POWER OUTAGES AND PRODUCTIVITY IN MANUFACTURING SECTOR

by

MEHMET MELİH DEĞİRMENCİ

Submitted to the Institute of Social Sciences

in partial fulfillment of

the requirements for the degree of

Master of Arts

Sabancı University

July 2016

POWER OUTAGES AND PRODUCTIVITY IN MANUFACTURING SECTOR

APPROVED BY:

Yrd. Doç. Dr. Esra Durceylan Kaygusuz (Thesis Supervisor) ....

Yrd. Doç. Dr. Remzi Kaygusuz ....

Yrd. Doç. Dr. Sadettin Haluk Çitçi ....

Date of Approval: ..25..07..2016.

ABSTRACT

POWER OUTAGES AND PRODUCTIVITY IN MANUFACTURING SECTOR

MEHMET MELİH DEĞİRMENCİ

M.A. Thesis, July 2016

Supervisor: Asst. Prof. Esra Durceylan Kaygusuz

Keywords: Power Outages, Productivity, OLS Model, 2SLS Model

This paper examines the possible effects that the power outages might have on the manufacturing sector in ten emerging countries including Turkey. The firm level data used here is retracted from the Enterprises Survey of World Bank and covers the period between the years 2006 and 2013. Ordinary Least Squares (OLS) and Two Staged Least Squares (2SLS) models have been adopted in the regression analysis of the cross-sectional and country based data. Our findings indicate that for ten countries – namely Turkey, Poland, Mexico, Romania, Hungary, Jordan, Brazil, Albania, Bosnia and Bulgaria – in the list of upper-middle income countries by the World Bank, power outages have a significantly negative effect on the respective country's firm level productivity. Specifically, we find that the firms experiencing power outages has productivity level 1.2 percent lower by using 2SLS model. Additionally, we also find that one additional power outage costs a 0.7 percent decrease in the firm's productivity level. Lastly, the average productivity difference between the firms those with a stable generator and non-owners is around 19 percent. These findings suggest that in leading growth and yielding employment opportunities, it is crucial to lower the power outages and improve infrastructural quality.

ÖZET

ÜRETİM SEKTÖRÜNDE ELEKTİRİK KESİNTİSİ VE ÜRETKENLİK

MEHMET MELİH DEĞİRMENCİ

Yüksek Lisans Tezi, Temmuz 2016

Tez Danışmanı: Yrd. Doç. Dr. Esra Durceylan Kaygusuz

Anahtar Kelimeler: Elektirik Kesintisi, Üretkenlik, OLS Modeli, 2SLS Modeli

Bu tezde Türkiye'nin de yer aldığı, gelişmekte olan on ülkede elektrik kesintisinin üretim sektörü üretkenliğine olan muhtemel etkileri incelenmiştir. Dünya Bankası'nın "Enterprises Survey" veri setinden elde edilen 2006 ve 2013 yıllarını içeren firma düzeyi veri kullanıldı. Yatay kesitsel ve ülke bazlı veri setini sıradan enküçük kareler ve 2SLS modelleri ile bağlaşım çözümlemesi yapılmıştır. Bulgularımız, Dünya Bankası'nın üst-orta gelirli ülkeler listesindeki on ülkede (Türkiye, Polonya, Meksika, Romanya, Macaristan, Ürdün, Brazilya, Arnavutluk, Bosna-Hersek ve Bulgaristan) elektrik kesintileri istatistiksel olarak anlamlı şekilde firma düzeyinde verimliliklerini olumsuz etkilediğini belirtmektedir. Özellikle, 2SLS model kullanılarak ulaşılan sonuçlarda, elektrik kesintisi yaşayan firmaların kesinti yaşamayan firmalaralara göre üretkenlik seviyeleri yüzde 1.2 daha azdır. Buna ek olarak, firma bir defa fazladan elektrik kesintisi yaşadığında, firmanın üretkenliği yüzde 0.7 oranında azaldığı sonucuna ulaştık. Son olarak, elektrik kesintisine karşı jeneratorü olan ile olmayan firma arasında ortalama yüzde 19'luk üretkenlik farkı olduğu sonucuna ulaştık. Bu sonuçlar, büyüme ve verimli istihdam olanakları açısından elektrik kesintilerinin azaltılmasının ve altyapı kalitesinin artmasının önemini ortaya koymaktadır.

ACKNOWLEDGMENTS

First of all, I am grateful to my thesis advisor, Esra Durceylan Kaygusuz, for her guidance throughout my M.A. education. She has helped me in this thesis with her valuable suggestions, motivated me when the problem I tried to solve seemed unsolvable, believed in me from the beginning, and trained me in preparation for my future studies. I also thank my thesis jury members, Remzi Kaygusuz and Sadettin Haluk Çitçi for examining my thesis.

I am grateful to the economics program at Sabanci University for giving me the opportunity to pursue my M.A. degree and for providing me the background knowledge to write this thesis.

Lastly, I would like to thank my wife Şehnaz Değirmenci, my friends and parents who have supported me in all possible ways throughout my life.

TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

Many of today's developing countries have instable power supply with high disruption costs, which has negative effects on efficiency, growth and competitiveness (Oshikoya and Hussain, 2001). Although Turkey has access to several energy sources ranging from coal to petroleum, its energy sector is in need of an important infrastructural improvement and investment. In fact, Turkey's electricity problem pertains to the infrastructural shortcomings rather than a lack of electricity thereof. A recent study by EUD (Electricity Producers Association) reports that TEİAŞ, the company managing Turkey's electricity transmission network, hasn't met their targets in connectivity levels set by the government yet. Lack of infrastructural investments and enough maintenance, often causes Turkey, and many other developing countries for that matter, to experience power outages, surges, brownouts and load shedding.

According to Nationwide Utilities' 2011 reports, power outages, which rarely is just a short term annoyance for a company and its employees, may go so far as to destroy a company's whole business. When the business isn't prepared for it, these outages may lead to a downtime, cause firms' data warehouse of information to be destroyed or disrupt the company's operation excessively. Although advance notices are given in case of planned outages, which then let companies to adjust to the upcoming outage and give them enough time to install back-up systems, most power outages are unplanned and stem from infrastructural problems. In both cases of the power outages – i.e. planned and unplanned – generators are used as a short-term solution which increases a firm's fixed costs and thus damaging its competitiveness. In the long term, it's governments' responsibility to overcome the unplanned power outages through better infrastructure.

In the country based analysis, World Bank surveys statistics show that among the ten countries listed in Table 1, Turkey is the one of the most affected countries by power outage. While Albania is at the top of the list with 4.4 times of number of power outage in a typical month, firms in Turkey are exposed to power outage 1.7 times on average compared to only 0.2 day a month in Poland. Besides, this outages cause a considerable loss in output. For instance, on average, power outage gave rise to 1% percent loss for the firms in Turkey whilst Mexico, being at the top of the list, encountered a significant production loss which amounts to 3.4% of total output. Additionally, by cross country analysis, World Bank enterprise survey statistics display that an average of 60% of firms identified electricity outage to be a problem in doing business in their countries. However, only around 30% percent of the firms in the analysis have generators compensate the effect of power outage.

Cross-country analysis of the relationship between productivity and infrastructural quality has so far been very limited due mainly to a lack of homogenous data. In most cases of the previous analysis, the World Enterprises Survey, which is built upon a number surveys conducted across a large number of developing countries, has been used. Thanks to its covering of an extensive list of countries in a homogenous manner, this data makes it possible to compare the productivities of different countries and industries.

