Electric Power Outages and the Productivity of Small and Medium Enterprises in Senegal

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ICBE-RF Research Report N0. 77/13

Investment Climate and Business Environment Research Fund

(ICBE-RF)

www.trustafrica.org/icbe

Dakar, November 2013

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This research was supported by a grant from the Investment Climate and Business Environment (ICBE) Research Fund, a collaborative initiative of TrustAfrica and IDRC. It's a working paper circulated for discussion and comments. The findings and recommendations are those of the author(s), and do not necessarily reflect the views of the ICBE-RF Secretariat, TrustAfrica or IDRC

Abstract

This paper assesses the impact of electricity outages on firms' productivity in Senegal, using cost technical and allocative efficiency scores. Results based on survey data from 528 businesses indicate that power outage duration has a positive significant effect on cost and technical efficiencies, and SMEs were more successful in doing so than larger ones. Further, power outages' frequency, duration and their perceived severity have negative effects on scale efficiency. Finding a solution to the power outage issue while affecting negatively cost efficiency, seems to promote technical and scale efficiencies. Further, having a loans and/or a credit line appeared to have positive effects on technical and scale efficiencies.

JEL Classification Codes: D24, L94.

Keywords: Power outages; Productivity; Efficiency; SMEs; Data Envelopment Analysis.

Table of contents

List of tables

1. Introduction

During the past decade, the Senegalese economy has undergone a major crisis in the electricity sector. Failed privatizations, the increased cost of fuel, and lack of public investments are the main factors that led to a poor electricity supply that shows in the daily occurrences of power outages. This environment has undoubtedly affected economic activities, particularly industrial production. In Senegal, the industrial sector contributes approximately 20 percent to GDP and employs around 12% of the labor force (YENIYF[2], 2009). Small and Medium Enterprises (SMEs), which constitute 95 percent of total businesses, play an increasing economic role, with a contribution to overall gross domestic product (GDP) going from 17 and 21 percent between 2003 and 2006 (World Bank, 2007). Despite their prevalence among businesses, and their relative importance in the Senegalese economy both in terms of wealth and employment generation, SMEs appear to be more vulnerable than large businesses to shocks from the economic environment, mainly because of their lack of adequate human and capital resources, compounded by relatively severe financial constraints. However, their lighter structure sometimes allows them more flexibility to cope with those shocks.

With the process of modernization, businesses tend to invest more in capital to improve their productivity, which makes electricity a major direct and indirect input in their production process and survival. SMEs tend to suffer more than large firms do from power outages. In fact, in the World Bank survey of Senegalese firms in 2006, 59 percent of SMEs reported electricity as a major obstacle to their activities, against a tiny 1 percent of large business firms. Furthermore, 25 percent of businesses reported losing more than 10 percent of their sales due to power outages, among which more than 90 percent are SMEs. In the survey done for this study, among the 57.5 percent of businesses that admitted electricity as a major concern, 97 percent are SMEs.

Technically, businesses could suffer from two types of power disturbances: poor quality, and power outages (Lineweber and McNulty, 2001). The first refers to the fluctuations in voltage, which could result in severe damage to machinery and equipment, and a corresponding high cost of frequent repair and replacement. The second relates to a complete loss of power, lasting from one second to hours. Because of the difficulty to obtaining relevant information on power fluctuations, this study focuses only on electricity shortages, for which more reliable data and measures can be collected. The extent of power outages can be measured by their frequency, their duration, or firms' self-assessment of the severity of the issue or the associated losses (Lineweber and McNulty, 2001; Jyoti and Ozbafli, 2006). The first two are referred to objective measures, while the last ones are subjective measures.

Power outages can affect businesses activities through a variety of channels, which eventually lead to negative effects on productivity. First, there is the efficiency channel, through which discontinuous power provision is synonymous with disruption in the production process, causing productive resources to lie idle, resulting in lower output level. Second, there are the costs associated with the replacement or repair of broken machines and equipment on the one hand, and the cost related to the spoilage of finished products or inventory on the other. Further, power shortages lead to extra cost to firms, because they often have to rely on alternative sources of energy, like rented or self-owned generators. Third, there is the quality channel, which is related to the rush to meet deadlines due to anticipated power outages, spoiled inventories, or malfunctioning machines. These phenomena could all affect the quality of a good or service produced

[2] YENIYF: The Youth Employment Network and the International Youth Foundation

by a business. This means businesses have to produce more goods to replace the low-quality units, or discarded units. Consequently, production cost further increases. Fourth, there is the uncertainty channel, which comes about because businesses could not predict with any accuracy the occurrence of power outages. This situation translates into uncertainty in meeting deadlines, getting materials from suppliers on time, or profiting from new market opportunities. In the end, it could lead businesses to idle more capital, and hire fewer workers consequently.

All these impediments lead to lower productivity or efficiency. The latter is measured in this paper using data envelopment analysis (DEA). Three indices of efficiency are considered: the cost efficiency, the technical efficiency, and the scale efficiency scores.

The economic effects of power outages on firms' activities have been analyzed in many studies (Lee and Anas, 1992; Steel and Webster, 1991; Adenikinju, 2005; Uchendu, 1993; Beenstock et al., 1997; Bernstein and Heaney, 1988; Caves et al. 1992; and Matsukawa and Fuji 1994). Most of these papers estimate the costs of power outages through either a subjective approach (self-assessment of lost production), or an objective approach (in which electricity intervenes directly as an argument in a production function). These various approaches, coupled with the specificities of countries under study, have translated into a wide range of estimates, which make it difficult to generalize the findings. Further, it seems that little attention has been devoted to the effect of power outages on productivity. Therefore, an analytical framework combining different approaches and extending the analysis of the costs to productivity losses would offer an important insight to the literature on the effects of power outages on firms' dynamics.

The main objective of this study is to quantify and analyze the adverse effects of power outages on the productivity of SMEs in Senegal. To that end, we analyze how each measure of power outages affects firms' productivity, in both its technical and allocative efficiency, and whether various alternatives to power generation are effective in mitigating the potential productivity losses associated with power outages.

To analyze the performances of businesses in the context failing electricity service, we use a cross-sectional study design. Data are collected from a sample of 528 businesses, with 2011 as the reference year, in Dakar, Kaolack, Saint Louis, and Thiès. A wide variety of statistical information is collected, mainly on electricity usage, output and inputs, the individual features of firms, and the characteristics of the business environment. This stock of information allows us to first generate measures of productivity using a non-parametric approach based on the widely used DEA analysis, and then model these productivity scores alternatively using a parametric framework.

In the results, power outages duration appeared to have a positive and significant effect on firms' productivity as measured by cost and technical efficiency scores, but also a negative effect on scale efficiency. This indicates that power outages, normally a hindrance to production, turned out to trigger best management practices from businesses, which mitigate the adverse effects of power outages. However, power outages did have a negative impact on scale efficiency, that is, in the context of power outages businesses were not motivated to grow toward their efficient scale. More importantly, the availability of loans or credit lines helped businesses to be more efficient in scale and technically.

