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Power Outages and Technical Efficiency of Manufacturing Firms: Evidence from Selected South Asian Countries

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ABSTRACT

The deficiency of secure and reliable electrical power is a constraint to firm performance and its competitiveness in developing countries. Several countries in the south Asian region face electricity shortages leading to frequent power outages. This study investigate the effect of power outages on the technical efficiency of firms in selected South Asian countries. The study employed the stochastic frontier approach to estimate the technical efficiency of firms. We use the OLS and Beta regression to estimate the effect of power outages on technical efficiency of manufacturing firms. The results of the study reveal that power outages reduce the technical efficiency of manufacturing firms operating in selected South Asian countries. These results are robust to the alternative empirical specifications and estimation techniques. Overall results suggest that South Asian countries should invest in the secure and reliable energy to amplify productivity growth and resulted competitiveness of firms in global market.

Keywords: Technical Efficiency, Power Outages, Manufacturing Firms, South Asia
JEL Classifications: D21, D22, O12

1. INTRODUCTION

The productivity growth has been on the central stage in development economics for last three decades. In this regard, Krugman (1994) goes so far as to proclaim that "Productivity is not everything, but in the long run it is almost everything." It reflects the key role of productivity growth in explaining long run growth process, cross country income differences, and living standard across the globe. There are various determinants of aggregate productivity growth, but increasing accessibility of firm level information is encouraging researchers and policy practitioners to emphasize more on the firm level productivity as key driver for aggregate productivity (Garone et al., 2020). Hence, existing literature documents different determinant of firm performance. The total factor productivity or technical efficiency of firm is positively associated with size (Wagner, 2002), skilled labor (Iranzo et al., 2008), innovation (Demmel et al., 2017), exporting (Martins and Yang, 2009), and imported inputs (Amiti and Koning, 2007; Goldberg et al., 2010).

In developing countries, the accessibility of cheap and uninterrupted power supply is an essential factor for production efficiency, economic competitiveness and successful catch-up with developed countries (Abdisa, 2018). To this end, South Asian countries are facing persistent shortages, and efficiency gap in production and distribution of electric power. The south Asian countries have to extend power supply and ensure electricity reliability. Looking forward, these countries will also need to fulfill the electricity demand for their fast growing economies. Power shortage is reflected from the fact that 250 million people in the south Asian region still live without access to electricity (World Bank, 2019). This implies that roughly a quarter of the global population without access to the electricity is living in the South Asian countries. The World Economic Forum (2019) in the Global Competitiveness Report for the year 2019 ranks 137 countries on the basis of electricity supply quality, places India at 108th, Pakistan at 99th, and Bangladesh at 68th while in case of electricity access it places India at 105th, Bangladesh at 108th, and Pakistan at 111th position[1]. Similarly, electric power deficiency badly affect the technical efficiency of the production unit in these economy. Despite the key role of electric power in development process, poor electricity infrastructure and shortages of electric power is major constraint that firms in south Asian countries face on daily basis (Oseni and Pollitt, 2015). The poor state of electricity infrastructure and severe deficit of electric power has diminished the firm technical efficiency in production and their competitiveness in international market (Oseni and Pollitt, 2015; Cissokho, 2019). Existing literature document that power deficit resulted in lower output and lower technical efficiency in developing countries (Bah and Fang, 2015). Given the pervasiveness of power shortages, this study is designed to investigate the effect of power outages on the technical efficiency of manufacturing firms in selected south Asian countries namely India, Pakistan and Bangladesh. These countries are selected because the manufacturing sector plays important role in these countries as compared to the other South Asian countries. There are few studies that are relevant with this work. For instances Cole et al. (2018) investigates the effects of power outages on the productivity of firms in Sub-Saharan Africa and finds negative effects of power outages on the productivity performance of firms. Similarly, Abotsi (2016) documents negative impact of power outages on the productive efficiency of firms in Africa. However, to the best of our knowledge there is hardly any study that investigate the effect of power outages on the technical efficiency of firms operating in selected south Asian countries.