The main aim of this study therefore is to investigate the impact of power infrastructure quality i.e. power disruptions on productivity in manufacturing firms of Turkey and some upper middle income countries comparable with Turkey. This paper investigates the effect of infrastructural quality on the productivity of the manufacturing firms in Turkey as well as those operating in similar upper-middle income countries. It's important to note here that the power's role in the production process isn't solely through facilitating the use of electric machinery, but also via adding to the productivity of other factor inputs such as labor. In this paper, we argue that the contribution of the electrical power - or a lack thereof – to the productivity isn't limited to the physical facilities but extends to the value of the outputs as well. Therefore, reliability and stability of the power infrastructure play as much - if not more - role in productivity as the power's availability itself. In this study, we use the number of days or hours spent without electricity and the average time elapsed during the outage as a proxy for the power reliability while also highlighting the importance of the firm specific factors. In other words, this study assumes that the power infrastructure reliability measured by the number of outages in a month to be more important that availability measure with the total production and consumption of electricity per capita.

A common problem faced in econometric modelling of the macro-level determinants of productivity is the endogeneity problem. If the countries have good power infrastructure, they also have high level of production and consumption. Countries with good power infrastructure also have a high production level and consumption, mainly because of their high income (Dollar and Kray, 2003). Thus, high productivity may increase growth and then consequently lead to an improvement in the quality of power infrastructure in a country, which creates an endogeneity problem. By using the firm level data, we may possibly reduce this bias since firms can be assumed to take power infrastructural data as given. At firm level, the quality and quantity of power infrastructure is given and thus not influenced by individual firms but by government policies. This overcomes or minimizes the feedback effects which create the problem of endogeneity. In addition to power related indicators, we also incorporate other firm specific characteristics that may affect the productivity such as firm's age, foreign ownership and presence of a generator.

The other motivation for this research is that studies that explore the relationship between power infrastructure and productivity in Turkey, particularly at firm level, have been very scarce due to the lack of available data. The report titled as "Turkey Investment Climate Assessment" published in 2007 by World Bank states that to improve Turkish firms' productivity, firm's access to infrastructure should be developed by reforming the energy sector. However, the current World Bank survey data provides a better alternative in filling that gap, as power infrastructure quality indicators measured at firm level are now available in the form of average number of days per month or hours a day without electricity as well as percentage of output lost due to power outages.

The World Enterprises Survey on manufacturing sectors from 10 countries namely Turkey, Poland, Mexico, Romania, Hungary, Jordan, Brazil, Albania, Bosnia and Bulgaria is the primary source of data used in this study. The surveys in these respective countries were done between the years 2006 and 2013. Selection process of the countries was based primarily on the list of upper middle income countries determined by World Bank and availability of the comparable data on the variables of interest. In order to analyze the relationship between productivity and power infrastructure variables by using cross-sectional data with considering the year and country specific effects, OLS and 2SLS models have been used. Our findings suggest that the power outages have negative effects on productivity. Hence, we conclude and advise that the governments should increase their investments on the power infrastructure to minimize the loss of output stemming from electricity shortages.

This study is organized as follows: section 2 reviews several empirical studies on productivity and electricity. In Section 3, we describe the data and variables used in the various equations of the model. In section 4, we discuss the methodological framework and in section 5, we cover findings and results respectively. Lastly, I conclude in a final section.

2. LITERATURE REVIEW

The literature review here is classified into three sections to facilitate the understanding. Firstly, the productivity and its determinants are summarized. In that matter, among the quantitative approaches of productivity estimation in the literature, the papers including deterministic models are chosen. In the second section, briefly the articles aiming to demonstrate the relation between the power infrastructure and output are analyzed. Lastly, by narrowing down the topic, the review focuses on the precise question of the relationship between productivity and power outage.

2.1. The productivity and its determinants

Understanding the determinants of productivity is at the heart of economic research. One of the major components of a firm's productivity, power infrastructure quality and its effect on productivity has first been studied by Schurr and Netschert (1978). Estimating Total Factor Productivity (TFP) as a function of electricity, their empirical paper forms the foundations of the productivity and power infrastructure analysis.

In their study of productivity using a panel data of manufacturing firms in Japan for the data collected in every five years from 1975 to 1990, Mizutani and Tanaka (2008) find that the power infrastructure contributes significantly to production in the private sector and show that the construction of infrastructure boosts the productivity of firms. Bronzini and Piselli (2009) find empirical evidence proving that the productivity is positively affected by public infrastructure while also pointing to the existence of a Granger-causality between productivity and infrastructure. Besides, Atems (2015) work also hints at a negative correlation between frequency of infrastructure and energy shocks and higher long-run productivity growth. Lastly, a study carried out by Ayuso, Barrera and Torres (2011) on Mexican states aims to identify the effect of infrastructures on Total Factor Productivity. Estimating their model with fixed effects, they find evidence proving the impact of infrastructures on TFP and its factors.

The extent to which electricity supply quality matters in deciding a firm's productivity isn't fully discovered. Specifically in Africa's case, the firms' productivity is mostly affected by infrastructure performance. The effect of infrastructural quality is also found to be no less than that of other factor such crime and financing availability. (Escribano et al., 2009).

Deraniyagala (2001) claims that the relationship between a firm's age and its productivity is rather unclear. While productivity is expected to be positively affected by age given the cumulative nature of production experience, an older firm may also find it more difficult to adapt to the ever-changing nature of technology and thus hinder its productivity by failing to adopt newer technology. Deraniyagala (2001) suggest a positive relationship between age and productivity but fail to prove the existence of one. It is expected in this research that an important part of the efficiency differences between firms should be explained by age and there should be a positive relationship between age and technical efficiency.

According to Fisher-Vanden, Mansur and Wang (2015), a firm's productivity is especially prone to the shocks in non-storable inputs – electricity in this case. They study a rich dataset of Chinese companies' responses to the power outages in the previous decade. They find that the Chinese firms, in general, react to the outages by switching from producing their own intermediate products to buying them directly from third parties. This unreliability of electricity has increased Chinese firms' unit production cost by no less than eight percent, while, on the other hand, there were no significant losses to productivity.

2.2. Power infrastructure and output

Schurr and Netschert (1978) suggest that with the invention of electrical motor in late 1800s, the relationship between electricity and production gained importance. They point out the coincidence of a sudden hike in overall production and an increase in the energy usage, mostly attributed to the electrification of the industry. Devine (1983) also suggested a connection between output growth and energy productivity. The switch from steam and water to electricity led to less wasting of energy and bettering of working environment, machine control and sparked the firms' growth. These, in turn, positively affected the production of capital and labor.

In their work on three manufacturing companies in Nepal, Jyoti et al (2006) find that unreliable electricity sources play a major role in high manufacturing costs in developing countries. Their study is able to accurately assess the extent of the effect power outages have on manufacturing costs. They also provide several ways to overcome the said problem. Detaching the effects of power outages caused by substation failures from other electricity system failures; they analyze the feasibility of privatized electricity substations. The study concludes that the private sector should, in fact, make the necessary investment given the possibility of such returns even in the case of no room for improvement in the generation capacity. Aschauer (1989) examines the relationship between macro-level productivity and government investment in the US for the second half of 20th century. Using a Cobb-Douglas production function, Aschauer finds a link between output per unit of capital input, labor capital ratio in the private sector and the ratio of public capital to private capital, which he uses as a proxy for the infrastructural inputs like electricity. Mas, Maudos, Prez and Uriel (1996) also find a strong relationship between public capital and productivity. In their work on Spanish regions, they come to the conclusion that economic infrastructure has a significant effect on productivity, while admitting to the difficulty of ascertaining the effect of specific indicators (e.g. electricity) when using composite indicators.

