Ali Fakih, Pascal Ghazalian* and Nancy Ghazzawi

The Effects of Power Outages on the Performance of Manufacturing Firms in the MENA Region

https://doi.org/10.1515/rmeef-2020-0011
Received February 24, 2020; accepted October 5, 2020

Abstract: Power supply in developing countries is often characterized by unreliability and inefficiency, resulting in disruption costs for operating firms. The extents of power outages in the Middle East and North Africa (MENA) region are more significant compared to other geo-economic regions. This paper examines the effects of power outages on the performance of manufacturing firms in the MENA region using a firm-level dataset derived from the World Bank's Enterprise Surveys (WBES) database. Firm performance is represented by sales, employment, and productivity growth rates. The extents of power outages are depicted by objective measures characterizing durations and frequencies of power outages, and by perception-based measures reflecting firms' perceived severity of power outages. The results emphasize the adverse consequences of power outages for the performance of manufacturing firms in the MENA region. They also suggest that different patterns of power outages have varying implications for firm performance, and that the effects of power outages exhibit variations with firm size.

Keywords: firm performance, firm productivity, MENA region, power outages, power supply

JEL Classifications: D22, D24, L94, Q49

1 Introduction

Power supply in developing countries has been generally characterized by unreliability and inefficiency, resulting in disruption costs that adversely impact the economic performance of firms. Ineffective privatization policies, corruption, increasing fuel costs, lack of public investment, political instability, and poor

***Corresponding author: Pascal Ghazalian**, Department of Economics, University of Lethbridge, T1K 3M4, Lethbridge, Alberta, Canada, E-mail: pascal.ghazalian@uleth.ca
Ali Fakih and Nancy Ghazzawi, Department of Economics, Lebanese American University, Beirut, Lebanon, E-mail: afakih@lau.edu.lb (A. Fakih), nancy.ghazzawi@lau.edu.lb (N. Ghazzawi)

infrastructure are amongst the factors that cause inadequate supply of electricity in developing countries and, hence, power outages (Um, Straub, and Vellutini 2009; Eberhard et al. 2011; Cissokho and Seck 2013; Moyo 2013). Power supply in most developing countries is generally assigned to the public sector. In parallel, the relatively limited private investments in the power infrastructure have been often attributed to restrictive regulations and to the tendency of investors to undertake alternative lower-risk/higher-return investment opportunities (Adenikinju 2003; Eberhard et al. 2011). Moreover, the prevalence of malformed energy subsidization policies in many developing countries[1] have resulted in inefficient allocation of resources and distorted pricing signals, leading to underinvestment in the energy sector and to increases in the incidents and durations of power outages (Um, Straub, and Vellutini 2009; Eberhard et al. 2011; Fattouh and El-Katiri 2013).

The extents of power outages in the Middle East and North Africa (MENA) region are more significant compared to many other geo-economic regions (Um, Straub, and Vellutini 2009; Fattouh and El-Katiri 2013). As an illustration, Table 1 shows some representative power outage statistics derived from the World Bank's Enterprise Surveys (WBES) database for different geo-economic regions.[2] These statistics indicate that manufacturing firms in the MENA region are subjected to the second highest average number of power outages per month amongst geo-economic regions of 16.5 times, and to the second longest average duration of a power outage incident amongst geo-economic regions of 4.9 h. Taken together, they reveal that manufacturing firms in the MENA region are exposed to the longest average total duration of power outages per month amongst geo-economic regions, standing at 64 h.[3] Also, they show that the average perceived value of losses of manufacturing firms in the MENA region due to power outages is important, standing at an average of 4.8% of total sales. These statistics could be indicative of significant negative effects on the performance of the MENA's manufacturing firms in terms of sales and productivity, signifying that the impact of power outages on business activities should be comprehensively examined through various channels and under different circumstances (Kinda, Plane, and Véganzonès-Varoudakis 2011). Also, they raise concerns that the absence of appropriate policies and reforms targeting the power infrastructure would restrain economic growth in the MENA region.

1 These energy subsidization policies are often implemented by governments in developing countries to maintain social and political stability (Um, Straub, and Vellutini 2009).

2 See Section 3 for details on survey and data.

3 In addition to power outages, poor quality of electricity (*e.g.* fluctuations in voltage) could also impact the performance of firms since it could affect the operation of production machinery and equipment, and it could inflict damage in them (Lineweber and McNulty 2001). There are no specific measures of the quality of electricity in the WBES database.

Table 1: Power outages reported by manufacturing firms by geo-economic region.