The rest of the study is organized as follows. Section 2 reviews the relevant literature and section 3 discusses the methodology. The section 4 present the empirical findings and discussions while section 5 concludes the study.

2. INSIGHTS FROM RELEVANT LITERATURE

Many studies have investigated the effect of power outages and poor quality electricity infrastructure on firms' productive efficiency and output growth in developing countries. Mostly these studies recommended that poor quality power provision significantly influence firms' operational and productive efficiency (Oseni and Pollitt, 2015). In this aspect, Cole et al. (2018) investigate the effect of power outages on the firm performance in terms of productive efficiency in Sub- Saharan Africa. The study finds that power outages and unreliable electric supply negatively related with firm productive efficiency and overall sale in fourteen Sub- Saharan economies. Moreover, study estimates the cost of power outages as 2.1% of total GDP and overall sale of the firms fell by 4.9%. Similarly, Abdisa (2018) examine the economic cost of power outages in terms of productivity performance use data of firms operating in Ethiopia. The results show that power outages increases firms' costs by 15% and also negatively affects firms' productive efficiency. The results also reveal that firms response to power outages by self-generating electricity using private electric generators. In another dimension, some studies investigates outages losses differential for the self-generating firms and that depends on the government electricity. For instance, Oseni and Pollitt (2015) investigate the loss differentials due to the self-generation in African firms. The empirical findings, however, reveal that those firms that engage in self-generation reduces output losses due to power outages. Similarly, Carlsson et al. (2020) explore the cost of power outages for manufacturing firms in Ethiopia and find that there substantial cost of power outages for small and medium enterprises in Ethiopia.

In the context of outages losses differential, Abdisa (2020) investigate the role of investment in self generation by manufacturing firms in 13 Sub-Saharan African countries. The results of the study show that firms' investment in the self-generation mitigates the negative impact of the power outages on firm performance. The results of the study further reveal that investment in self-generation reduces output losses to 2–24% depending upon the vulnerability of a firm to power interruptions. More recently some studies examine the impact of power outages on the firms' total factor productivity and technical efficiency in different countries. For example, Cissokho (2019) investigates the cost of power outages in terms of productivity losses to the manufacturing firms in Senegal using panel data approach. The empirical findings of the study reveal that power outages have negative effect on the firms' technical efficiency. In similar line, Abotsi (2016) investigates the effect of power outages on firms' technical efficiency in production and finds that power outages negatively affect the technical efficiency in African countreis. Geginat and Ramalho (2018) investigate the cost and time associated with 1st time electricity connections for firms operating across the globe in 183 economies and it implications for the firms in terms of technical efficiency and competitiveness across the global landscape. The results of the study find that there is significant variations of cost and time associated with the electricity connections across the global landscape. The countries where bureaucratic procedures is simple and state apparatus working efficiently provides electricity connections in low cost to the small and medium firms. The study also finds that less costly electricity connections in terms of time and money are associated with better performance of firms in those countries.

Hashemi et el. (2018) estimates the opportunity cost of power disruptions and outages to the firms involved in spinning, steel re-rolling, and oxygen production in Nepal. The results reveal that losses varies form 11-35% of net sale revenue depending upon the nature of industry and vulnerability of industry to the power outages. Similarly, Iimi (2011) investigates the impact of quality of public provision of utilities on the firms' productivity and competitiveness. The results of the study reveals that intensity and frequency of power outages significantly affects the firm productivity performance and its competitiveness in international market. Filippini et al. (2020) examines the effect of energy efficiency program on the technical

1 World Bank (2019) reports that 85.2 % of population in Bangladesh, 95.2 % of population in India, and 71.1 % of population in Pakistan have access to electricity in year 2018

efficiency of firms in China. The results reveal that efficiency program increases the technical efficiency of firms and resulted in total factor productivity growth by 3.1% per annum. Although, few studies examine the effect of power outages on the technical efficiency firms operating in the Sub-Saharan African countries. However, there is hardly any study that explore the effect of power outages on firms' technical efficiency in selected south Asian countries. Hence this consequent study investigates the effect of power outage on the technical efficiency of manufacturing firms operating in selected south Asian countries.