Estache's work (2005) on Sub Saharan Africa's infrastructural quality suggests a significant contribution of infrastructural factors in growth. Estache finds that if Africa had Korea's infrastructural quality and level, Africa's income per capita would increase by around one percent. Similarly, Esfahani and Ramirez (2003) suggest a link between Africa's low growth and its low level of infrastructural investment. Hulten (1996) claims that the difference in infrastructural quality can be accounted for around thirty percent of the growth difference in Africa and East Asia. Allcott, Collard-Wexler and O'Connell conduct a similar study on Indian textile plants and they find that the power outages decrease output by one percent, but has less effect on productivity since most of the inputs in that sector are storable. Due to the economies of scale, they suggest that small firms are affected worse by the shortages.

2.3. The relation between power outages and productivity

Moyo's (2013) analyzes the infrastructural quality of power and its relation to productivity of manufacturing in African companies. Using data from the World Bank enterprise surveys, Moyo proves that the infrastructural quality is a major determinant of productivity. In doing so, he measures infrastructural quality of power with hours spent per day without electricity and the output loss caused thereof. The said variables, Moyo suggests, plays a significant role in Uganda, Tanzania and Zambia's productivity besides the food and agriculture sectors' productivity. His suggestion is that African governments should overcome the problem of unreliable power supply.

Abotsi (2015) also underlines the crucial role of power supply in the productivity. He suggests that any shortcomings in the power supply will lead to a reduction in productive efficiency and output levels. In a later study on African companies, Abotsi (2016) examines the deterring effects of power outages on efficiency. Adopting a stochastic production frontier and a two-tail Tobit model, he finds that productive efficiency is negatively affected by the number of power outages experienced in a month. He then suggests an extensive investment on the power infrastructure to overcome the impact of unreliable power supply on productivity of the African firms.

Cissokho and Seck (2013) claim that unstable power supply may affect a firm's business activities and then decrease its productivity. These effects on the firm's business activity come in two forms – efficiency and quality. Efficiency costs are those on the production processes caused through costs in search for the new energy sources and the replacement costs because of the broken machinery. Quality costs are the resulting flaws on the products and services. Moyo's analysis of the effect of number of power outages on the production efficiency is an important study in this regard. He finds that power outages have worse impact on small firms compared to what they have on larger firms. (Moyo, 2012). It is important to note that the studies usually find that the duration of outages (hours spent without electricity in a day) has more influence on a firm's productivity than that of the frequency of the outages. Another important finding is that while power outages have usually been associated with less productivity, some studies claim vice versa. A study in Senegal, for example, reports that manufacturing firms are positively affected by the outages thanks in large part to the fact that they encouraged improved management practices to overcome the effects of outages and that less productive firms have been eliminated.

According to Alam (2013), the extent to which a company is affected by unreliable power supply very much depends on how power-intensive the industry is. He finds that frequency of the power outages decrease the total production and net income of some electricity-intensive sectors more than the others. While there are a lot of studies focusing on the cost and effect of unreliable power supply on production and cost of firms, (Alam, 2013; Adenikinju, 2005; Beenstock et al., 1997; Bernstein and Heganazy, 1988; Caves et al., 1992; Lee and Anas, 1992, there aren't as many focusing specifically on the effect of the frequency of power outages on firms' productivity levels.

Focusing on the manufacturing sector in Nigeria, another study of Moyo (2012) analyzes the effect of power disturbances on productivity. His analysis with the OLS and Tobit models indicates that the power outages negatively affect the productivity of the firms and to a larger extent the smaller firms. Based on the significance of the variable, he suggests that to stimulate growth, Nigerian authorities should seek way to improve the energy infrastructure and its supply.

Moreover, Scott et al. (2014) discussed that electricity reliance affects the SMEs' productivity in manufacturing sector negatively, however, the effect is not statistically significant in most cases. For the most SMEs, electricity disruption may not affect the competiveness since the share of electricity cost is generally low in the total costs of firms. However, since the power infrastructure quality affects the amount and location of firms' investment, it has indirectly negative effect on production and productivity of firms. Therefore, politicians should improve the performance of power infrastructure to overcome the problem of loss due to unplanned disruptive electricity outages. The alternative electricity sources, renewable energy or the establishing well developed generators might be possible solutions for them.

Trend of productivity and its growth is similar to trend of power infrastructure quality and its consumption level. There might be causation between infrastructure quality and growth. There are several papers in the literature states that electricity improves both the productivity of firm and country. (Fedderke and Bogetic, 2006; Kirubi et al., 2009; Grimm et al., 2011). Besides, the easy access to the power supply give rise to high productivity of firms. Although the effects of manager ability, finance structure and location, have a higher impact on productivity, power infrastructure reliance has still significant effects on small and medium sized firm's productivity. The reason for the lower impact might be low usage of electrical machinery in the production of these firms. Also, the precaution for the possible power outage not well developed can be reason for significant effect on productivity of firms. (World Bank, 2008; Grimm et al., 2011).

To the best of my knowledge, this paper is one of the first to analyze the link between power outages and productivity in the Turkish manufacturing firms. Some of the Turkish studies that contain power infrastructure and productivity are as follows. Firstly, Fedderke and Kaya (2014) study the impact of some key infrastructures such as transportation, telecommunication and electricity on labor productivity for Turkish economy. They basically find that electricity infrastructure has significant effect on labor productivity of manufacturing firms in Turkey. The study of Bayat et al. (2011) examine the relationship between electricity consumption and employment in the manufacturing sector in Turkey between 1960 and 2005. The paper states that GNP has a significant positive impact on electricity consumption and employment. Moreover, Polat & Uslu (2012) study the relationship among the energy consumption, employment and output for Turkey during the period of 2005 and 2010 within a cointegration and causality framework. By using the ARDL bounds testing for cointegration, they indicates that there is a cointegration between electricity and output. Furthermore, when the consumption of electricity reduces, it is expected that the output decreases in Turkey as well. Contrary to Bayat et al. (2011) paper, they states that there is no statistically significant relationship between electricity consumption and employment. Lastly, in the paper of Aslan, Ari and Zeren (2013), the effect of electricity consumption on economic development level is studied. As local and international based analysis, the results demonstrate that the electricity consumption has positive effect on economic development.

3. DATA AND METHODOLOGY

The World Bank's Enterprise Survey provides a unique source of information that can be used to measure TFP across a large set of developing countries. The data used for TFP analysis in this paper cover manufacturing firms in ten different countries. All data used in this analysis were collected from World Bank's Enterprise Survey depending on data availability of countries conducted between 2006 and 2013. The coverage of the countries is presented in Table 1. The table also shows the number of firms that are included in the analysis for each country.

The World Bank's Enterprise Survey is a firm-level survey of a representative sample of the country's private sector. The surveys cover a broad range of business environment topics including access to finance, corruption, infrastructure, crime, competition, and performance measures.

The World Bank's Investment Climate Surveys (ICS) on manufacturing sectors from Turkey, Poland, Mexico, Romania, Hungary, Jordan, Brazil, Albania, Bosnia and Bulgaria are the primary source of the data used in this study. These countries selected from the list of upper-middle income countries of World Bank. Besides, these countries are commonly examined in the literature such cross country analysis containing Turkey. The surveys in these respective countries were done between the years 2006 and 2013 and the total number of firms covered is around 2000. In addition, since large sized sample leads to increased precision in estimates of the population, the cross country analysis is used in the regression analysis. As it is summarized in table below, all developing countries analyzed in this study encounter a problem of power outages.