Geo-economic region	Number of power outages per month	Duration of a power outage incident (hours)	Value of losses due to power outages (% of total sales)
Middle East and North Africa (MENA)	16.45	4.90	4.78
East Asia and the Pacific (EAP)	1.33	1.74	0.86
Eastern Europe and Central Asia (ECA)	2.18	1.68	1.39
Latin America and the Caribbean (LAC)	1.55	1.35	1.28
South Asia (SA)	37.72	1.80	5.98
Sub-Saharan Africa (SSA)	11.10	6.04	6.39
High income, OECD countries	0.60	0.70	0.33
High income, non-OECD countries	0.54	1.04	0.22

Source: The World Bank's Enterprise Surveys (WBES) database.

Power outages have generally direct and indirect effects on the overall performance of firms, causing increases in economic costs, reductions in produced quantities, and eventually decreases in sales and productivity (Arnold, Mattoo, and Narciso 2008; Fattouh and El-Katiri 2013; Fisher-Vanden, Mansur, and Wang 2015). The direct effects of power outages can be underlined through the following points. First, power outages generate costs that could be instantaneous (not proportional to the duration of power outages) such as losses of computer files and programmes, and that could be proportional to the duration of power outages, such as idle machinery and labour (de Nooij, Koopmans, and Bijvoet 2007). Second, power outages cause disruptions of the production process, leading to reductions in intermediate and final outputs. Third, increasing shortages in power supply compel firms to undertake precautionary measures and to use alternative power sources such as generators (Fisher-Vanden, Mansur, and Wang 2015). These measures could impose additional economic costs on firms. Fourth, higher frequencies and durations of power outages could accelerate and/or cause deterioration of production machinery and equipment, eventually causing breakdowns and/or damages. Fifth, high frequencies and long durations of power outages could negatively impact the productivity and efficiency of the labour force, and

could generate opportunity costs associated with idle machinery and labour force.[4]

The indirect effects, which encompass behavioural responses of individuals, are associated with negative implications of power outages for both consumer confidence and labour force (Munasinghe 1980). High frequencies and long durations of power outages tend to increase the costs of living, deteriorate individuals' well-being and demotivate them from performing their jobs (Munasinghe 1980). The indirect effects of power outages could also reduce demand, which could in turn induce markedly decreases in firms' sales, efficiency, and productivity.[5] The implications of power outages for the performance of manufacturing firms in the MENA region come in addition to other challenges, particularly those associated with deficiencies in business climate and infrastructure that lessen firm competitiveness in the domestic and international markets (Kinda, Plane, and Véganzonès-Varoudakis 2011).

Energy is often deemed to be an important factor that affects the economic growth rate since production is normally determined as a function of capital, labour and energy, *inter alia* (Berndt and Wood 1975; Munasinghe and Gellerson 1979; Stern 1993, 2000; Esfahani and Ramírez 2003). Thus, a reliable power supply service in terms of availability, quality, and costs is expected to promote firm performance (Arnold, Mattoo, and Narciso 2008). In this context, Kessides (1993) indicates that an adequate power infrastructure tends to raise the productivity of other factors of production and, hence, firm productivity. Also, there exist some macroeconomic evidence from the MENA and other developing geo-economic regions that underscore the negative effects of power outages and/or the positive effects of reliable energy supply system on national economic growth rates (*e.g.* Ferguson, Wilkinson, and Hill 2000; Um et al., 2009; Bhattacharya and Wolde 2012).[6]

This paper contributes to the empirical literature by examining the effects of power outages on the performance of manufacturing firms in the MENA region, using both objective and perception-based measures of power outages. It complements the existing empirical studies that investigate the implications of power outages for firm performance and national economic growth rate in other geo-

4 The costs of power outages tend to be higher when power outages are unstructured and incidental compared to when they are structured/scheduled and notified (de Nooij, Koopmans, and Bijvoet 2007).

5 It is worth noting that enduring problems of power outages could compel entrepreneurs, firms, and in some cases governments to pursue renewable energy alternatives.

6 Eschenbach and Hoekman (2006) find that improved service infrastructure, depicted through an index that covers electricity and other services, promotes economic growth in transition economies.

economic regions (*e.g.* Abeberese 2017; Abotsi 2016; Cissokho and Seck 2013; Igwe, Onjewu, and Nwibo 2018; Kaseke and Hosking 2013).[7] Also, it adds to the empirical literature by investigating whether different patterns of power outages have varying effects on firm performance, and whether the effects of power outages exhibit variations with firm size. Besides, it presents a methodological contribution where perception-based measures of power outages and other firm variables are instrumented, and different estimation approaches are implemented. This paper relies on a dataset extracted from the WBES database, which characterizes a comprehensive source of firm-level data in developing economies. Firm performance is represented through three main indicators: annual sales growth rate, annual employment growth rate and annual labour productivity growth rate. The extents of power outages are depicted by objective measures covering durations and frequencies of power outages, and by perception-based measures that are derived from firms' perceived severity of power outages such as, perceived value of losses due to power outages and identification variable on whether electricity constitutes a major constraint for firm operation.[8]

The main empirical results underline negative implications of power outages for the performance of manufacturing firms in the MENA region, particularly in terms of sales and labour productivity growth rates. There are negative but relatively smaller effects of power outages on employment growth rate, which could be indicative of partial compensation for the power-outage-caused inoperativeness of production machinery with supplementary workers. Also, the results imply that different patterns of power outages have varying implications for firm performance, and they tentatively suggest that the negative effects of power outages exhibit variations with firm size, being more significant in the case of smaller firms.