The remainder of the paper is organized as follows: the next section presents the literature on power outages; section 3 explores the electricity sector in Senegal; sections 4 and 5 cover the methodology and data analysis, section 6 discusses the results; and at last, section 7 makes conclusions.

2. Literature Review

Power outages affect both developed and developing countries. This is shown in the relatively vast literature that covers firms from both parts of the world. However, the extents of their magnitude, their frequency, as well as their underlying causes differ from one group to the other. Developing countries turn out to be more affected by insufficient provision of electricity power, and within these countries, SMEs appear to suffer the most (Lee and Anas, 1992; Steel and Webster, 1991).

Electricity is a significant component of virtually any production process. As such, limited supply has the potential to, directly and/or indirectly, affect the economic activities of firms. In documenting such a crucial economic role of energy, a common approach in the literature is to measure the output loss associated with electricity outages. One of the analytical frameworks used is a production function in which electricity contributes directly to firms' output as a separate input, and indirectly as a determinant of the extent to which other direct inputs such as capital equipment is used (see for instance Adenikinju, 2005).

An alternative approach, a subjective method, is based on self-assessment by which surveys ask firms to quantify the loss they incur due to power outages. This approach relies on the assumption that firms well positioned to provide relatively accurate valuation of how much it cost them to replace more frequently or to repair damaged machinery or equipment, or to assess the lost output due to idled inputs. A simple approach to evaluate the costs of power outages consist of just aggregating the cost amounts provided in the survey. However, many biases can plague the outcome, since firms may have the tendency to overestimate the incurred costs, hence, over-emphasizing the constraint that electricity poses to their business activity (see Uchendu, 1993).

An indirect approach similar to the latter is based on how much firms spend on acquiring and running generators. As shown earlier, firms may turn to the generation of their own electricity. Such approach offers better insights than the former based on a production function, because it may be impossible to differentiate between electricity-constrained firms that are functioning properly thanks to generators and firms that are not facing power outages. Compared with the self-assessment approach, the values one gets from this proxy method tend to be more accurate, or at least less prone to biases that are associated with firms' own assessment. However, this proxy method is not immune from problems, in the sense that the amount spent on power generation may not provide clear indication on the true cost of power outages. In fact, some firms, facing financial constraints (which could result from power outages), may not be able to satisfy their whole need of energy. Further, just relying on how much they spend on generators could exclude firms not using generators and thus have a tendency to systematically under estimate the cost associated with electricity outages (see among others Beenstock et al., 1997; Bernstein and Heaney, 1988).

These analytical frameworks have generated different estimates of the cost of electricity shortages to firms. The literature documents a wide range that varies across countries, industries, and firms. For instance, Caves et al. (1992) suggest that the costs range between $1.27 and $22.46 per kWh, and that the costs to SMEs were, systematically, higher compared with those of large businesses. These costs also appeared to be higher compared with those incurred by households, for whom the numbers varied between $0.02 and $14.61 per kWh. Other studies suggested even larger numbers. For instance, Matsukawa and Fuji (1994) estimated the cost to Japanese firms at $118 to $149 per kWh.

These large differences appear to be related to the various specificities of countries and industries, as well as the methodological approaches used in the estimation of the costs of power outages. To deal with this apparent sensitivity, we will try to combine various approaches to measuring the incidence of power

outages. Both objective and subjective measures of power outages will be used alternatively, that is, the frequency, and the length of electricity outages, and firms' self-assessment of the extent to which electricity is an obstacle to firms' activity.

3. Electricity Sector Background in Senegal

A favorable business environment is crucial for the development of businesses. Within that environment, the quality of the inputs, and that of the electricity, especially in Senegal, is of a particular importance, because of the crisis the sector has undergone over the past decade.

As in many formerly colonized developing countries, Senegal also tried to fill the gap created by decolonization. Because of the weak local private sector, the government got involved in the production of certain goods and services, and sectors such as water and electricity were nationalized.

Until 1960, the production of electricity was mostly private. In the late 1960s and early 1970s, however, the nationalization process started; the first phase covered the 1972-1983 period, with the signing of an "affermage" contract (EDS) and the creation of a public company, the Senegalese Electricity Company (SENELEC); the second phase started in 1983 with the creation of a national company, SENELEC, holding the monopoly in the sector.

Until 1996, the sector went through many problems, and bore heavily on the public finances, triggering pressure from major lenders (World Bank, and the IMF) for the privatization of electricity distribution in Senegal. In fact, below-target investment, combined with poor maintenance of dilapidated generation facilities, led to a poor quality of service with an increasingly high number of power outages. Many businesses that could afford it settled on generating their own power.

The privatization process started effectively in December 1996, and in March 1999, 34 percent of the shares of SENELEC were sold to Hydro-Quebec International and Elyo jointly. This first privatization of the electricity sector in Senegal lasted only 18 months. A new elected government in Senegal, in 2000, bought the shares sold to Hydro-Quebec International and Elyo and launched a second privatization process in 2001 that weighed less on the bidding price, and more on the technical and investment issues, and the majority of the shares tendered. This privatization has been unsuccessful so far.

As of 2010, 33 percent of the electricity delivered to SENELEC comes from the Manantali hydroelectric plant, and the rest of the electricity used in Senegal comes from thermal production using liquid hydrocarbons. The company's own production went down by 10.4 percent between 2009 and 2010, which was in part compensated by an increase in the purchase of electricity from private suppliers by 22.1 percent; total production, in the end went up by 5.2 percent.

The deficit in electricity production led to deep decrease in the service quality, with the deficit in production increasing by 121 percent in 2010, mainly due to problems related to fuel supply, maintenance, investment, and the network (Electricity Sector Regulation Commission for of the (ESRC), 2011). With power outages frequently occurring at a daily rhythm, around 97 percent of all businesses surveyed in Senegal by the World Bank in 2007 have experienced electricity-related problems, and almost all of them used generated electricity; at least 37 percent own or share their generator against 63 percent not having generators at all. With only 16% of projected investment in electricity production actually undertaken (10.227 vs. 63.885 billion CFA Francs in 2010), it is very likely that the increasing demand will not be satisfied (WB, 2007; ESRC, 2011). Small and medium enterprises, and particularly the small ones that have problems generating their own power, will run into a great deal of problems in their operations. Profitability will be at risk,

leading to problems such as refusal of funding by banks, or lack of internally generated financial resources to develop or integrate new technologies.

4. Methodology

In this research, we describe the constraints and performance of businesses in the context of failing electricity service. Further, we quantify and explain how establishments' performance is related to some of their characteristics, as well as to some characteristics of the environment in which they evolved. The study is cross-sectional in its design. Data are collected on a sample of businesses, with 2011 as the reference year. After a descriptive analysis of the information obtained, we proceed with an econometric analysis to evaluate how businesses' productivities are related to power outages.