Table 1 – Summary of Country Level Power Outages

Countries	# of Power Outage in Month	Loss due to Power Outage
Turkey	1.7	0.9%
Poland	0.2	0.2%
Mexico	3.5	3.4%
Romania	1.4	0.7%
Brazil	1.6	1.3%
Jordan	2.2	1.2%
Albania	4.1	2.6%
Bosnia	1.0	0.3%
Bulgaria	1.2	0.4%
Hungary	0.3	0.2%

Source: World Enterprise Survey

Firm-level surveys have been conducted since the 1990's by different units within the World Bank. The Enterprise Surveys implemented in Eastern Europe and Central Asian countries are also known as Business Environment and Enterprise Performance Surveys (BEEPS) and are jointly conducted by the World Bank and the European Bank for Reconstruction and Development.

The surveys conducted by World Bank customized are according to the operations of firms such as manufacturing or services. Although many questions overlap, some are only applicable to one type of business. For example, retail firms are not asked about production and nonproduction workers. In this study, only firms in manufacturing sector is used, since these firms are more capital or machine intensive for the production of goods that needs electricity while operating.

3.1 Estimation of TFP

Total factor productivity (TFP) is a measure of efficiency and thus an important indicator for policymakers. Using micro level data from manufacturing industries in 10 developing countries, this paper analyzes TFP performance at the firm-level during the period of 2006 and 2013.

Most of the research in the recent literature have been focusing on the role of factor inputs and technical advancement in yielding growth. Thanks in large part to Solow's seminal work (1957), productivity has been regarded as the key factor for achieving growth. As the span and the depth of the data available to the researchers have expanded, we are now able to examine the complex nature of productivity and suggest policies to improve productivity and, thus, growth. Bailey, Hulten and Campbell's (1992) research on the U.S. manufacturers and Tybout's (1996) on developing countries have been some of the very first examples of firm-level productivity analysis.

As used in the study of Syverson (2011), a Cobb-Douglas production function with three factors of production—capital, labor and material—is used to estimate TFP. Firm sales are used to measure output; the replacement value of machinery, vehicles and equipment are used to measure capital; labor is assessed by the total compensation of workers including wages, salaries and bonuses; and material goods are determined by the cost of raw materials and intermediate materials. TFP is estimated as the residual term of the production function. The TFP values used in this paper are estimated based on the Cobb-Douglas production function that is a logarithmic production function with capital, labor and materials as input factors.

4. DATA AND VARIABLES

Table 2 reports the descriptive statistics used in our analysis to evaluate the infrastructure quality of the countries studied. Before analyzing our findings, it is essential to describe each variable in the table. The first variable in Table 2 ("Has Outage") reflects whether the establishment has experienced any power outages over the fiscal year. The dummies 1 and 0 are assigned to the answers "Yes" and "No" respectively. The second variable ("Number of Outage") refers to the average number of power outages experienced by the establishment in a typical month of a fiscal year. Throughout our regression analysis, "Number of Outage" variable has been multiplied by 12 in order to the use the average yearly data. The third variable ("Average Duration Outage") reflects the average time elapsed during the power outages.

The fourth and fifth variables are related to power generator of firms. "Has generator" is the answer of the question that over the course of fiscal year, did this establishment own or share a generator? The dummy variable takes the value of 1, if the answer is "Yes" and 0 otherwise. Lastly, the fifth variable in Table 2 titled as "Share Generator" is related with the following question that in fiscal year, what percentage of this establishment's electricity came from a generator or generators that the establishment owned or shared?

Table 2 – Summary of Power Infrastructure Quality

	Has Outage	Number of Outage	Average Duration Outage	Has Generator	Share Generator
mean	0,6	4,9	2,7	0,3	42,4
std dev	0,5	11	6,3	0,5	46,1
max	1	150	100	1	100
min	-	-	1	-	-
obs	2326	1170	1120	2074	371

Source: World Enterprise Survey

Table 2 presents a summary of the descriptive statistics for the countries subject to our analysis. Our findings suggest that, on average, 60% of the firms are exposed to power outages, which is a significant problem in the infrastructure of the countries. Moreover, on average, firms experience power outage 4.9 times in a typical month. A power outage lasts 2.7 hours which corresponds to around 11% of day hours. A typical power outage costs the company 6.3% of its output for that year. Despite this significant loss in their output due to power outages, only 30% of the companies own a generator. These indicators led us to examine the effect of infrastructure on productivity for the manufacturing sector. It is worth noting that since the number of observations for the share_generator is significantly low, robustness of the respective analysis is expected to be low as well.

Table 3 reports the foreign ownership of firms and firms' inputs such as labor, capital and material. Log transformations is applied on the variables in the regression.

Table 3 – Factors of Production

	Output	Labor	Material	Capital	Foreign Ownership
mean	626 M	28 M	91 M	72 M	2.2
std dev	1300 M	52 M	89 M	336 M	12.3
min	2980	148	67	1998	0
max	6300 M	476 M	2400 M	432 M	100

Source: World Enterprise Survey

Table 3 display the firm's structure in terms of factors of production and its shareholder's ratio. The foreign ownership is the important factor for the effect of power outage. It is expected that increase in foreign ownership ratio will decrease the loss due to power outage since foreigners are able to overcome this problem by taking precautions or using their own technological development.

5. MODEL

There are a number of methodologies that can be used to estimate productivity, each with its own strengths and weaknesses. One can use index numbers, parametric and non-parametric methods, data envelope analysis and stochastic frontiers. Two-Stage Least Squares (2SLS) regression analysis is a statistical technique that is used in the analysis of structural equations. This technique is the extension of the OLS method. It is used when the dependent variable's error terms are correlated with the independent variables. Similar to estimation of Syverson (2011) study, we measure firm level total factor productivity (TFP) using a standard Cobb–Douglas production function as follows:

$$y_i = \alpha_0 + \alpha_1 l_i + \alpha_2 m_i + \alpha_3 k_i + \varepsilon_i \quad (1)$$

In this model, y refers to the log of output of firm i, k is log of stock of capital, m is log of material inputs and l is log of cost of workers in each firm. In order to calculate total factor productivity (TFP), the common approach is to obtain estimates of the elasticities of output with respect to inputs (α_1; α_2 and α_3) and then treat TFP as residuals of Eq. (1). Thus, TFP is the portion of output not explained by the amounts of inputs used in production and its aim is to identify output differences that cannot be explained by input differences at firm level. Hence, the way of measuring TFP is to use a Cobb–Douglas production function as follows.

$$Ln(TFP)_i \equiv y_i - \alpha_1 l_i - \alpha_2 m_i - \alpha_3 k_i = \varepsilon_i \quad (2)$$

Using this method, the TFP estimates from Eq. (2) would need to be regressed using a second stage model against a set of determinants such as the quality of power infrastructure variables which do not take place while estimating Eq. (1). In this model, output refers to total annual sales of firms. Besides, while labor refers to total annual cost of labor including wages, salaries, bonuses and social security payments, capital refers to total rental cost of machinery, vehicles, equipment, land and buildings. Lastly, material refers to total annual cost of raw materials and intermediate goods used in production.

$$Ln(TFP)_i = \alpha_0 + \alpha_1 PINFRA_i + \alpha_2 Generator + \alpha_3 ForeignOwnership + \varepsilon_i \quad (3)$$

Here, the variable of PINFRA is a measure of the quality of power infrastructure and Generator is the variable related to firms' generator facilities. Lastly, the foreign ownership is the variable that display the attributes of shareholders. The PINFRA variable is used separately in the model for different quality measures like has outage, number of outage and average duration outage. We include generator ownership to ascertain whether such ownership does minimize the negative effects of power outages on productivity. We capture this effect by including the generator ownership as a dummy variable.