3. ECONOMETRIC MODEL AND VARIABLE SPECIFICATIONS

We use the stochastic frontier approach to measure the technical efficiency of firms to examine the effect of power outages on technical efficiency in production. With the Cobb-Douglas technology, the log linear transform model appear as

$$y_j = x_j\beta + v_j - \mu_j \; j = 1,2,\ldots,N \tag{1}$$

Where y_j is output of the firm j and x_j is the vector of inputs such as labor and capital. v_j is purely random error term while μ_j is technical inefficiency. The stochastic frontier production function for equation (1) can we written as

$$y_j = x_j\beta + v_j - s\mu_j \; j = 1,2,\ldots,N \tag{1}$$

$$where\ s = \begin{cases} 1, & for\ production\ functions \\ -1, & for\ cost\ fucntions \end{cases}$$

The stochastic frontier models mostly use the half normal distribution (N^+ $(0, \sigma^2\mu)$), and truncated normal distribution (N^+ $(\mu, \sigma^2\mu)$) for μ_j (Meeusen and van den Broeck, 1977; Parmeter et al., 2019).

The log-likelihood function for half-normal model can be written as

$$lnL = \sum_{i=1}^{N} \left\{ \frac{1}{2} ln\frac{2}{\pi} - ln\sigma s + ln\Phi\left(-\frac{s \in_j \lambda}{\sigma s} \right) - \frac{\in^2_j}{2\sigma^2 s} \right\}$$

and truncated-normal model

$$lnL = \sum_{i=1}^{N} \left\{ -\frac{1}{2}\ln(2\pi) - ln\sigma_s - ln\Phi \right.$$

$$\left. \left(-\frac{\mu}{\sigma s\sqrt{\gamma}} \right) + ln\Phi\left[\frac{(1-\gamma)\mu - s\gamma \in_j}{\{\sigma^2 s\gamma(1-\gamma)\}^{1/2}} \right] - \frac{1}{2}\left(\frac{\in_j + s\mu}{\sigma s}\right)^2 \right\}$$

$$where\,\sigma_s = (\sigma^2_{\mu} + \sigma^2_{v})^{\frac{1}{2}},$$

$$\lambda = \frac{\sigma_\mu}{\sigma_v}, \gamma = \frac{\sigma^2_\mu}{\sigma^2_s}, \in_j = v_j - \mu_j, and\ \Phi()$$

is the cumulative distribution function.

In the first step, we measure technical efficiency by stochastic frontier approach while in second step we estimate the effect of power outages on the technical efficiency of firms. Hence, we estimate the following equation to investigate the effect of power outages on the firms' technical efficiency.

$$TE_j = \beta_0 + \beta_1 Outages_j + \sum_{i=1}^{n} \alpha_i x + \mu_j \tag{3}$$

Where TE_j is the technical efficiency of firm J estimated through the stochastic frontier production function while $Outages_j$ is the power outages, and is the set of control variables in the model.

3.1. Data and Variables

This study is based on the firm-level data for three south Asian economies namely India, Pakistan and Bangladesh and provided by the World Bank's Enterprise Surveys unit. According to the World Bank "random sample of firms is drawn from the population of manufacturing sectors in each country by size, region, and two-digit industry". The dependent variable is the technical efficiency of the firm and measured through the stochastic frontier model. We use the log of the value added as proxy of the total output. Our variable of interest is the power outages. We use the three measures for the power outages. First, we use the dummy variable equal to one if firms experienced the power outages zero otherwise. Second, we use the average number of outages in typical month an establishment experienced. We also use loss due to power outages as percent of total sale. The study use the firm age, size, foreign ownership, innovation and exporting status as control variables. The detail description of the variables is available in A 1 of Appendix A

4. FINDINGS AND DISCUSSIONS

The key objective of this research exercise is to investigate the effect of power outages on the technical efficiency of the firms operating in the three largest South Asian economies namely India, Pakistan and Bangladesh. To meet the desired objective, the empirical exercise is carried out in two steps. In first step, we estimate the technical efficiency of firms using stochastic frontier approach while in second step we estimate the effect of power outages on the technical efficiency of firms. We use three alternative measures of power outages. First measure (*Outages*_1) is the dummy variable equal to one if firms experienced the power outages zero otherwise. Second measure (*Outages*_2) is the average number of outages in typical month an establishment experienced. Third measure (*Outages*_3) is the loss due to power outages as percent of total sale.