4.1 Questionnaire and Sampling Methodology

The methodological approach relies on collecting firm-level data. A survey was conducted in early 2013. The questionnaire was made up of seven main sections, each focusing on a specific aspect of businesses. Sections 1 and 2 aimed at collecting identity data and general information on the sampled units (age, sector, size, legal status, ownership, management, etc.). Section 3 focused on the main idea of this study, which is electricity (source, self-generation, outages, estimated losses, etc.). Sections 4 and 5 dealt with production and cost-related issues (turnover, market destination, type, costs, investment, market structure, capacity utilization, etc.). Finally, section 6 tries to capture how businesses are related to the financial sector (relationships with banks), while section 7 covers employment-related questions (distribution of workers by gender and qualification, types of labor contracts, etc.).

The final sample was drawn from a list of more than 6.000 businesses stratified based on two criteria; regions (Dakar, Thiès, Saint Louis, and Kaolack) and sectors (construction, commerce, industry, and other services). The proportion of businesses by region and by sector was maintained to determine the final number of sampling units to be surveyed. For each region, and for each sector, the sample units were drawn randomly.

4.2 Econometric Analysis

Our empirical approach consists of two parts. The first part deals with the evaluations of firms' performance. Here we use two approaches. One is technical efficiency, in the sense of firms' ability to extract the most output out of a given set of inputs. Another one is allocative efficiency, which consists of minimizing the use of inputs for a given level of output. In each case, we compute a measure of multifactor productivity (MFP). To do so, we use a non-parametric approach based on Data Envelopment Analysis (DEA), which is very popular in evaluating firms' performance (Cooper et al., 2007). Unlike measurement strategies based on econometric regressions, such an approach makes no prior hypothesis about the data generating process, and instead lets the data reveal the most appropriate functional form of, say, the technical process that transforms inputs into output.

More precisely, the DEA approach is based on linear programming techniques that derive an efficient frontier. The best-performing firms in the sample are used to draw the efficiency frontier; the efficiency of the remaining units is measured relatively to the former. Therefore, firms located at that frontier are considered to operate at full potential, meaning either producing the maximum level of output for the inputs it mobilizes, or operating with the least amount of input to obtain a given level of output. Most of the time,

firms operate below the efficient level. The DEA approach provides index numbers that tell how far each firm is from the efficient frontier. The indices vary from zero (a zero output and non-zero input) to one (the highest level of efficiency).

The second part uses alternatively each measure of efficiency (technical and allocative) and tries to understand what may drive differences in firms' performance, in a regression analysis. We regress the efficiency score on two sets of explanatory variables E and X, as shown in Equation (1)

$$Y_i = \alpha_0 + E_i\gamma + X_i\beta + \varepsilon_i \quad (1)$$

where Y_i is the efficiency score of firm i, E_i a set of regressors related to electricity, X_i a vector of characteristics associated with businesses and their environment, α_0, γ, and β the model parameters, and ε_i an error term. The survey collected information on electricity outages, namely their frequency, duration, and severity. Variables related to a firm's characteristics include its size, age, ownership, manager profile, capital per worker, human capital, and whether it possesses alternative sources of electricity (i.e. generators). The variable that captures the business environment is whether the firm is located in a free-trade zone, which makes them eligible for some fiscal advantages on their purchases of inputs and on profit, in their export and import activities.

5. Data

The data were collected on businesses in four regions in Senegal, Dakar, Kaolack, Saint Louis, and Thiès. Completing the survey met some challenges worth mentioning. The first one was related to non-cooperative units. Some businesses refused to respond to the survey, fearing the data might fall into the hands of the tax administration. The second challenge was related to non-existing firms still in the data. The last challenge consisted of displaced firms, which might still exist, but their addresses were not up-to-date in our sampling list. The treatment of all these three issues remained the same: The corresponding unit was replaced by another unit drawn randomly in the same sector and within the same region. Questionnaires were filled on 528 businesses in total, with Dakar accounting for 328, Kaolack 30, Saint Louis 70, and Thiès 100.

Based on the number of employees, there were 411 small firms, 104 medium ones, and 13 large businesses, accounting for respectively 77.8, 19.7, and 2.5 percent of the whole sample. These firms were distributed across two broad sectors: services and manufacturing. The bulk of the sample is in the former sector, which represents around 79 percent of the surveyed firms. They mainly operated in wholesale, retail, and other non-specified areas. The manufacturing businesses were mostly found in activities related to food processing, textiles and garments, chemicals, rubber and non-metallic minerals, and machinery and equipment; the details are shown in Table 1.

Table 1: Distribution of sampled firms across sectors and size

	SMEs				Total SMEs	Large Enterprises
	Dakar	Thiès	St Louis	Kaolack		
	percentages					
Agrifood	1.9	3.5	1.5	1.0	1.8	0.0
Textile and garments	1.3	0.0	10.1	2.0	2.5	0.0
Chemicals rubber and non-metallic minerals	2.2	0.0	4.3	0.0	1.9	0.0
Machinery and equipment	3.8	3. 5	7.3	3.0	4.1	7.7
ITC and electronic appliances	2.8	3.5	8.7	1.0	3.3	0.0
Construction	6.9	3.5	1.5	10.1	6.6	7.7
Wholesale and retail	29.6	48.3	36.3	49.3	35.3	7.7
Hotels et restaurants	5.0	10.3	10.1	4.0	5.8	0.0
Transportation	3.5	0.0	0.0	1.0	2.3	7.7
Other services	38.7	24.1	14.5	27.3	32.4	69.2
Other Manufacturing	4.4	3.5	5.8	1.0	3.9	0.0
Total	100	100	100	100	100	100
Count	318	29	69	99	515	13

Source: Enterprises Survey, 2013

Table 2 shows some of the general characteristics of the surveyed firms. The average age was 16.22 years for SMEs and 18.42 for large businesses. When it comes to the legal status, businesses tend to prefer to be limited liability corporations (LLC), and on average, around 40 percent of SMEs and 84 percent of large businesses have adopted this legal status. The structure of firms' ownership appears to be very concentrated: the shares of the main owner in ownership were 87 and 75 percent on average, respectively, for SMEs and for large businesses. Domestic owners controlled around 87 percent of the shares of SMEs and 62 percent of large businesses. Further, most of the businesses sold much of their output in domestic markets, with 93.4 and 83 percent for SMEs and larger businesses, respectively.

The financial profile paints a picture that is well documented in the literature, of the many constraints enterprises face in their interactions with the banking system. Fewer than 19 percent of SMEs have applied for loans and were rejected most of the time. This proportion was 23 percent among large businesses. The latter suffered less from the financial constraints, with around 31 percent the businesses that applied for a loan having a credit line or a loan, against 15.4 percent for SMEs.