Using the 2SLS regression model, we first estimate the production function and then capture productivity using the results of the first estimation. Hence, the dependent variable used here is measured with some error, which affects the standard errors. Estimated dependent variable, compared to the true Yi, includes some error term that is uncorrelated with the independent variables and errors with the 2nd stage estimation. Therefore, because covariance between independent variable and the error term is uncorrelated, the coefficient is consistently estimated. The only shortcoming of the 2SLS in this case is that the error in dependent variable reduces the power of statistical tests.

Another approach in literature is to directly include the determinants of output and thus TFP into Eq. (1) and run OLS regression. It suggests to test directly whether such determinants are statistically significant. By using this method, TFP is defined as any change in output that is not due to changes in factor inputs, we include these determinants directly into Eq. (1) and variables related to power infrastructure. Thus, this model assumes here that TFP is a function of firm's foreign ownership and quality of electricity infrastructure.

However, as a general rule, when a variable is endogenous, it will be correlated with the disturbance term, hence it violates GM assumptions and makes our OLS estimates inconsistent. Then, we have a problem if $cov(\varepsilon, x) \neq 0$, i.e. when x is an endogenous variable. In this case, the OLS estimator is inconsistent and none of usual hypothesis testing (t-Student, F-tests) are valid.

When deciding on whether to use OLS or 2SLS, there is a trade-off: the OLS estimator is more efficient (has a smaller variance) and the 2SLS estimator is unbiased if some explanatory variables are endogenous. The Hausman test is designed to examine whether some explanatory variables are endogenous (favors the use of 2SLS) or not (favors the use of OLS). In other words, Hausman test helps to measure robustness of 2sls estimation. After estimating the model with 2sls, the metric nR^2 is calculated where n is the number observation. This calculated value is tested by a chi-square distribution with degrees of freedom. If nR^2 is higher than critical value according to Chi-Square distribution table, it is interpreted that 2sls is the robust estimation compared to OLS regression which has an endogeneity problem. In our results, for each estimation we calculated the value of nR^2. Since, the calculated value is higher than the critical value (4.61) at 10% significance level, we decided to use the 2sls model in our analysis.

6. RESULTS

We do our estimations using Ordinary Least Squares (OLS) and Two Staged Least Squares (2SLS) models and the cross country results are presented below as follows and the econometric software used is STATA version 14. We first estimated cross sectional model by using OLS model and its results reported in the Table 4. Then, according to main model of this study, the results of 2SLS model are summarized in Table 5. Moreover, we went further and for each country the 2SLS model is applied and these results are presented in Table 6-7-8. Lastly, in Table 9, the analysis covering the comparison of Turkey with other countries is reported. In these regressions, we used different indicators of power infrastructure quality in order to check whether the estimations are robust or changes with variable specifications. As a result, in both cross country and country level analysis power infrastructure quality has significant effect on productivity of the firms.

Table 4 – Cross country results using OLS model

VARIABLES	(1) Output	(2) output	(3) Output	(4) output	(5) output	(6) output	(7) output	(8) output	(9) output	(10) output	(11) output	(12) output	(13) output	(14) output	(15) output	(16) Output
Material	0.395***	0.397***	0.439***	0.438***	0.399***	0.446***	0.391***	0.441***	0.450***	0.433***	0.440***	0.445***	0.431***	0.394***	0.435***	0.433***
	(0.0149)	(0.0149)	(0.0198)	(0.0210)	(0.0150)	(0.0356)	(0.0148)	(0.0198)	(0.0478)	(0.0197)	(0.0210)	(0.0500)	(0.0209)	(0.0149)	(0.0197)	(0.0209)
Capital	0.294***	0.297***	0.237***	0.242***	0.304***	0.212***	0.292***	0.243***	0.176***	0.233***	0.246***	0.157***	0.240***	0.299***	0.238***	0.243***
	(0.0123)	(0.0123)	(0.0167)	(0.0181)	(0.0122)	(0.0327)	(0.0123)	(0.0168)	(0.0440)	(0.0167)	(0.0182)	(0.0476)	(0.0180)	(0.0122)	(0.0167)	(0.0181)
labor	0.244***	0.239***	0.254***	0.245***	0.240***	0.225***	0.230***	0.245***	0.252***	0.244***	0.236***	0.263***	0.233***	0.232***	0.237***	0.227***
	(0.0172)	(0.0172)	(0.0230)	(0.0242)	(0.0171)	(0.0412)	(0.0171)	(0.0232)	(0.0571)	(0.0230)	(0.0243)	(0.0580)	(0.0241)	(0.0171)	(0.0231)	(0.0242)
has_outage		-0.0257*			-0.0293	-0.0702*	-0.0751*							-0.0314		
		(0.0146)			(0.0359)	(0.0399)	(0.0427)							(0.0357)		
number_of_outage			0.0136***					0.0132***	0.00437	0.0135***					0.0132***	
			(0.00379)					(0.00378)	(0.00741)	(0.00377)					(0.00376)	
average_duration_outage				-0.0577**							-0.00620**	-0.00595	-0.00515*			-0.00556*
				(0.0294)							(0.00293)	(0.00915)	(0.00291)			(0.00290)
has_generator					0.214***			0.203***			0.195***			0.193***	0.177***	0.166***
					(0.0463)			(0.0591)			(0.0628)			(0.0462)	(0.0590)	(0.0626)
share_generator						0.000112			0.00186			0.00336				
						(0.00146)			(0.00206)			(0.00213)				
foreign_ownership							0.00526***			0.00537***			0.00594***	0.00472***	0.00509***	0.00571***
							(0.000761)			(0.000983)			(0.00106)	(0.000752)	(0.000985)	(0.00107)
Age	8.47e-05	8.11e-05	4.56e-05	5.38e-05	8.09e-05	0.00543**	8.52e-05	6.30e-05	0.00879**	6.52e-05	7.01e-05	0.00894**	7.18e-05	8.41e-05	7.97e-05	8.54e-05
	(6.76e-05)	(6.77e-05)	(0.000178)	(0.000178)	(6.62e-05)	(0.00259)	(6.72e-05)	(0.000177)	(0.00369)	(0.000177)	(0.000177)	(0.00385)	(0.000177)	(6.59e-05)	(0.000176)	(0.000176)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.844***	2.848***	2.902***	3.143***	2.666***	3.824***	3.149***	2.926***	3.305***	3.227***	3.178***	3.751***	3.468***	2.937***	3.229***	3.484***
	(0.188)	(0.188)	(0.250)	(0.266)	(0.187)	(0.488)	(0.192)	(0.251)	(0.604)	(0.256)	(0.267)	(0.640)	(0.270)	(0.191)	(0.256)	(0.271)
R-squared	0.828	0.829	0.854	0.852	0.833	0.871	0.831	0.853	0.867	0.856	0.851	0.873	0.855	0.834	0.856	0.854

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

As Table 4 estimated with OLS model states, the variables related to power outages such as *has_outage, number_of_outage* and *average_duration_outage* have statistically significant effects on productivity. Dummy variable *has_outage* leads to approximately 2.6% percent decrease in productivity by holding constant the other variables. The negative impact of *has_outage* may increase up to 7.5% when the *foreign_ownership* is added to regression equation. Since, the addition of *foreign_ownership* helps to observe its effect on productivity; it enables us to detect higher level of the damage coming from *has_outage* variable.