The remainder of this paper is structured as follows. Section 2 reviews the related literature on the effects of power outages on firm performance and economic growth. Section 3 presents the empirical model, and describes the dataset and the variables used through the empirical analysis. Section 4 presents and discusses the benchmark empirical findings, using objective measures of power outages. Section 5 presents and discusses supplementary empirical results, using perception-based measures of power outages. Section 6 includes concluding remarks, and sets policy recommendations.

---

7 This empirical literature reports varying effects of power outages in qualitative and quantitative terms, warranting distinct empirical analyses across geo-economic regions and countries.

8 This categorization into objective and perception-based measures is highlighted in many other studies (*e.g.* Arnold, Mattoo, and Narciso 2008; Kaplan and Pathania 2010; Cissokho and Seck 2013).

2 Related Literature

There is a range of empirical literature that underlines the negative effects of inadequate and inefficient power infrastructure on firm performance in different developing geo-economic regions. In the case of sub-Saharan Africa (SSA), Kaseke and Hosking (2013) examine the impact of inadequate power supply on the economic performance of firms. They attribute the inadequacy in power supply to low investments in electricity production and to some other factors, such as oil price shocks, conflicts, and nature-related causes (*e.g.* drought). They emphasize that inadequate power supply would bring about decelerated economic growth rates and lower productivity levels in SSA. Moyo (2013) examines the relationship between power infrastructure, depicted through power outage measures and productivity of manufacturing firms in SSA. Moyo (2013) finds that lower quality of power infrastructure adversely impacts productivity of firms – with more significant effects on smaller firms, and he suggests once again that governments could tackle this problem by adopting suitable policies that would lead to improvements to the power infrastructure.[9] Arnold, Mattoo, and Narciso (2008) analyse the implications of service inputs (including electricity among other services) for total factor productivity of firms located in SSA, and find that increases in the extents of power outages have detrimental effects on firm performance.

A parallel research line carried out the analysis for specific countries in SSA. Moyo (2012) finds negative effects of power outages on the productivity of manufacturing firms in Nigeria. He indicates that the main causes of power disruptions in Nigeria are the poorly built facilities and inadequate power infrastructure, and the surge in the demand for electricity by Nigeria's manufacturing sector. He insinuates that there is an urgent need for governmental interventions to improve power supply through deliberate efforts to develop and improve the power infrastructure. Cissokho and Seck (2013) assess the impact of power outages on firm productivity using a survey dataset composed of firms located in Senegal. They find that electricity disruptions lead to increases in production costs, and that they negatively impact scale efficiency of firms. Also, they find that smaller firms adjust better to power outages in general compared to larger firms. They call for governmental interventions to improve the quality of the power infrastructure, and to facilitate the access to loans and credits for businesses in order to enhance productivity of firms and to promote their competitiveness and growth.

9 Also, Abotsi (2016) finds that increasing power outages in SSA countries have negative impacts on production efficiency, and indicates that a poor power infrastructure restricts power supply. This restriction induces firms to resort to less-energy intensive means, eventually leading to increases in production costs and to decreases in sales.

Some studies carried out the analysis for countries in South Asia (SA). Abeberese (2017) analyzes the relationship between electricity costs and the performance of manufacturing firms in India. She finds that firms tend to decrease their electricity consumption with higher electricity prices, inducing them to switch to less electricity-intensive production processes. These implications may result in missed productivity-enhancing opportunities. Abeberese (2017) shows that higher electricity prices have negative effects on firm output, labour productivity and machine/equipment intensity. She notes that higher intensities in electricity use have important implications for productivity growth, underlining the importance of making electricity affordable and available for manufacturing firms in India. Also, she suggests that the government in India should facilitate interruptible contracts, which should be financially affordable and politically feasible, rather than raising prices or making structural changes in power plants. Fernandes (2008) analyzes the determinants of total factor productivity of firms located in Bangladesh, and finds that power supply problems have significant negative effects on firm performance. Also, Grainger and Zhang (2019) emphasize the adverse effects of power outages on the performance of manufacturing firms in Pakistan, and they indicate that a more reliable power supply would significantly contribute in improving firm productivity.