Table 2: General characteristics of businesses

	SMEs				Total SMEs	Large Enterprises
	Dakar	Kaolack	Saint Louis	Thiès		
Age (years)	16.3	20.3	14.8	16.0	16.2	18.4
Limited Liability Corporation (% of firms)	50.2	51.7	14.5	26.3	40.9	84.6
Proprietorship	43.5	41.4	69.6	63.6	50.8	0.0
Share of the main owner in the capital (%)	86.1	84.7	94.00	91.9	86.6	74.8
Domestically Owned shares firms (%)	86.5	83.4	95.9	92.4	87.0	61.8
Output sold in domestic markets (%)	93.0	97.2	98. 7	98.1	93.4	83.4
Businesses that applied for a loan (%)	18.0	34.5	10.1	19.2	18.1	23.1
Average number of applications	2.0	1.4	2.1	1.3	2.0	1.7
Application rejected (average)	1.2	0.4	1.0	0.4	1.1	0.6
Establishment with a credit line/loan (%)	15.2	37.9	7.3	15.2	15.4	30.8

Source: Enterprises Survey, 2013

The energy sector in Senegal, electricity especially, is dominated by one big public firm, SENELEC. Ninety nine percent of enterprises reported SENELEC as their main provider of electricity. It is therefore clear that

the crises undergone by this company will challenge almost all businesses. Table 3 summarizes data on electricity and electricity-related issues. The year 2011 will remain among the periods most affected by power outages. Fifty seven percent of total businesses reported electricity as a major concern; taking size into account, this affected 57, and 62 percent of SMEs and large businesses respectively. In fact, in a typical month power outages occurred 26 times on average for the former and 15 times for the latter, with an outage lasting 2 hours in general. Regions seemed to have a different experience, with Thiès leading in both the number and length of power outages, with respectively 35 times a month and a duration of 3 hours per outage on average. Consequently, businesses faced a certain number of challenges, leading to some adjustment or coping costs. For instance, 41 percent of SMEs and 46 percent of large businesses reported that production stopped during power outages. Businesses that continued operating during outages had their capacity reduced to around 80 percent for SMEs and 90 for larger businesses. The immediate consequence following this problem was related to whether or not wages for idled worker were paid. Ninety-six and 99 percent of SMEs, among those for which activities stopped during outages, and all of their larger counterparts, reported paying wages for workers in electric outage time. That was probably because wages were, and still are, negotiated on a monthly instead of an hourly basis in Senegal. Nonetheless, it could be a major source of inefficiency since more output could have been reached for the same cost. For businesses in agri-food, the losses could take other forms like losing stocked outputs that were heavily electricity-dependent, dairy products for instance. Respectively, 27 and 15 percent of SMEs and large enterprises reported their product quality to be affected by power outages. In the end, SMEs reported losing 10.1 million FCFA, against 346 million for large businesses, amounting in relative terms, respectively, to around 4.8 and 8.25 percent of their total sales in 2011.

Besides the costs mentioned above, power outages could cause many other inconveniences that trigger uncertainty in business activities with its load of costs that could come in many ways. Every business is connected to the rest of the economy, and further, to the rest of the world, by linkages to suppliers (backward linkages) and customers (forward linkages). Any constraint, especially one affecting production directly as is the case of electric power outages, on a supplier could translate into a constraint for a business and further to its customers.

Forty-six percent of SMEs and large enterprises have experienced delivery delay from their suppliers. On the other hand, 56 and 83 percent of SMEs and large businesses reported to have experienced delivery delay to their customers. These inconveniences are very rarely isolated. They often lead to some more unfavorable situations such as facing penalties, and/or losing customers or some market opportunities. Five percent of SMEs, and 12.5 percent of large enterprises, for example, have faced some penalties because of delivery delays; further, 4.3 and 12.5 percent of SMEs and of large businesses, respectively, reported having lost market opportunities due to power outages. The uncertainty created by these issues could have some ramification directly related to the dynamic of the businesses in terms of investing more in capital or hiring more workers. In fact, 24 percent of SMEs reported that their hiring decisions are affected by power outages; the figure was 34 percent for investment decisions. For large enterprises, the figures were, respectively, 15 and 31 percent. One would expect, therefore, scale efficiency to be adversely affected by power cuts.

In a heavily oil-dependent country with an inefficient energy-production sector, one would expect the constraints electricity poses to business activities to be relatively very pronounced. Table 4 puts the energy profile of Senegal in the wider context of Sub-Saharan Africa (SSA) and the world. Enterprises in Senegal appeared to face more electricity constraints compared to their African and global counterparts. To begin with, 57 percent of businesses identified electricity as a major constraint to their activities, which was above the average for SSA and in the world, but less than in Nigeria. In a typical month, businesses faced power outages 26 times on average, which is more than twice the frequency observed in SSA, and three times the world average. Nigeria, however, had the same frequency. A typical power outage lasted 2.29 hours on average, which was less than the duration in the regions retained for comparison.

Table 3: Electricity and Power Outage related issues

	SMEs				**Total SMEs**	**Large Enterprises**
	Dakar	Kaolack	Saint Louis	Thiès		
Supplied by SENELEC (%)	98.7	99.0	100.0	100.0	99.0	92.3
Average price per kWh (CFAF)	170.8	191.9	177.7	213.7	173.0	198.1
Average electricity consumption electricity month (kWh)	2684.6	4255.7	1101.5	1514.2	2599.0	6222.1
Electricity is a major concern (%)	55.2	58.6	65.2	58.8	57.4	61.5
Number of electrical outages in a typical month	25.6	18.2	20.8	34.9	25.8	14.9
Duration of a typical electrical outage (hours)	2.2	1.4	1.8	3.1	2.3	1.6
Does production stop in case of a power outage? (% of yes)	44.6	44.8	35.8	31.6	41.0	46.2
Are wages paid in case of a power outage? (% of yes)	98.4	100.0	100.0	99.0	98.8	100.0
Is product quality affected by power outages (% of yes)	28.6	27.6	21.7	27.3	27.4	15.4
Losses due to electrical outages (total value, millions of CFAF)	10.3	3.8	0.9	5.4	10.1	346.0
Losses due to electrical outages (% of annual sales)	4.9	0.9	5.2	4.4	4.8	8.3
Average capacity utilization because of power outages	80.3	74.8	90.3	77.8	80.6	90.6
Do power cuts affect hiring decisions (% of yes)	25.9	10.3	32.4	17.2	24.2	15.4
Do power cuts affect investment decisions (% of yes)	32.8	34.5	40.6	31.3	33.7	30.8
Delivery delays from suppliers due to power cuts (% of yes)	50.5	34.5	44.9	39.4	46.7	46.2
Delivery delays to customers due of power outages (% of yes)	58.6	50.0	45.9	56.3	55.9	62.5
Associated penalties (% of total sales)	4.0	7.1	0.0	11.3	4.8	12.5
Loss of customers	17.3	28.6	32.8	22.5	21.0	0.0
Loss of market opportunities	4.4	7.1	4.9	2.8	4.3	12.5
Other inconvenience	15.7	7.1	16.4	7.0	13.9	12.5

Source: Enterprises Survey, 2013

Because of the higher frequency of power outages, the proportion of firms that own generators is much larger in Senegal than elsewhere. Almost 91 percent of firms generated electricity from alternate sources, which amounted to 31 percent of total electricity used. In SSA, the figures was 44 percent of businesses owning or sharing a generator, for 13.8 percent of electricity used generated, lower than in Nigeria (44% of businesses, 48% of electricity) and in the world at large (32% of firms and 7% of electricity generated).