Moreover, a one-hour increase in the average duration of the power outage, which corresponds to a yearly increase of the number of outages hours, results in a decline of around 5.8% in total yearly production, holding all the other independent variables constant. When the dummy variable of *has_generator* is added, the negative effect of average outage duration may decrease up to 0.6% percent. If duration of electricity disruption lasts longer, it may cause higher loss in output of the firms. Therefore, the results meet our expectations.

In addition, Table 4 basically presents that the negative effect of power outages can be reduced by using the generator in operations. The dummy variable of *has_generator* has significant positive effect on productivity between the value of 17% and 21% percent. It is notable findings that when the *has_generator* and *has_outage* variables used in the same regression, the coefficient of *has_outage* becomes statistically insignificant. Hence, it is interpreted that the generator helps to overcome the power disruption problem.

Lastly, Table 4 also reports that the *foreign_ownership* variable has a statistically positive significant effect on the productivity for the firms. If the share of foreign ownership increases one unit, it is expected that productivity of firm will increase around %0.5 percent. These results seem to explain why firms with foreign ownership are affected less from the power outage as the literature's findings reported.

The number of outages variable yields significantly positive effects on production, which contradicts with our expectations and findings above. Also, although share generator variable, which represents the share of electricity produced by a generator in total electricity used the firm, has a significantly positive effect on the output; the amount is less than expected. This problem might stem from the number of missing data, since only 12% of the surveyors answered the question. In the following section, we establish more robust model by adopting the 2SLS model.

As Table 5 estimated with 2SLS model represents, the variables related to power outages such as *has_outage*, *number_of_outage and average_duration_outage* have statistically significant effects on productivity. Dummy variable *has_outage* give rise to 1.2% percent decrease in productivity. Hence, the productivity conditional on firm having power outage is less than cases where the firms have no facing power outage.

We find that a one unit increase in number of outages per year leads to 0.7% decrease in productivity, meaning a one-time increase in the average number of outages per week – i.e. 52 times a year – would cost a loss of 36% in productivity. A one-hour increase in the average duration of the power outage, which corresponds to a yearly increase of number of outage, results in a decline of around 0.2% percent, holding all the other independent variables constant. High numbers of hours without electricity or high numbers of electricity outage give rise to higher loss in output of firm. Therefore, it has a negative effect on productivity and the results support the expectation.

Table 5 – Cross country results using 2SLS model

VARIABLES	(1) lnprod	(2) lnprod	(3) lnprod	(4) lnprod	(5) lnprod	(6) lnprod	(7) lnprod	(8) lnprod	(9) lnprod	(10) lnprod	(11) lnprod	(12) lnprod	(13) lnprod	(14) lnprod	(15) lnprod
has_outage	-0.0116**			-0.0319*	0.0664	-0.0111*							-0.0302		
	(0.00516)			(0.0181)	(0.148)	(0.00631)							(0.0688)		
number_of_outage		-0.00719*					-0.00648**	-0.00655	-0.00704*					0.00651	
		(0.00409)					(0.00288)	(0.00942)	(0.00398)					(0.00626)	
average_duration_outage			-0.00245*							-0.00193*	-0.0319	-0.00225*			0.00391
			(0.00139)							(0.00109)	(0.0262)	(0.00128)			(0.00959)
has_generator				0.195**			0.261**			0.262**			0.179**	0.228*	0.220*
				(0.0816)			(0.116)			(0.130)			(0.0820)	(0.117)	(0.131)
share_generator					-0.00325			-0.00182			-0.00363				
					(0.00230)			(0.00288)			(0.00326)				
foreign_ownership						0.00246**			0.00435***			0.00539***	0.00225*	0.00394**	0.00501***
						(0.00114)			(0.00165)			(0.00183)	(0.00115)	(0.00166)	(0.00184)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.896***	-0.801***	-0.658***	-0.934***	-0.964***	-0.912***	-0.847***	-0.895**	-0.826***	-0.706***	-0.280	-0.696***	-0.947***	-0.867***	-0.735***
	(0.141)	(0.203)	(0.240)	(0.142)	(0.350)	(0.141)	(0.204)	(0.436)	(0.203)	(0.241)	(0.568)	(0.239)	(0.142)	(0.203)	(0.240)
R-squared	0.083	0.049	0.040	0.088	0.122	0.087	0.057	0.128	0.061	0.047	0.098	0.056	0.091	0.067	0.061

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

.

In addition, Table 5 states that the generator compensates the effect of power outage partially. By holding the *has_outage* variable constant, it is expected that the dummy variable of *has_generator* may leads to 19% percent increase in productivity. When the generator is implemented to operation, it helps to minimize negative impact on productivity. Hence, the generator ameliorate moderately power infrastructure problem. This variable is consistently positive and especially more effective when the regression is applied with the average duration of outage. The reason for this result might be that generator is more needed when power outage lasts longer. Moreover, the *share_generator* variable turns out to have a significantly negative effect on productivity – a 1% increase in the share of electricity produced by generator leads to a 0.3% decrease in productivity. This result might be justified by the idea that an increase in the share of generator-produced electricity indirectly hints at the fact that the firm experiences more power outages, which means less productivity as shown by the *number_of_outages* variable.

According to results of Table 5, foreign ownership is statistically positive significant effect on productivity for the firms. If the share of foreign ownership increases one unit, it is expected that productivity of firm will increase between 0.2% and 0.5% percent, holding all the other independent variables constant. As in the literature review mentioned, firms with contains foreign ownership in management are more productive than local firms. The reasoning behind this result is that in order to improve the productivity of firm, foreign owners bring their technology and skills.

Table 6 – Summary of country level results using 2SLS model

VARIABLES	Turkey Prod	Albania prod	Bosnia prod	Bulgaria prod	Hungary prod	Jordan prod	Brazil prod	Mexico prod	Poland prod	Romania prod
has_outage	-0.045*	-0.0401	-0.031*	0.0042	0.0102	-0.0399*	-0.0282*	-0.0594*	0.0111	-0.0751**
	(0.026)	(1.115)	(0.0176)	(0.572)	(0.259)	(0.0226)	(0.0160)	(0.0338)	(0.236)	(0.0364)
has_generator	0.398*	0.468*	0.168*	-0.0207	0.534*	0.612*	0.420	0.354***	0.261	-0.368
	(0.215)	(0.266)	(0.0955)	(0.839)	(0.288)	(0.324)	(0.516)	(0.132)	(0.331)	(0.545)
foreign_ownership	0.0812**	0.1106**	0.0321*	0.0259**	0.0368	-0.000276	0.0239***	0.0863**	0.1457***	0.0125**
	(0.0361)	(0.0492)	(0.0182)	(0.0115)	(0.326)	(0.00417)	(0.00671)	(0.00183)	(0.00330)	(0.00521)
year_dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.857***	-0.991**	-1.312***	-1.269**	-1.150***	-2.421***	-0.683**	-1.588***	-0.598***	-1.535***
	(0.139)	(0.440)	(0.326)	(0.475)	(0.237)	(0.703)	(0.334)	(0.0686)	(0.145)	(0.370)
R-squared	0.078	0.053	0.069	0.060	0.087	0.071	0.167	0.070	0.085	0.156