The empirical literature also comprises studies for countries in East Asia and the Pacific (EAP). Fisher-Vanden, Mansur, and Wang (2015) estimate the impact of electricity shortages on the economy and the environment in China. They find that firms exposed to limited power storage suffer from low productivity, and that firms subjected to frequent and long durations of power outages may resort to alternative means of getting electricity such as, self-generating, purchasing intermediate goods, and/or improving technical efficiency. Using a dataset covering energy-intensive firms from a variety of industries in China, they find that many firms underwent a re-optimization, shifting from energy to materials (*i.e.* buying instead of making), and that there is no statistical evidence of increases in self-generation. Also, they find that firms have partially reduced their carbon emissions despite incurring extra costs. Ba Trung and Kaizoji (2017) examine the effects of business environment on the productivity of manufacturing firms in Vietnam, and they find that inadequate power supply has detrimental effects on firm performance. They indicate that Vietnam, and other developing countries in general, are required to implement institutional reforms to improve infrastructure and the provision of public goods and services.

Analysing the implications of power outages for firm performance can be linked to a broader empirical literature that examines the promoting effects of improved service infrastructure on economic growth and firm productivity (*e.g.* Tybout 2000; Esfahani and Ramírez 2003; Eschenbach and Hoekman 2006; Eifert

et al., 2008; Yeaple and Golub 2007; Um, Straub, and Vellutini 2009). For instance, Eifert et al. (2008) find that costs related to inadequate infrastructure and services, including electricity infrastructure, constitute high shares of total production costs in SSA, negatively impacting firm performance. Using a dataset that comprises developed and developing countries, Yeaple and Golub (2007) show positive relationships between infrastructure and industry-level productivity, and they report adverse implications of power outages for firm performance. Also, Um, Straub and Vellutini (2009) reveal that adequate service infrastructure that comprises a reliable power supply system has positive effects on national economic growth rate and on total factor productivity in the MENA region. However, they find that the return on infrastructure is lower in the MENA region compared to other geo-economic regions.

3 Data and Variables

This paper uses the WBES database, which comprises observations on firms located in the MENA region, to implement the empirical analysis.[10] The WBES database is a comprehensive source of firm-level data in emerging and developing countries. It covers various indicators of firm characteristics and performance such as, exporting activities, ownership structure, composition of labour, employment, sales and productivity. This dataset also includes different variables that cover the extents of power outages. This dataset is used to empirically examine the effects of power outages on firm performance. The general form of the empirical model in this study is determined as:

$$FPerf_i = \beta_0 + \beta_1 PO_i + \beta_2 FV_i + \mu_i^d + \varphi_i^c + \omega_i^t + \varepsilon_i \quad (1)$$

where $FPerf_i$ is a representative firm performance variable, PO_i is a vector of power outage variables, and FV_i is a vector of firm variables. Also, the general form of the empirical model includes industry-specific, country-specific, and time-specific effects (μ_i^d, φ_i^c, and ω_i^t, respectively). Table 2 presents descriptive statistics of the variables used in the empirical analysis. These variables are reviewed in the following paragraphs.

Firm performance is depicted through three main variables: (1) annual sales growth rate (*Sales_Growth*) defined as the percentage change in real total sales of

10 The MENA countries, and the corresponding survey year/fiscal year are: Algeria (2007/2006), Egypt (2007/2005; 2008/2007; 2013/2012; 2016/2015), Iraq (2011/2010), Jordan (2006/2005; 2013/2012), Lebanon (2009/2008; 2013/2012), Morocco (2007/2005; 2013/2012), Syria (2009/2008), Tunisia (2013/2012), West Bank and Gaza (2006/2006; 2013/2012), and Yemen (2010/2009; 2013/2012).

Table 2: Descriptive statistics.

Variables	Definition	Mean	St. Dev.	Min.	Max.
Sales_Growth	Annual sales growth rate (%)	−8.20	22.98	−93.55	66.54
Employment_Growth	Annual employment growth rate (%)	2.04	14.46	−63.64	93.75
LProductivity_Growth	Annual labour productivity growth rate (%)	−9.51	23.99	−97.02	66.54
Number_PO	Number of power outages in a typical month	16.45	34.27	0	390
Duration_PO	Duration of a power outage incident (hours)	4.90	36.24	0	720
TDuration_PO	Total duration of power outages per month (hours)	64.00	148.12	0	720
MConstraint_PO	Firms identifying electricity as a major constraint (binary variable)	0.39	0.49	0	1
VLoss_PO	Value of losses due to power outages (% of sales)	4.78	10.32	0	70
PForeign_Own	Private foreign ownership (% of total ownership)	4.98	19.96	0	100
Export_Activities	Sales that are exported directly and indirectly (% of sales)	12.98	27.89	0	100
Firm_Age	Firm age since establishment (years)	20.06	16.27	1	156
Firm_Size	Average number of total permanent full-time workers	98.97	291.28	1	2,500
Non_Prod_Wk	Non-production workers (% of total full-time workers)	23.31	22.11	0	100
Skilled_Prod_Wk	Skilled production workers (% of total full-time workers)	49.38	64.12	0	100