The proportion of firms that owned a generator was greater in our sample than that revealed by the World Bank Enterprises Survey for Senegal in 2007, which was 49 percent. That could be explained by a worsening of the crisis in the electricity sector in Senegal, with the government so far failing to bring any significant institutional change in the sector. This effort on the part of firms was translated into a larger proportion of self-generated energy consumption. This adaptation strategy appears to be paying off, since it seemed to have helped avert the negative impact of power outages. In effect, the average losses due to power outages amounted to 5.1 percent of total sales, which was lower than the SSA (6.7% of sales) and Nigeria (8.9% of sales), but a bit higher than the world average of 4.8 percent.

Table 4: Power Outages in Senegal, in Sub-Saharan Africa, and in the world

Indicator	Senegal* (2011)	Nigeria	Sub-Saharan Africa	World
Number of electrical outages in a typical month	25.8	26,3	10,7	8,6
Duration of a typical electrical outage (hours)	2.3	8,2	6,6	4,0
Losses due to electrical outages (% of annual sales)	5.1	8,9	6,7	4,8
Percent of firms owning or sharing a generator	90.7	85,7	43,6	31,6
Proportion of electricity from a generator (%)	30.8	47,5	13,8	7,1
Percent of firms identifying electricity as a major constraint	57.5	75,9	50,3	39,2

*Sources: Adenikinju, 2005; * from Enterprises Survey, 2013.*

The productivity of businesses may be measured using three types of productivity indices: cost efficiency, technical efficiency, and scale efficiency scores. These scores of efficiency are typically measured using data envelopment analysis, which uses the concept of relative efficiency. The output variable used is the total sales of businesses; the inputs are capital and labor. A business is efficient given the available information if, compared with other businesses, its output cannot be improved with the level of input it uses, or if, given its level of output, its input usage cannot be improved (Cooper et al. 2010). This definition refers to technical efficiency, which is evaluated by comparing each business to its most similar units in terms input- and output mixes on the frontier. Scale efficiency refers to a business's ability to choose the optimal scale of production to generate a given level of output. It considers the fact that a bigger or smaller size in producing a given production level could induce some inefficiency in a business. And cost efficiency, which is also referred as economic efficiency, integrates both technical efficiency and allocative efficiency. The latter accounts for whether the business is using, given their prices, the least costly combination of inputs (Coelli, 1996).

Considering cost efficiency and technical efficiency, in general, firms were very far away from their efficiency frontier. As shown in Table 5, the average scores were 0.063, 0.019, and 0.413, respectively, for cost, technical and scale efficiencies for SMEs. Large businesses seemed to have a lower efficiency scores except for scale efficiency, where the average score was above 50 percent. SMEs appeared to score better in cost and technical efficiency, while their larger counterparts did better in scale efficiency.

Table 5: Distribution of Efficiency Score across Firms

		SMEs	Large Enterprises	Total
Cost Efficiency	Mean	0.06	0.02	0.06
	Std. Dev	0.00	0.00	0.00
Technical Efficiency	Mean	0.02	0.01	0.02
	Std. Dev	0.00	0.001	0.00
Scale Efficiency	Mean	0.41	0.52	0.41
	Std. Dev	0.02	0.08	0.02

6. Estimation Results

In the regression analysis, the dependent variables are the efficiency scores, which are proportions since each firm's performance is given relative to the best-practice peer on the frontier. The dependent variables are therefore bounded between zero and one, with the possibilities of some observations taking the values zero or one. OLS estimates of such variables could lead to some nonsensical predictions with values outside the boundaries. Models to handle these types of data were developed by Papke and Wooldridge (1996), and implemented in Stata using a generalized linear model (GLM) (Baum, 2008). Nevertheless, the OLS

estimates, considered as benchmarks, are presented in the appendixes in tables A5-A7. Tables 6-8 present the results of the GLM estimates of the different productivity scores on some power outage measures, and on some firm and business-environment characteristics.

Table 6 shows the estimation results for firm productivity as measured by cost efficiency. In columns 1 and 3, electric power outages are measured by the number of power outages in the year, or by a dummy (major_concern) that takes on the value of one if a business considered electricity as a major problem and zero otherwise. None of these variables showed a significant effect on cost efficiency. However, when we consider the duration of the power cuts (column 2), it had a positive and significant effect on cost efficiency. Common sense leads one to expect a negative effect. These results, if odd in some ways, could reveal successful coping strategies by businesses to poor electricity service. From the early 2000s until 2012, power outages were occurring on a daily basis. With an average of 26 outages a month, businesses were therefore experiencing power outages more than once every business day. Let us also note that among businesses that identified electricity as a major concern, the proportion owning or sharing a generator increased from 47 percent in 2006 (World Bank's business environment survey in Senegal) to 90 percent in 2011. Table 7 displays similar results, with electric outage duration affecting positively and significantly productivity, as measured by technical efficiency. Apparently, businesses learn to get by the electricity issues. When power outages, in a long period, become daily events, as in Senegal, one would naturally expect businesses to organize their activities in ways that could cancel the rationally expected adverse effects. The strategies could come in the form of shifting workers from tasks intensive in electricity to tasks that are less demanding, or that do not need electricity; and/or businesses could intensify production at times when electricity was still running. Electricity outages, while a hindrance to production activities, appeared in this context as a source of motivation to better management practices. This explanation, however, is plausible only when one considers two factors. First, if one considers the level of efficiency scores of businesses in 2011 (table5), cost and technical efficiencies had averages of 6.3 and 2 percent respectively. At such a low level of productivity, it could be understandable that, in their effort to get by power outages, businesses ended up doing better. With respect to scale efficiency, however, the average score were 41.3 percent, which is much larger than the cost and technical efficiency scores. At higher level, progress is more difficult; therefore, it would make sense that businesses received adverse effects on scale efficiency in the context a frequent electric power outage. Second, faced with some extra costs due to power outages, only the more dynamic and productive businesses survived, the inefficient ones exited the markets. Therefore, the positive effect could be much because of a survival bias.

All three measures of the quality of electricity service, that is, the number and duration of outages, and the dummy measuring whether electricity is a major concern for the business, had negative and significant effect on scale efficiency. While one can understand that firms resort to better strategies to cope with electricity outages, growing a business in such a context is, however, a different issue. It makes sense that this environment would hinder the motivation for firms to grow. In fact, some businesses confessed that their hiring and/or investing decisions are affected by power outages. It seems, therefore, that the ability of businesses to reach the optimal scale of production was constrained somehow by the poor quality of electricity service.

These results make sense if one considers the level of efficiency scores of businesses in 2011 (Table5). Cost and technical efficiencies had averages of 6.3 and 2 percent respectively. At such a low level of productivity, it is understandable that, in their effort to get by power outages, businesses ended up doing better. With respect to scale efficiency, however, the average score was 41.3 percent, which is much larger than the cost

and technical efficiency scores. At a higher level, progress is more difficult; therefore, it would make sense that businesses faced adverse effects on scale efficiency in the context frequent electric power outages.