The Table 1 presents the results of the OLS estimates of equation (3).

The results reported in empirical specification (1) show that coefficient of first measure of power outages (*Outages*_1) is statistically significant with the negative sign. This result supports the claim that power outages reduce the productive efficiency of the manufacturing firms in selected South Asian countries. The results reported in third column of the Table 1 (empirical

Table 1: OLS estimates of effect of power outages on productive efficiency of firms

Variables	(1)	(2)	(3)
	TE	TE	TE
Size	0.0392*** (0.0107)	0.0295** (0.0129)	0.0374** (0.0146)
Age	0.0158 (0.0171)	0.0203 (0.0200)	0.0148 (0.0220)
Credit	0.0394*** (0.00393)	0.0442*** (0.00464)	0.0307*** (0.00521)
w_skills	0.0284** (0.0167)	0.0290** (0.0149)	0.0348** (0.0126)
imp_tech	0.0697*** (0.00403)	0.0785*** (0.00478)	0.0905*** (0.00522)
Export	0.0103** (0.00315)	0.0968** (0.0376)	0.0127** (0.00426)
Outages_1	–0.0387** (0.0161)		
Outages_2		–0.0427** (0.0155)	
Outages_3			–0.0823*** (0.0164)
_cons	0.684*** (0.00700)	0.672*** (0.00804)	0.668*** (0.00889)
N	4721	4721	4721
CFE	Yes	Yes	Yes
IFE	Yes	Yes	Yes
R^2	0.61	0.68	0.46

Hetroskedasticity adjusted robust standard errors in parentheses.*P<0.1, **P<0.05 ***P<0.01

specification (2)) show that the second measure of power outages (*Outages*_2) is statistically significant with negative sign. We find similar result for the third measure of power outages reported in fourth column of Table 1 (empirical specification (3)). These results also corroborates the claim that power outages reduce the productive efficiency of manufacturing firms in selected South Asian countries. This result is consistent with existing literature on subject. For instance, Cole et al. (2018) and Abotsi (2016) find identical results for the selected African countries while Cissokho (2019) finds similar results for the manufacturing firms operating in Senegal.

Our results show that all control variables have the expected signs. For instance, the size, access to credit (*credit*), skilled workers (*w_skills*), imported technology (*imp_tech*) and exporting activity of firms (*export*) is positively associated with technical efficiency of firms and statistically significant in all three specifications. These results are consistent with existing literature on the technical efficiency of firms. For instance, Cole et al. (2018) find that size, exporting activity, excess to credit is positively associated with technical efficiency of firms However, our result show that age of the firm is statistically insignificant in all three specifications. This result is in line with the Hsieh and Klenow (2014) that find similar results for India and Mexico.

We also use some alternative control variables to test the reliability of our results. In Table 2, we replace skilled workers (*w_skills*) with education of workers (*w_edu*) and imported technology with imported inputs (*import_inp*).

The results reported in Table 2 (empirical specification 1–3) show that all three measures of power outages remain statistically significant with negative signs. These results again validate the claim that inadequate electricity reduce the productive efficiency of manufacturing firms operating in selected South Asian countries. The control variables in our empirical models such as size of firms (*size*), access to credit (*credit*), education of workers (*w_edu*), imported inputs use in production process (*import_inp*) and exporting status of firms (*export*) are statistically significant with positive signs in all three specifications (1–3). However, age of firms (*age*) is statistically insignificant with positive sign. We also include the dummies in all empirical specifications (1–3) to capture the country fixed effects (CFE) and industry fixed effects (IFE).