Source: The World Bank's Enterprise Surveys (WBES) database.

current fiscal year relative to the previous fiscal year, (2) annual employment growth rate (*Employment_Growth*) defined as the percentage of annual change in full-time employment between the current fiscal year and the previous fiscal year and (3) annual labour productivity growth rate (*LProductivity_Growth*) defined as the percentage change in labour productivity between the current fiscal year and the previous fiscal year, where labour productivity is constructed as the ratio of real sales to total full-time employment.[11] The descriptive statistics reveal negative

11 There are different measures of productivity. For instance, productivity can be defined as total output divided by total input capital, or it can be represented through total factor productivity. In this paper, the empirical analysis relies on the readily available labour productivity variable, which can be conveniently related to the other firm performance variables (*i.e.* sales growth and employment growth).

average annual sales and labour productivity growth rates of −8.2 and −9.5%, accompanied with standard deviations of 23.0 and 24.0%, respectively. The average annual employment growth rate is positive, standing at 2.0% with a standard deviation of 14.5%.

The dataset includes power outage variables that are based on objective measures, covering frequency/number of power outages in a typical month (*Number_PO*), duration of power outages in a typical power outage incident (*Duration_PO*) and total duration of power outages per month (*TDuration_PO*). The latter is derived as an interaction between the first two variables. The dataset also covers power outage variables that characterize perception-based measures, reflecting firms' perceived severity of power outages. The perception-based power outage variables that are used through this empirical analysis consist of an identification binary variable on whether electricity constitute a major constraint to firm operation (*MConstraint_PO*), and a continuous variable displaying the perceived value of losses due to power outages in percentage of total sales (*VLoss_PO*).[12, 13] The perceived severity of power outages would typically proxy the real extents of power outages, which affect firm performance. However, firm performance could have an impact on the formation of perceptions about the severity of power outages. This potential endogeneity issue is tackled by instrumenting the perceptions about power outages through the empirical analysis.[14]

The power outage variables are indicative of the inadequacy of the power infrastructure, and they are expected to have negative effects on firm performance indicators, which are expressed through lower productivity and lower production/sales, *inter alia* (Abeberese 2017; Adenikinju 2003; Arnold, Mattoo, and Narciso 2008; Fisher-Vanden, Mansur, and Wang 2015; Moyo 2013). The effects of power outages on employment are arguably ambiguous. Power outages would reduce growth potentials of firms, leading to lower employment growth rates. On the other hand, power outages would result in inoperative machinery and equipment, compelling manufacturing firms to compensate for these deficiencies with

12 The surveys are answered by senior managers and business owners, whose assessments of values of losses caused by power outages are more likely to be based on their general perceptions rather than on methodological economic analyses. As such, the reported value of losses due to power outages can be categorized as a perception-based measure.

13 In this context, Jyoti, Ozbafli, and Jenkins (2006) note that the costs of power outages can be estimated through the losses in value added or in net revenue. These power outage costs are mainly associated with labour and machinery costs, material spoilage costs, and restarting costs, *inter alia*.

14 This is realized by using the location-industry-country averages, excluding firm's own observation, as instruments through the empirical analysis. Alternatively, the actual number and duration of power outages are used to instrument the perceptions about power outages.

supplementary labour force. Descriptive statistics indicate that manufacturing firms in the MENA region are averagely exposed to a frequency of power outages and to a typical duration of a power outage incident of 16.5 times and 4.9 h, respectively. These statistics are associated with relatively large standard deviations (34.3 times and 36.2 h, respectively), implying considerable variations through the observations. The statistics show that the average total duration of power outages per month facing manufacturing firms in the MENA region stands at a mean of 64 h with a relatively large standard deviation of 148.1 h. The mean perceived value of losses due to power outages stands at 4.8% of total sales (with a standard deviation of 10.3% of total sales). Also, the statistics show that 39% of manufacturing firms in the MENA region identify electricity as a major constrain to their operations.

The empirical specifications include various firm characteristics that are discussed next. Firm size (*Firm_Size*) – This variable is represented by the total number of permanent full-time workers. Larger firms often realize economies of scale, and they have better market knowledge and resources that would render them less vulnerable to market shocks or crisis (Jensen, McGuckin, and Stiroh 2001; Moyo 2012). Many studies point out that there are relatively high proportions of small firms that shortly exit the market after entering, and that these small firms are often characterized by lower productivity levels (Audretsch, Santarelli, and Vivarelli 1999; Taymaz 2005; van Biesebroeck 2005). Also, they indicate that the time period that precedes market exit is generally characterized by decreasing productivity.[15]

