.40%
Total	1 294	5 765	7 059	18.33%	81.67%	100%	100%	100%	100%
women									
No	976	4 260	5 236	18.64%	81.36%	100%	75.43%	73.89%	74.17%
Yes	318	1 505	1 823	17.44%	82.56%	100%	24.57%	26.11%	25.83%
Total	1 294	5 765	7 059	18.33%	81.67%	100%	100%	100%	100%
Export									
No	1 029	4 736	5 765	17.85%	82.15%	100%	79.52%	82.15%	81.67%
Yes	265	1 029	1 294	20.48%	79.52%	100%	20.48%	17.85%	18.33%
Total	1 294	5 765	7 059	18.33%	81.67	100%	100%	100%	100%

Source: Authors based on the WBES 2006-2023**.**