To avoid the adverse effects of power outages, many firms developed coping strategies consisting of generating their own electricity by means of owning, sharing, or renting a generator, or else by getting electricity from a self-producer. The variable, *solution,* is introduced to capture the effects on productivity of businesses having a solution to their power outage issues. This variable had a negative significant effect on cost efficiency, which is understandable for, for a given level of output, an alternative source of electricity would only add more cost. Further, because of the economies of scale associated with such a public utility, the unit cost to a given firm producing electricity for its own use should be far greater than the unit cost incurred by a large monopoly firm supplying a larger market. In fact, the kilowatt per hour of electricity has cost businesses that had an alternative solution 12129.7 FCFA, against only 179.4 when it was from SENELEC. Therefore, to produce a given level of output, businesses would incur a greater cost by generating their own electricity than by obtaining it from the market. However, as one would expect, an alternative source of energy has a positive and significant effect on technical and scale efficiencies. Naturally, at times of power shortage, businesses without a solution would have no choice but idle part of their capital and consequently, some of their workers. Having a solution at hand to that problem allowed enterprises to use more of their capacity than otherwise. Consequently, they were able to produce more, which could explain also the positive significant effect on technical efficiency.

The level of capital per worker had a negative significant effect on both cost and technical efficiencies. Capital per worker increases either because of a capital increase or of a labor decrease. These cases could mean that too much capital is available, thus an extra cost, or there are too few workers for the available capital, thus in both cases capital is less productive. Therefore, cost and technical efficiencies would be adversely affected. Scale efficiency, however, is positively and significantly affected by capital per worker, which is expected. This result implies that most businesses were operating on the economies of scale part of their production function, using less capital than the long-run cost-minimizing level.

SMEs appeared to perform better compared with their larger counterparts by all measures of productivity. In effect, as indicated in Tables 6-8, the coefficient estimates of the variable *sme*, appeared positive and significant, and the magnitude was larger for cost efficiency, followed by technical efficiency. This result confirms what the statistical analysis showed in Table 5, with SMEs performing relatively better compared with larger businesses. It implies, therefore, that SMEs did a better job of cost and production management; further, they appeared to be closer to their efficient scale compared with larger ones. In fact, given their size, SMEs are more flexible in implementing adjustments in management, which puts them ahead in such an environment in terms of productivity.

The proportion of skilled labor in the work force, and the level of education of the manager, did not show a significant effect on cost and technical efficiencies, but they affected scale efficiency positively and significantly. In contrast, scale efficiency did not appear to be affected by the experience of the manager in the sector of activity, which had a positive and significant effect on cost and technical efficiency. Scale efficiency, therefore, seemed to draw more on human capital in the work force and the education of the manager, while cost and technical efficiency drew more on the experience of the manager.

The older the businesses, the less cost- and technically efficient they are, but they appeared to be more scale efficient. Enterprises in free trade zones performed better in terms of technical and scale efficiencies, while they did poorly in terms of cost efficiency. The larger the share of the main owner of a business, the less well it did in scale efficiency, but when considering cost and technical efficiencies, however, the effects

were not significant. The domestically owned share of businesses had a positive significant effect on cost efficiency, but the effect on technical efficiency was negative and significant.

Loans and credit lines come with a cost for businesses, since they had to face the payments of capital and interest. One would expect a negative effect of such variable on cost efficiency. Nevertheless, having a loan or a credit line has shown no significant effect on establishments' cost efficiency. However, it had positive significant effects on technical efficiency and scale efficiency. Loans and credits lines were major factors in businesses' technical and scale efficiencies. Probably, businesses in these cases were motivated to manage efficiently, since they face reimbursement on their loan and/or credit. Further, the availability of these funds appeared to have helped businesses to grow closer to their efficient scale.

7. Conclusion

Small and medium enterprises play a crucial role in Senegalese economy, both in terms of wealth and employment generation. Yet, their activities, and even survival, are hindered by many constraints, including poor electric service quality that shows up as daily power outages since the early 2000s. This study was concerned with the measurement of the losses associated with electric power outages, and the analysis of how business productivity is related to those events. Data were collected on a sample of 528 businesses.

Fifty seven percent of businesses indicated that electricity is a major constraint to their activities. That figure was higher than the SSA and world averages, even if it was lower than that of Nigeria. A typical month registered 26 outages on average, with an outage lasting 2 hours and a quarter. Among businesses experiencing hardship because of electricity issues, the proportion of businesses owning or sharing a generator were 91 percent. The average loss finally amounted to 5.1 percent of their total sales, higher than the world average even it was lower than in Nigeria or in Sub-Saharan Africa.

The duration of power outages turns out to be more of a motivation than a hindrance to businesses. Indeed, it appears to have a significant positive effect on cost and technical efficiencies, but this may just reflect survivor bias; further, firms with good electricity sources could have survived even if they are not very efficient. Power outage duration, however, had an adverse effect on scale efficiency, as did the number and severity of power outages. Adapting to these issues allowed businesses to gain on technical and scale efficiencies, but adversely affected their cost efficiency. Access to loans and credit lines had significant positive effects on both technical and scale efficiencies. SMEs appeared to do better compare to their larger counterparts.

The policy implications that could be drawn from these results go first toward promoting a better quality of electricity service. The most efficient businesses coped successfully to the issues brought by power outages, attributing more the positive effects to survival bias. However, they still lagged in scale efficiency, therefore, in growth. Further, solving the electricity outage problems would allow businesses to save on the efforts and resources diverted to coping strategies, and thus gain more on cost efficiency and even technical efficiency if resources are reallocated to improve production management. Second, improving businesses' access to credits and loans would not only strengthen their productivity, but also promote their growth.

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Annexes

Table 6: Determinants of Cost or Economic Efficiency

	(1)	(2)	(3)
	deacost1	deacost2	deacost3
outage_num	0.000		
	(0.000)		
outage_dur		0.006***	
		(0.001)	
major_concern			0.056
			(0.051)
solution	-0.578***	-0.585***	-0.584***
	(0.056)	(0.051)	(0.049)
age	-0.005	-0.005*	-0.005
	(0.003)	(0.003)	(0.004)
lcap_worker	-0.043***	-0.043***	-0.040***
	(0.016)	(0.015)	(0.015)
sme	1.305***	1.273***	1.303***
	(0.055)	(0.028)	(0.034)
hum_cap	0.164	0.138	0.130
	(0.178)	(0.160)	(0.188)
experience	0.010**	0.011**	0.011**
	(0.005)	(0.005)	(0.004)
educ_high	-0.128	-0.101	-0.138
	(0.117)	(0.090)	(0.101)
zone	-0.301***	-0.301***	-0.314***
	(0.044)	(0.053)	(0.032)
capsh_owner	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)
shar_nation	0.004***	0.004***	0.003***
	(0.000)	(0.000)	(0.000)
credit_loan	0.074	0.082	0.093
	(0.060)	(0.067)	(0.057)
N	342	346	347
R2	0.330	0.329	0.322
Dev	188.863	184.605	188.129
pval	0.000	0.000	0.000

Notes: standard errors are in parentheses, and significance at 1, 5, and 10 percent is indicated respectively by ***, **, and *.