Exporting activities (*Export_Activities*) – This variable is defined as the percentage of total sales that are exported either directly or indirectly. Exporting activities are expected to have positive effects on firm performance, since exporting activities are associated with accessibility to larger markets, and since they often generate promoting spillover effects through learning-by-exporting. Also, exporting activities would expose firms to higher competition levels in international markets, compelling firms to seek and adopt better technologies and management practices, *inter alia* (Bernard and Jensen 1999; Wagner 2007). The exporting activities variable is likely to be endogenous in the empirical model. While exporting activities would normally enhance firm performance, some effects could be also running from firm performance towards exporting activities. For instance, firms can get engaged in more exporting activities with a

15 It is worth noting that some surviving small firms that overcome the market competitiveness hurdle may subsequently enjoy relatively higher productivity growth rates compared to large firms. Hence, a higher proportion of surviving firms with higher productivity growth rates may dampen (or even reverse) the positive empirical relationship between firm size and productivity.

competitive performance and high productivity. In order to address this potential endogeneity issue, the exporting activities variable is instrumented with location-industry-country averages excluding firm's own observation through the empirical analysis.

Firm age since establishment (*Firm_Age*) – This variable is expected to have a positive effect on firm performance. The accumulation of production and market knowledge and the realization of economies of scale are generally enhanced with firm age, implying that new (young) entrants tend to have lower productivity levels compared to incumbent (older) firms (Jensen, McGuckin, and Stiroh 2001; Moyo 2012). However, the effect of firm age on firm performance could be negative with higher growth rates of surviving new firms.[16] Private foreign ownership (*PForeign_Own*) – This variable is defined as the percentage of firm ownership retained by foreign individuals, companies, and/or organizations. Private foreign ownership is expected to enhance firm performance, since it tends to induce channelling and spillovers of technologies and knowledge-related assets to foreign affiliates and it promotes more efficient use of resources (Javorcik 2004).

Labour composition of firms in terms of non-production workers (*Non_Prod_Wk*) and skilled production workers (*Skilled_Prod_Wk*) – These variables are defined as the percentage of non-production workers and skilled production workers in total full-time employment, respectively. They are normally expected to exhibit positive relationships with firm performance since human capital derived from education and training tends to enhance firm competitiveness and productivity (Blundell et al. 1999). However, the prevalence of comparative advantage in the production of unskilled-labour intensive goods (vis-à-vis comparative disadvantage in the production of skilled-labour intensive goods) in the manufacturing sector could attenuate (or even reverse) this positive relationship.

4 Benchmark Empirical Results

The benchmark empirical analysis is implemented with objective measures of power outages through different empirical specifications and alternative measures and combinations of variables. The corresponding empirical results from the annual sales growth, employment growth and labour productivity growth equations are presented in Table 3, Table 4, and Table 5, respectively. The estimated coefficients are generally reported with robust standard errors, whereas clustered

16 New entrants are generally exposed to high market exit rates, and surviving firms tend to have relatively high productivity growth rates (Jensen *et al.*, 2001).

standard errors (by country-year cluster group) are presented when including national variables in the empirical specifications.[17]c As noted in the previous section, the exporting activities variable is instrumented using the location-industry-country averages – excluding firm's own observation, and the empirical analysis is carried out through the two-stage least squares (2SLS) estimator.[18]

In these tables, columns (i) present the results from the empirical specifications that include the total duration of power outages (*TDuration_PO*) as the basic power outage variable. The estimated coefficient on this variable in the sales growth equation is negative and statistically significant at the 1% level, revealing the adverse effects of power outages on sales growth rate. Specifically, an increase in *TDuration_PO* by 10 hours per month would lead to a decrease in annual sales growth rates by 0.30 percentage points (pps), *ceteris paribus*.

In the case of employment growth, the estimated coefficient on *TDuration_PO* is negative and statistically significant at the 5% level. It indicates that an increase in total duration of power outages by 10 hours per month would lead to a decrease in annual employment growth rates by 0.10 pps, *ceteris paribus*. These results may not necessarily mean that power outages have milder impacts on employment growth rate in absolute terms, but they could rather stem from some potential mitigation efforts exercised by the manufacturing firms in the MENA region to partially compensate for the power-outage-caused inoperativeness of production machinery with supplementary workers. In other words, the initial negative effects of power outages on employment growth could be moderated by such firms' efforts, leading to a lower (net) negative effect of power outages on employment growth rate.

The results from the labour productivity growth equation show a negative effect of *TDuration_PO* that is statistically significant at the 5% level. The estimated coefficient indicates that an increase in total duration of power outages by 10 hours per month would induce a decrease in annual labour productivity growth rates by 0.14 pps, *ceteris paribus*. Given that labour productivity is technically constructed

---

17 The corresponding robust variance can be depicted as: $Var(\widehat{\beta})^r = (X'X)^{-1}\left[\sum_{i=1}^{N}(\hat{u}_i X_i)'(\hat{u}_i X_i)\right](X'X)^{-1}$ (for a large number of observations N), where $\hat{u}_i$ is the residual of the ith observation. The clustered variance can be generally represented as: $Var(\widehat{\beta})^c = (X'X)^{-1}\left[\sum_{g=1}^{G}(\hat{u}_g X_g)'(\hat{u}_g X_g)\right](X'X)^{-1}$, where g denotes cluster group.