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

Table 7 – Summary of country level results using 2SLS model

VARIABLES	Turkey prod	Albania prod	Bosnia prod	Bulgaria prod	Hungary prod	Jordan prod	Brazil prod	Mexico prod	Poland prod	Romania prod
number_of_outage	0.00119	-0.480*	0.0238	-8.43e-05	-0.131**	-0.0172	-0.0153	0.00247	0.00394	-0.111***
	(0.0117)	(0.272)	(0.0153)	(0.0645)	(0.0566)	(0.0340)	(0.0283)	(0.0122)	(0.00789)	(0.0381)
has_generator	0.533*	1.729	-1.355	0.949	0.0616	0.1130***	0.445	0.380**	0.422	-0.741
	(0.277)	(1.526)	(0.887)	(1.179)	(0.363)	(0.039)	(0.765)	(0.163)	(0.514)	(0.519)
foreign_ownership	0.0730*	0.0465*	0.0960	0.0471*	0.0578**	0.0357	0.192**	0.119	0.184**	0.0518*
	(0.041)	(0.026)	(0.150)	(0.027)	(0.0257)	(0.0476)	(0.085)	(0.222)	(0.082)	(0.0294)
year_dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-1.042***	1.364	-1.501**	-1.281*	-0.302	-2.911***	-0.386	-1.592***	-0.888***	-0.606**
	(0.146)	(1.288)	(0.544)	(0.614)	(0.366)	(0.728)	(0.446)	(0.0956)	(0.265)	(0.227)
R-squared	0.105	0.154	0.366	0.250	0.279	0.214	0.114	0.102	0.334	0.133

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

Table 8 – Summary of country level results using 2SLS model

VARIABLES	Turkey prod	Albania prod	Bosnia prod	Bulgaria prod	Hungary prod	Jordan prod	Brazil prod	Mexico prod	Poland prod	Romania prod
average_duration_outage	0.0128	0.0854	-0.548	-0.163	0.00987	-0.206*	0.0186	-0.0148	-0.0279	-0.0208*
	(0.0158)	(0.418)	(0.495)	(0.568)	(0.0371)	(0.112)	(0.0302)	(0.0118)	(0.0637)	(0.011)
has_generator	0.0854	0.112	0.379	1.149	0.177	0.435*	0.754	0.494***	0.512	-1.436
	(0.275)	(2.590)	(1.093)	(1.565)	(0.444)	(0.246)	(0.927)	(0.189)	(0.711)	(1.231)
foreign_ownership	0.0610**	0.0253*	0.0167**	0.00160	0.00119	0.00143	0.0293*	0.0315*	0.104***	0.0960**
	(0.0271)	(0.0144)	(0.0074)	(0.021)	(0.00458)	(0.00530)	(0.0166)	(0.0179)	(0.00868)	(0.0421)
year_dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.890***	-0.806	-2.114*	-1.852	-0.373	-0.988	-0.338	-1.283***	-0.440***	-0.662**
	(0.144)	(2.240)	(0.995)	(1.069)	(0.353)	(0.614)	(0.427)	(0.0866)	(0.112)	(0.312)
R-squared	0.013	0.041	0.160	0.166	0.009	0.154	0.131	0.035	0.036	0.318

Standard errors in parentheses
*** p<0.01
** p<0.05
* p<0.1

Another aspect of this study contains the country based estimations as reported in Table 6-7-8. In these estimation, the main aim is to examine the relationship between power infrastructure quality and firm's productivity. In order to observe this effect, 2SLS regression analysis is used. While in Table 6, the impact of *has_outage* on the firm's productivity is examined, the effect of number of outages for the firm's productivity is analyzed in Table 7. Lastly, Table 8 measures the average duration of outage's effect on productivity of firms. Consequently, the each variables related to power infrastructure quality estimated separately for country level data.

According to Table 6, *has_outage* has statistically significant effect on productivity in most countries. Especially, in Turkey the firms facing power disruption 4.5% percent less productive than the firms those has no problem with the power supply. Similarly, the power outage is a problem at approximately same level for Romania, Mexico and Albania. Having generator and foreign ownership has a positive effect on firms' productivity.

As Table 7 states that the effect of number of outages on firm's productivity negative and statistically significant. Although the coefficient is statistically significant for Turkey case, the firms operating in Romania, Albania and Hungary suffering from the power outage. For instance, most notably as 1 unit increase in number of outage leads to 4.8% decrease in productivity of firms in Albania. The coefficient of having generator is positive demonstrating that generator ownership is beneficial for firms.

Last regression analysis of this study in Table 8 displays that average duration of outage has significant effects on firms' productivity in some countries such as Jordan and Romania. The one unit increase in average duration of outage gives rise to 2% percent decrease in productivity of firms. Hence, the countries should deeply consider to improve their power infrastructure quality in order to reach healthy manufacturing sector. The effect of *has_outage, has_generator* and *foreign_ownership* have statistically significant effect on firms' productivity for both Turkey and other countries. Hence, bringing foreign investment to country and motivating the firm for having generator may help to overcome the problem of power infrastructure.

7. CONCLUSION

The primary objective of this study was to examine the role played by the quality of power infrastructure on firm productivity in the manufacturing sector in the countries listed as Turkey, Poland, Mexico, Romania, Hungary, Jordan, Brazil, Albania, Bosnia and Bulgaria. The World Bank enterprise data enables us to bring down the analysis of power infrastructure from macro to micro level analysis and this is appropriate since firms are the ones directly affected by inadequate power facilities compared to using country level studies.

The findings above show that the reliability of power infrastructure measured as various way, have a significant effect on productivity of manufacturing firms. The power infrastructure evaluated with the data of power outage, number of power outage and average duration of power outage. Although the impact of power outages on productivity seems to vary from country to country, it is not a negligible effect. It is possible that the effect depends on what level uses a power in production and generator performance of them.

Another issue in this analysis is to measure the effect of generator on reducing the negative impact of power outage. As regression analysis states that in most of the equations, having generator is consistently significant on decreasing the negative effect of power outage both at country and cross-sectional level. Hence, it can be interpreted that generators may lessen problems associated with power disruptions. Therefore firms in countries with electricity disruptions should be encouraged or assisted in acquiring alternative energy sources like generators.

The negative impact of power outages variable on productivity suggests that reliable power supply is important in production. Therefore, it is needed that the government should burden the responsibility for power supply to ensure minimum power disruptions in order to protect firms. Further research can and should be constructed to investigate the firm size analysis to reach accurate and precise policies. Accordingly, the dynamics of each country should be deeply examined.

8. BIBLIOGRAPHY

Abotsi, A. (2015). Foreign Ownership of Firms and Corruption in Africa. SSRN Electronic Journal.

Abotsi, A. (2016). Power Outages and Production Efficiency of Firms in Africa. SSRN Electronic Journal.

Adenikinju, A. (2005), Analysis of the Cost of Infrastructure Failures in a Developing Economy: The Case of the Electricity Sector in Nigeria (No. 148). Nairobi: African Economic Research Consortium.

Alam, Muneeza (2013). "Coping with Blackouts: Power Outages and Firm Choices." Working Paper, Yale University (November).

Allcott, H., Collard-Wexler, A. and O'Connell, S. (2016). How Do Electricity Shortages Affect Industry? Evidence from India †. American Economic Review, 106(3), pp.587-624.

Aslan, T, Ari, A & Zeren, F (2013) 'The Impact of Electricity Consumption on Economic Development in Turkey: A Geographically Weighted Regression Approach', Siyaset, Ekonomi ve Yönetim Ara tırmaları Dergisi, 2013, Yıl:1, Cilt:1, Sayı:1.

Atems, B. (2015). A note on the determinants of long-run aggregate state productivity growth. Applied Economics Letters, 22(16), pp.1287-1292.