4.1. Robustness Check

The dependent variable of this study is technical efficiency of manufacturing firms estimated through the stochastic frontier model. The technical efficiency of firm *j* is a fraction ($TE_j \in (0,1)$), hence to estimate the effect of power outages on technical efficiency of firms the Beta regression model proposed by Papke and Wooldridge (1996) can be an alternative estimation technique. Beta regression provides the unbiased and efficient estimators for those fractions ($TE_j \in (0,1)$) where boundary points are not part of the set.

Table B1 in appendix B reports the results of the effect of power outages on the technical efficiency of firm estimated through Beta regression. The results reported in Table B1 in Appendix B reveal that power outages enter in our empirical specifications (1–3) with statistically significant negative signs. Hence, the results of our study are robust across alternative estimation techniques. Our control variables size of firms (*size*), age of firms (*age*), access to credit (*credit*), imported technology (*imp_tech*), exporting status (*export*) is statistically significant with positive signs.

We re-estimate the effect of power outages on the technical efficiency of firms using the beta regression with some alternative control variables. We replace skilled workers (*w_skills*) with education of workers (*w_edu*) and imported technology with imported inputs (*import_inp*). The Table B2 in Appendix B report the results of effect of power outages on the technical efficiency using alternative estimation techniques. The results again show that coefficients of power outages measures are statistically significant with negative sings in all three empirical specifications (1–3). Overall results of the study validate the claim that energy gap in selected South Asian countries deteriorate the productive efficiency of manufacturing firms.

Table 2: OLS estimates of effect of power outages on productive efficiency of firms

Variables	(1)	(2)	(3)
	TE	TE	TE
Size	0.0383*** (0.0105)	0.0251* (0.0126)	0.0276 (0.0148)
Age	0.0183 (0.0168)	0.0237 (0.0197)	0.0130 (0.0219)
Credit	0.0333*** (0.00385)	0.0380*** (0.00456)	0.0307*** (0.00517)
w_edu	0.0397*** (0.00377)	0.0356*** (0.00445)	0.0409 (0.0741)
import_inp	0.0237*** (0.0533)	0.0252*** (0.0658)	0.0381*** (0.0114)
Export	0.0134*** (0.0313)	0.0131*** (0.0375)	0.0102* (0.0433)
Outages_1	–0.0166 (0.00265)		
Outages_2		–0.0164 (0.0000256)	
Outages_3			–0.0844*** (0.000163)
_cons	0.594*** (0.00970)	0.599*** (0.0111)	0.651*** (0.0177)
N	4721	4721	4721
CFE	Yes	Yes	Yes
IFE	Yes	Yes	Yes
R^2	0.66	0.70	0.50

Hetroskedasticity adjusted robust standard errors in parentheses. *P<0.1, **P<0.05, ***P<0.01

5. CONCLUSION

Many countries of the South Asian region face electricity shortage as a result these countries confront frequent power outages. These frequent outages has profound implications for the productivity of firms which affect their global competitiveness. This study investigates the effect of power outages on the technical efficiency of manufacturing firms operating in selected South Asian countries India, Pakistan and Bangladesh. We employ the stochastic frontier approach to estimate the technical efficiency of firms. In second step we estimate effect of power outages on the technical efficiency of firms using the OLS and Beta regression.

The empirical findings of the study reveal that power outages have statistically significant negative effect on the technical efficiency of the manufacturing firms operating in selected South Asian countries. These results validates the claim that power outages impede the performance of manufacturing firms which indirectly affect their global competitiveness and export performance. Our results also reveal that firm size and age is positively associated with technical efficiency of manufacturing firms. Further, firms with access to credit, imported technology, larger share of skilled workers, and involve in exporting activity are more productive than their counterparts. Similarly, firms with larger share of educated workers and using imported inputs in their production process also more productive than their counterparts. These results are robust to the alternative estimation techniques and alternative empirical specifications.