18 The corresponding estimated coefficients can be represented as: $\widehat{\beta}_{2SLS} = (X'P_Z X)^{-1}(X'P_Z Y)$ with $P_Z = Z(Z'Z)^{-1}Z'$, where the instruments in Z are characterized by $E(Zu) = 0$. The empirical analysis is alternatively carried out through the generalized methods of moments (GMM) estimator. The latter chooses the value $\widehat{\beta}$ that minimizes a quadratic function of the moment condition, where $\widehat{\beta} \equiv argmin_{\beta}\left\{\frac{1}{N}\sum_i Z_i u_i(\beta)\right\}'\left\{\frac{1}{N}\sum_i Z_i u_i(\beta)\right\}$ with $u_i(\beta) = Y_i - X_i'\beta$ for the linear specification.

Table 3: Effects of power outages on sales growth rate of manufacturing firms using objective measures of power outages.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
TDuration_PO	−0.030***		0.025**	−0.025***		−0.026***	−0.026***	−0.028***
	(0.007)		(0.010)	(0.005)		(0.006)	(0.007)	(0.008)
Number_PO		−0.121***	−0.159***		−0.080***			
		(0.019)	(0.025)		(0.021)			
Duration_PO		−0.037	−0.120		−0.065			
		(0.122)	(0.146)		(0.112)			
Firm_Size	0.007***	0.007***	0.007***	0.010***	0.010***	0.010***	0.0010***	0.0010***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Export_Activities	0.096***	0.080***	0.079***	0.036*	0.039**	0.041**	0.046**	0.049**
	(0.015)	(0.015)	(0.015)	(0.020)	(0.018)	(0.018)	(0.020)	(0.020)
Firm_Age	−0.083***	−0.074***	−0.076***	−0.101***	−0.109***	−0.114***	−0.121***	−0.120***
	(0.022)	(0.021)	(0.021)	(0.015)	(0.021)	(0.021)	(0.024)	(0.024)
PForeign_Own	0.019	0.021	0.010	0.008	0.020	0.017	0.018	0.018
	(0.015)	(0.016)	(0.016)	(0.012)	(0.016)	(0.016)	(0.020)	(0.020)
Non_Prod_Wk							0.086***	0.085***
							(0.030)	(0.030)
Skilled_Prod_Wk							−0.010	−0.010
							(0.019)	(0.019)
Qual_PS				2.014***				
				(0.479)				
TDuration_PO × *Firm_Size*								0.0001
								(0.0001)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	3,024	3,024	3,024	3,024	3,024	3,024	2,597	2,597

Notes: The estimations are implemented through the two-stage least squares (2SLS) estimator. Different empirical specifications are used, some of which include industry, country, and year fixed effects. Robust standard errors are in parentheses, with ***, **, and * denoting statistical significance at the 1, 5, and 10% level, respectively. Also, clustered standard errors are presented in specifications that include national variables.

Table 4: Effects of power outages on employment growth rate of manufacturing firms using objective measures of power outages.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
TDuration_PO	−0.010**		−0.008*	−0.006**		−0.005	−0.004	−0.005
	(0.005)		(0.005)	(0.003)		(0.005)	(0.006)	(0.006)
Number_PO		−0.054***	−0.044**		−0.024*			
		(0.013)	(0.021)		(0.014)			
Duration_PO		−0.030	−0.053		−0.032			
		(0.064)	(0.070)		(0.060)			
Firm_Size	0.005***	0.005***	0.005***	0.006***	0.007***	0.007***	0.008***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Export_Activities	0.067***	0.060***	0.055***	0.040**	0.036**	0.032**	0.048***	0.049***
	(0.011)	(0.011)	(0.011)	(0.020)	(0.016)	(0.015)	(0.016)	(0.016)
Firm_Age	−0.118***	−0.113***	−0.110***	−0.110***	−0.109***	−0.112***	−0.097***	−0.097***
	(0.016)	(0.016)	(0.016)	(0.012)	(0.016)	(0.016)	(0.018)	(0.018)
PForeign_Own	−0.024**	−0.019*	−0.018*	−0.017	−0.019*	−0.019*	−0.017	−0.017
	(0.010)	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.011)	(0.011)
Non_Prod_Wk							0.036	0.036
							(0.023)	(0.023)
Skilled_Prod_Wk							−0.016	−0.016
							(0.014)	(0.014)
Qual_PS				2.185***				
				(0.292)				
TDuration_PO × Firm_Size								0.0001
								(0.0001)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	3,551	3,551	3,551	3,551	3,551	3,551	3,048	3,048

Notes: The estimations are implemented through the two-stage least squares (2SLS) estimator. Different empirical specifications are used, some of which include industry, country, and year fixed effects. Robust standard errors are in parentheses, with ***, **, and * denoting statistical significance at the 1, 5, and 10% level, respectively. Also, clustered standard errors are presented in specifications that include national variables.