Table 7: Determinants of Technical Efficiency

	(1)	(2)	(3)
	te_chn1	te_chn2	te_chn3
outage_num	0.000		
	(0.000)		
outage_dur		0.005***	
		(0.001)	
major_concern			0.017
			(0.063)
solution	0.247***	0.217**	0.228***
	(0.072)	(0.087)	(0.074)
age	-0.006***	-0.007***	-0.006***
	(0.001)	(0.001)	(0.001)
lcap_worker	-0.022***	-0.021***	-0.020***
	(0.006)	(0.006)	(0.006)
sme	0.902***	0.840***	0.899***
	(0.068)	(0.081)	(0.067)
hum_cap	0.049	0.046	0.034
	(0.224)	(0.209)	(0.213)
experience	0.016***	0.017***	0.017***
	(0.005)	(0.005)	(0.005)
educ_high	0.117	0.140	0.115
	(0.170)	(0.176)	(0.168)
zone	0.170**	0.176**	0.171**
	(0.067)	(0.078)	(0.075)
capsh_owner	0.003	0.003	0.003
	(0.004)	(0.004)	(0.004)
shar_nation	-0.001	-0.001	-0.001*
	(0.001)	(0.001)	(0.001)
credit_loan	0.300***	0.297***	0.314***
	(0.057)	(0.061)	(0.058)
N	374	378	379
R2	0.202	0.195	0.194
Dev	76.126	75.592	76.569
pval	0.000	0.000	0.000

Notes: standard errors are in parentheses, and significance at 1, 5, and 10 percent is indicated respectively by ***, **, and *.

Table 8: Determinants of Scale efficiency

	(1)	(2)	(3)
	scal1	scal2	scal3
outage_num	-0.000**		
	(0.000)		
outage_dur		-0.003***	
		(0.000)	
major_concern			-0.106***
			(0.023)
solution	1.008***	0.991***	0.990***
	(0.019)	(0.020)	(0.019)
age	0.008***	0.009***	0.008***
	(0.001)	(0.001)	(0.001)
lcap_worker	0.068***	0.066***	0.066***
	(0.002)	(0.002)	(0.002)
sme	0.390***	0.396***	0.372***
	(0.010)	(0.008)	(0.009)
hum_cap	0.263***	0.284***	0.313***
	(0.009)	(0.007)	(0.014)
experience	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)
educ_high	0.125***	0.114***	0.124***
	(0.014)	(0.012)	(0.010)
zone	0.401***	0.405***	0.432***
	(0.023)	(0.025)	(0.014)
capsh_owner	-0.006***	-0.005***	-0.005***
	(0.000)	(0.000)	(0.000)
shar_nation	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
credit_loan	0.277***	0.292***	0.280***
	(0.023)	(0.022)	(0.022)
N	374	378	379
R2	0.561	0.565	0.566
Dev	1328.745	1348.811	1349.290
pval	0.000	0.000	0.000

Notes: standard errors are in parentheses, and significance at 1, 5, and 10 percent is indicated respectively by ***, **, and *.

Table A- 1: Distribution of Businesses across Activities (percentages)

	Dakar				Kaolack			
	Small	Medium	Large	Total	Small	Medium	Large	Total
Agrifood	0.42	6.41	0.00	1.83	0.00	20.00	0.00	3.33
Textile and garments	1.25	1.28	0.00	1.22				
Chemicals rubber and non metalic minerals	2.08	2.56	0.00	2.13				
Machinery and equipment	2.08	8.97	10.00	3.96	0.00	20.00	0.00	3.33
ITC and electronic appliances	3.33	1.28	0.00	2.74	4.17	0.00	0.00	3.33
Construction	3.75	16.67	0.00	6.71	0.00	20.00	0.00	3.33
Whoolesale and retail	36.67	7.69	10.00	28.96	58.33	0.00	0.00	46.67
Hotels et restaurants	4.17	7.69	0.00	4.88	8.33	20.00	0.00	10.00
Transportation	2.92	5.13	10.00	3.66				
Other services	38.75	38.46	70.00	39.63	29.17	0.00	100.00	26.67
Other Manufacturing	4.58	3.85	0.00	4.27	0.00	20.00	0.00	3.33
	Saint Louis				Thiès			
	Small	Medium	Large	Total	Small	Medium	Large	Total
Agrifood	1.49	0.00	0.00	1.43	0.00	5.26	0.00	1.00
Textile and garments	10.45	0.00	0.00	10.00	2.50	0.00	0.00	2.00
Chemicals rubber and non metalic minerals	4.48	0.00	0.00	4.29	2.50	5.26	0.00	3.00
Machinery and equipment	7.46	0.00	0.00	7.14	1.25	0.00	0.00	1.00
ITC and electronic appliances	8.96	0.00	0.00	8.57				
Construction	1.49	0.00	0.00	1.43	7.50	21.05	100.00	11.00
Whoolesale and retail	37.31	0.00	0.00	35.71	61.25	0.00	0.00	49.00
Hotels et restaurants	8.96	50.00	0.00	10.00	3.75	5.26	0.00	4.00
Transportation					0.00	5.26	0.00	1.00
Other services	13.43	50.00	100.00	15.71	21.25	52.63	0.00	27.00
Other Manufacturing	5.97	0.00	0.00	5.71	0.00	5.26	0.00	1.00

Table A- 2: Definitions of the Variables

Variables	Definitions
ce_deacost	Cost or economic efficiency
te_chn	Technical efficiency
scal_e	Scale efficiency
age	Age of enterprises
capsh_owner	Capital share of the main owner
credit_loan	Does the business benefit from a loan or a credit line
outage_dur	Duration of a typical electrical outage (hours)
educ_high	Level of education of the principal manager
experience	Number of years of experience of manager in the sector
hum_cap	Share of skilled labor in total employment
lcap_worker	log of capital labor ratio
major_concern	Severity of power outages
outage_num	Number of electrical outages the year
shar_nation	Proportion of the capital of the business of private national ownership
sme	Is the business an SME or not
solution	Does the business have a solution to its power outage problem (generator ownership, sharing or renting, or getting supply from someone else at time of power outage)
zone	Location in a free zone

Table A2:						
			Mean	Std. Err.	Min	Max
SMEs	Dakar	ce_deacost	0.060	0.004	0.008	0.493
		te_chn	0.019	0.002	0.002	0.308
		scal_e	0.414	0.016	0.022	0.998
	Kaolack	ce_deacost	0.134	0.039	0.003	1.000
		te_chn	0.090	0.037	0.002	1.000
		scal_e	0.559	0.043	0.014	1.000
	Saint Louis	ce_deacost	0.114	0.021	0.0102	1.000
		te_chn	0.019	0.003	0.001	0.169
		scal_e	0.319	0.030	0.030	0.935
	Thiès	ce_deacost	0.084	0.013	0.003	0.700
		te_chn	0.024	0.006	0.001	0.643
		scal_e	0.420	0.028	0.364	0.990
	Total	ce_deacost	0.063	0.003	0.003	1.000
		te_chn	0.019	0.001	0.001	1.000
		scal_e	0.413	0.015	0.014	1.000
Large Businesses		ce_deacost	0.020	0.004	0.010	0.031
		te_chn	0.009	0.001	0.005	0.209
		scal_e	0.523	0.077	0.019	1.000
Total		ce_deacost	0.063	0.003	0.003	1.000
		te_chn	0.019	0.001	0.001	1.000
		scal_e	0.414	0.015	0.014	1.000