These results can provides profound implications for the conducive business environment and relative policy support for technical efficiency and competitiveness of manufacturing firms in global market.

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APPENDIX A

Table A1: Variables and their description

Variables	Description
Output (y)	1. Log of the total annual sales of firms 2. Log value added of firm
Labor(l)	"Log of full time workers. It includes both permanent and temporary workers"
Capital (k)	"Logarithm of the establishment's net book value of machinery, vehicles, and equipment, and land and buildings"
Age (age)	"Logarithm of age of an establishment in a years"
Imported input (import_inp)	"Ratio of imported inputs in total annual purchase of material inputs and/or supplies"
Imported Technology(imp_tech)	"Dummy variable equal to one if firm use imported technology"
Firm Size (F_Size)	"Logarithm of number of full- time employees."
Access to Credit (credit)	"Percentage of working capital financed by banks and non-bank borrowing"
Power outages (Outages_1)	"dummy variable equal to one if firms experienced the power outages zero otherwise"
Power outages (Outages_2)	" average number of outages in typical month an establishment experienced"
Power outages (Outages_3)	"Loss as percentage of total annual sales due to power outages."
Workers skills(w_skills)	"Ratio of skilled production workers to unskilled production workers."
Education of workers (w-edu)	"Percentage of full time permanent workers who completed secondary school"
Export (export)	"Dummy variable equal to one if firm export either directly or indirectly"

APPENDIX B

Table B1: Estimates of effect of power outages on technical efficiency of firms through beta regression

Variables	(1)	(2)	(3)
Size	0.0916***	0.0409**	0.0413**
	(0.0301)	(0.0172)	(0.0181)
Age	0.0275*	0.0375**	0.0340**
	(0.0138)	(0.0136)	(0.0154)
Credit	0.105***	0.115***	0.0816***
	(0.0111)	(0.0133)	(0.0169)
w_skills	0.0311**	0.0938**	0.0782**
	(0.0132)	(0.0162)	(0.0195)
imp_tech	0.0110***	0.0824***	0.0160***
	(0.0013)	(0.0037)	(0.0071)
Export	0.0215***	0.0183**	0.0190**
	(0.00887)	(0.0089)	(0.00938)
outages_1	–0.0307**		
	(0.0123)		
outages_2		–0.0287**	
		(0.0113)	
outages_3			–0.0238***
			(0.00989)
_cons	0.472***	0.477***	0.443***
	(0.0198)	(0.0260)	(0.0294)
Scale			
_cons	3.443***	3.428***	3.442***
	(0.0212)	(0.0254)	(0.0319)
N	4721	4721	4721
CFE	Yes	Yes	Yes
IEF	Yes	Yes	Yes
R^2	0.64	0.72	0.54

Standard errors in parentheses *P<0.05, **P<0.01, ***P<0.001

Table B2: Estimates of effect of power outages on technical efficiency of firms through beta regression

Variables	(1)	(2)	(3)
	TE	TE	TE
Size	0.0411***	0.0274**	0.0325**
	(0.0124)	(0.0115)	(0.0126)
Age	0.00782	0.0135	0.103
	(0.0241)	(0.0309)	(0.0721)
w_edu1	0.230***	0.133*	0.1670**
	(0.0404)	(0.0528)	(0.056)
Imported inputs	0.220***	0.127**	0.192**
	(0.0872)	(0.0528)	(0.0647)
Export	0.0445**	0.0412**	0.0621**
	(0.0170)	(0.0180)	(0.018)
outages_1	–0.0426**		
	(0.0163)		
outages_2		–0.0481*	
		(0.0198)	
outages_3			–0.141***
			(0.0420)
_cons	0.399**	0.608***	0.430
	(0.128)	(0.169)	(0.475)
Scale			
_cons	2.936***	2.799***	2.206***
	(0.0484)	(0.0589)	(0.105)
N	4721	4721	4721
R^2	0.58	0.67	0.54

Heteroskedasticity adjusted robust standard errors in parentheses. *P<0.05, **P<0.01, ***P<0.001