Bayat, T, Aydin, AF, Kayhan, S & Adiguzel, U (2011) 'Causality Analysis of Economic Growth, Electricity Consumption and Employment in Manufacturing Industry: Examples of Turkey', Akademik Fener.

Beenstock, M., Goldin, E., Haitovsky, Y. (1997). The cost of power outages in the business and public sectors in Israel: Revealed preference vs. subjective valuations. The Energy Journal, 8, 39-61.

Bernstein, M., Heganazy, Y. (1988), Economic costs of electricity shortages: Case study of Egypt. The Energy Journal, 9, 173-188.

Bronzini, R. and Piselli, P. (2009). Determinants of long-run regional productivity with geographical spillovers: The role of R&D, human capital and public infrastructure. Regional Science and Urban Economics, 39(2), pp.187-199.

Caves, D.W., Herriges, J.A., Windle, R.J. (1992). The cost of electric power interruptions in the industrial sector: Estimates derived from interruptible service programmes. Land Economics, 68, 49-61.

Deraniyagala, S. (2001). The impact of technology accumulation on technical efficiency: An analysis of the Sri Lankan clothing and agricultural machinery industries. Oxford Development Studies, 29(1), 101-114.

Devine, W., 1983. From Shafts to wires:historical perspective on electrification. Journal ofEconomic History 2,347–372.

Dollar, D & Kray, A. (2003): Institutions, trade and growth. Journal of Monetary Economics Vol 50(1).

Esfahani, H., Ramirez, M.T., 2003.Institutions, infrastructure and economic growth.Journal ofDevelopmentEconomics 70,443–477.

Estache, A., 2005.What do we know About Sub-Saharan Africa's Infrastructure and the Impact of its 1990 Reforms. Mimeo, World Bank, Washington DC.

Fedderke, J. and Bogetic, Z. (2006): Infrastructure and Growth in South Africa: Direct and Indirect Productivity Impacts of Nineteen Infrastructure Measures. World Bank Policy Research Working Paper, Washington D.C.

Fedderke, J. W. and T. E. Kaya. "Productivity Impact of Infrastructure in Turkey, 1987–2006". J. Infrastruct. Syst. 20.3 (2014): 04014011. Web.

Fisher-Vanden, K., Mansur, E.T., Wang, Q. (2012), Costly Blackouts? Measuring Productivity and Environmental Effects of Electricity Shortages (No. 17741).

Grimm, M., Hartwig, R. and Lay, J. (2011) How Much Does Utility Access Matter for the Performance of Micro and Small Enterprises? Accessed from http://bit.ly/1Ge4hlF.

Gujarati, D. and Porter, D. (2009). Basic econometrics. Boston: McGraw-Hill Irwin.

Hulten, C., 1996.Infrastructure, Capital and Economic Growth. How Well You Use it May Be More Important than How Much You Have. NBER Working Paper Series 5847.

Jyoti, R., Ozbafli, A. and Jenkins, G. (n.d.). The Opportunity Cost of Electricity Outages and Privatization of Substations in Nepal. SSRN Electronic Journal.

Kirubi, C. and Jacobson, A. and Kammen, D. M. and Mills, A. (2009): Community-Based Electric Micro-Grids Can Contribute to Rural Development: Evidence from Kenya. World Development, 73, pp. 1208–1221.

Lee, K.S., Anas, A. (1992), Impacts of Infrastructure Deficiencies on Nigerian. Washington, D.C: Manufacturing: Private Alternatives and Policy Options (No. 98).

Mas, M., Maudos, J., Prez, F., Uriel, E., 1996. Infrastructure and productivity in the Spanish regions. Regional Studies 7(30), 641–649.

Mizutani, F. and Tanaka, T. (2008). Productivity effects and determinants of public infrastructure investment. Ann Reg Sci, 44(3), pp.493-521.

Moyo, B. (2012) Do Power Cuts Affect Productivity? A Case Study of Nigerian Manufacturing Firms, International Business & Economics Research Journal, Vol 11, Number 10.

Moyo, B. (2013), Power infrastructure quality and manufacturing productivity in Africa: A firm level analysis. Energy Policy, 61, 1063-1070.

Moyo, B. (2013), Power infrastructure quality and manufacturing productivity in Africa: A firm level analysis. Energy Policy, 61, 1063-1070.

Oshikoya T and Hussain N (2001): Infrastructure for Economic Development in Africa, paper presented at the 2nd Forum on African Perspective, ADB-OECD, Paris and France.

Polat, O & Uslu, EE (2010) ‘Causality between Energy Consumption, Employment and Output in Turkey: Evidence from Monthly Data’, Paper for the 7th Silk Road International Conference 2010.

Powermag. (2015). Global Business Report: Power in Turkey. [Online] Available at: http://www.powermag.com/wp-content/uploads/2015/05/Turkey-Power-2015-Power-Report-v5-Web.pdf [Accessed 7 Jul. 2016].

Schurr S and Netschert B (1978): Energy in the American Economy: 1850-1975. An economic study of its history and prospects Baltimore. John Hopkins University Press.

Scott, A, Darko, E, Seth, P & Rud, J-P (2013) Job Creation Impact Study: Bugoye Hydropower Plant, Uganda, report prepared for the Private Infrastructure Development Group.

Scott, A., Darko, E., Lemma, A., & Rud, J.-P. (2014). How does electricity insecurity affect businesses in low and middle income countries? London: Overseas Development Institute.

Solow, R. (1957). Technical Change and the Aggregate Production Function. The Review of Economics and Statistics, 39(3), p.312.

Syverson, Chad. What Determines Productivity?. Journal of Economic Literature 49.2 (2011): 326-365.

Tybout, James (2000). "Manufacturing Firms in Developing Countries: How Well Do They Do, and Why?" Journal of Economic Literature, Vol. 38, No. 1 (March), pages 11-44.

Warren D. Devine (1983). From Shafts to Wires: Historical Perspective on Electrification. Journal of Economic History, 43, pp 347-372.

9. APPENDICES

Table 9 – First Stage of 2SLS Model Cross Country Analysis

	(1)
VARIABLES	output
Material	0.432***
	(0.0148)
Capital	0.209***
	(0.0111)
Labor	0.275***
	(0.0166)
Age	2.94e-05
	(6.92e-05)
Constant	2.933***
	(0.111)
R-squared	0.814

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

10. GLOSSARY

Output: Total annual sales of firm i, log transformation is applied on the variable.

Labor: Total annual cost of labor including wages, salaries, bonuses and social security payments for firm i, log transformation is applied on the variable.

Capital: Total rental cost of capital including machinery, vehicles, equipment, land and buildings for firm i, log transformation is applied on the variable.

Material: Total annual cost of raw materials and intermediate goods used in production for firm i, log transformation is applied on the variable.

Has outage: Dummy variable which takes the value 1 if a firm reports engagement power outages during the period 2006-2013.

Number of outage: Number of outages in a typical month during the period 2006-2013 for firm i.

Average duration outage: Average duration of outages in typical outage during the period 2006-2013 for firm i.

Has generator: Dummy variable which takes the value 1 if a firm has generator facility.

Share generator: It reports percentage of this establishment's electricity coming from a generator or generators that the establishment owned or shared.

Foreign ownership: It reports the percentage of a firm i, owned by foreign individuals, companies or organizations.

Age: The difference between the year of survey and the year beginning operation of establishment.

Year Dummy: Dummy variable which takes the value 1 if year is 2013.

Country Dummies: Dummy variable for each country which takes the value 1 according to country.