Table A- 3: Descriptive statistics of variables in regression analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
outage_num	514	313,5	273,7	0	2160
outage_dur	521	27,3	22,4	0	160
major_concern	525	0,4	0,5	0	1
solution	527	0,6	0,5	0	1
age	514	15,3	11,5	1	72
lcap_worker	467	13,2	2,2	5,73	19,58
sme	528	1,0	0,2	0	1
hum_cap	528	0,8	0,3	0	1
experience	513	19,1	9,9	1	66
educ_high	528	0,7	0,4	0	1
zone	525	0,1	0,3	0	1
capsh_owner	460	87,4	24,1	0	100
shar_nation	523	86,7	32,2	0	100
credit_loan	525	0,2	0,4	0	1

Table A- 4: Correlation Matrix of Explicative Variables

	outage_num	outage_dur	major_concern	solution	age	lcap_worker	sme	hum_cap	experience	educ_high	zone	capsh_owner	shar_nation	credit_loan
outage_num	1.000													
outage_dur	-0.049	1.000												
major_concern	0.031	0.123	1.000											
solution	0.072	-0.010	0.056	1.000										
age	-0.025	-0.017	-0.112	0.009	1.000									
lcap_worker	0.065	0.037	0.054	0.171	0.043	1.000								
sme	0.026	0.034	-0.003	-0.072	0.003	0.128	1.000							
hum_cap	-0.029	0.049	0.048	0.032	0.042	-0.095	-0.036	1.000						
experience	0.038	-0.035	-0.090	-0.008	0.532	0.095	-0.025	-0.065	1.000					
educ_high	-0.055	-0.072	-0.019	0.220	0.055	0.031	-0.085	0.221	0.022	1.000				
zone	0.020	0.022	0.083	0.139	0.061	0.162	-0.228	-0.045	0.018	0.032	1.000			
capsh_owner	0.064	0.023	-0.015	0.024	0.063	0.038	0.183	-0.091	0.125	-0.006	-0.133	1.000		
shar_nation	0.030	-0.011	0.046	-0.030	-0.141	0.021	0.161	-0.116	-0.053	0.032	-0.010	0.071	1.000	
credit_loan	0.020	0.010	-0.011	0.181	0.003	0.134	-0.097	-0.110	0.047	0.023	0.215	-0.085	0.022	1.000

Table A- 5: OLS Estimates of the Determinants of Cost or Economic Efficiency

	(1)	(2)	(3)
	deacost1	deacost2	deacost3
outage_num	0.001		
	(0.002)		
outage_dur		0.043**	
		(0.017)	
major_concern			0.380
			(0.831)
solution	-3.644***	-3.681***	-3.659***
	(0.869)	(0.836)	(0.846)
age	-0.026	-0.027	-0.025
	(0.032)	(0.032)	(0.032)
lcap_worker	-0.242	-0.230	-0.220
	(0.163)	(0.154)	(0.160)
sme	4.574**	4.342**	4.600**
	(2.011)	(1.937)	(2.004)
hum_cap	1.027	0.930	0.786
	(1.561)	(1.512)	(1.564)
experience	0.054	0.059	0.058
	(0.047)	(0.046)	(0.047)
educ_high	-0.833	-0.696	-0.907
	(1.016)	(0.999)	(1.004)
zone	-1.476	-1.426	-1.574
	(1.102)	(1.062)	(1.227)
capsh_owner	0.008	0.009	0.007
	(0.018)	(0.018)	(0.018)
entr_national	0.019*	0.020*	0.018*
	(0.011)	(0.011)	(0.011)
credit_loan	0.455	0.429	0.567
	(1.076)	(1.036)	(1.074)
N	342	346	347
r2	0.131	0.146	0.129
F	3.042	3.283	3.019
pvalue	0.008	0.005	0.008

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A- 6: OLS Estimates of the Determinants of Scale efficiency

	(1)	(2)	(3)
	scal_e1	scal_e2	scal_e3
outage_num	-0.003		
	(0.006)		
outage_dur		-0.073	
		(0.075)	
major_concern			-2.434
			(3.278)
solution	22.875***	22.467***	22.480***
	(3.313)	(3.295)	(3.329)
age	0.189	0.197	0.182
	(0.165)	(0.165)	(0.163)
lcap_worker	1.563**	1.523**	1.538**
	(0.766)	(0.762)	(0.771)
sme	8.256	8.381	7.894
	(18.594)	(18.739)	(18.759)
hum_cap	6.030	6.542	7.115
	(6.600)	(6.560)	(6.576)
experience	-0.028	-0.022	-0.026
	(0.199)	(0.198)	(0.199)
educ_high	2.810	2.531	2.820
	(3.795)	(3.821)	(3.817)
zone	9.356*	9.488*	10.127*
	(5.638)	(5.725)	(5.828)
capsh_owner	-0.123*	-0.121*	-0.119*
	(0.067)	(0.066)	(0.067)
entr_national	-0.003	-0.004	0.000
	(0.048)	(0.048)	(0.048)
credit_loan	6.508	6.861	6.574
	(4.808)	(4.853)	(4.803)
N	374	378	379
r2	0.244	0.241	0.239
F	9.634	9.788	9.753
pvalue	0.000	0.000	0.000

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A- 7: OLS Estimates of the Determinants of Technical Efficiency

	(1)	(2)	(3)
	te_chn	te_chn2	te_chn3
outage_num	0.000		
	(0.001)		
outage_dur		0.011	
		(0.008)	
major_concern			0.019
			(0.126)
solution	0.439*	0.386	0.408*
	(0.248)	(0.241)	(0.134)
age	-0.012	-0.013	-0.012**
	(0.011)	(0.011)	(0.003)
lcap_worker	-0.046	-0.044	-0.041**
	(0.069)	(0.070)	(0.012)
sme	1.406***	1.318**	1.390***
	(0.537)	(0.510)	(0.171)
hum_cap	0.103	0.103	0.075
	(0.735)	(0.702)	(0.440)
experience	0.032**	0.033**	0.033*
	(0.016)	(0.016)	(0.012)
educ_high	0.195	0.252	0.199
	(0.437)	(0.441)	(0.282)
zone	0.322	0.344	0.325*
	(0.801)	(0.787)	(0.136)
capsh_owner	0.004	0.005	0.005
	(0.005)	(0.005)	(0.006)
entr_national	-0.002	-0.001	-0.002
	(0.005)	(0.005)	(0.001)
credit_loan	0.633	0.633	0.659**
	(0.564)	(0.546)	(0.175)
N	374	378	379
r2	0.084	0.085	0.079
F	1.350	1.364	.
pvalue	0.257	0.249	.

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$