Table 5: Effects of power outages on labour productivity growth rate of manufacturing firms using objective measures of power outages.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
TDuration_PO	−0.014**		−0.014	−0.013**		−0.014**	−0.015**	−0.016**
	(0.007)		(0.010)	(0.006)		(0.007)	(0.007)	(0.007)
Number_PO		−0.058**	−0.050*		−0.060***			
		(0.025)	(0.033)		(0.022)			
Duration_PO		−0.006	−0.011		−0.035			
		(0.095)	(0.112)		(0.108)			
Firm_Size	0.003*	0.003*	0.003*	0.003**	0.003**	0.003**	0.003*	0.003*
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Export_Activities	0.028	0.020	0.020	0.004	0.004	0.005	0.009	0.009
	(0.018)	(0.018)	(0.018)	(0.014)	(0.018)	(0.018)	(0.020)	(0.020)
Firm_Age	−0.018	−0.014	−0.014	−0.029*	−0.023	−0.025	−0.048*	−0.048*
	(0.023)	(0.023)	(0.023)	(0.016)	(0.024)	(0.024)	(0.027)	(0.027)
PForeign_Own	0.027*	0.030*	0.031*	0.027**	0.028*	0.026*	0.029*	0.029*
	(0.016)	(0.016)	(0.016)	(0.012)	(0.015)	(0.015)	(0.016)	(0.016)
Non_Prod_Wk							0.057**	0.057**
							(0.028)	(0.028)
Skilled_Prod_Wk							0.010	0.010
							(0.015)	(0.015)
Qual_PS				0.012				
				(0.294)				
TDuration_PO × *Firm_Size*								0.0001
								(0.0001)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	2,982	2,982	2,982	2,982	2,982	2,982	2,570	2,570

Notes: The estimations are implemented through the two-stage least squares (2SLS) estimator. Different empirical specifications are used, some of which include industry, country, and year fixed effects. Robust standard errors are in parentheses, with ***, **, and * denoting statistical significance at the 1, 5, and 10% level, respectively. Also, clustered standard errors are presented in specifications that include national variables.

as a ratio of total sales to total employment, these outcomes are concordant with the estimates obtained from the sales growth and employment growth equations.

These benchmark results are reminiscent of Kessides (1993) argument which implies that power is a major factor of production whereby changes in availability and/or costs would trigger direct impacts on the marginal productivity and performance of firms. Also, these results are consistent with those found in some previous empirical studies that underline the adverse effects of power outages on firm performance in different geo-economic regions (*e.g.* Abeberese 2017; Arnold, Mattoo, and Narciso 2008; Fisher-Vanden, Mansur, and Wang 2015; Moyo 2013). The negative implications of power outages for sales and labour productivity growth rates underline that electricity disruptions constitute an important obstacle for manufacturing firms in the MENA region. When electricity is disrupted, the operation and efficiency of machinery and labour would consequently drop. This situation would directly impact production and productivity of firms. It would adversely affect employment, but it could also induce power-outage-driven substitution of machinery and equipment with labour in the production process.

The estimated coefficients on the control variables show statistically significant effects that generally match the *a priori* expectations. The results indicate that larger firms have higher annual sales, employment, and labour productivity growth rates. For instance, an increase in firm size by one hundred full-time workers is associated with rises in these rates by 0.7, 0.5, and 0.3 pps, respectively, *ceteris paribus*. Larger firms often have better market knowledge and resources, and the realization of economies of scale would render them less vulnerable to market shocks or crisis (Jensen, McGuckin, and Stiroh 2001; Moyo 2012). Also, these results are consistent with the occurrence of relatively high proportions of small laggard and/or low-productivity firms, which eventually tend to exit the market (Audretsch, Santarelli, and Vivarelli 1999; Taymaz 2005; van Biesebroeck 2005).

Exporting activities have positive and statistically significant effects on annual sales and employment growth rates. Specifically, an increase in the ratio of exports to total sales by 10 pps would raise sales and employment growth rates by 0.96 and 0.67 pps, respectively, *ceteris paribus*. Meanwhile, the effect of exporting activities on annual labour productivity growth rates is positive but statistically insignificant. Amongst the results, we find that older (more established) manufacturing firms in the MENA region have lower annual sales and employment growth rates, *ceteris paribus*. The effect of private foreign ownership on annual labour productivity growth rate is positive and statistically significant at the 10% level. This effect could be associated with spillovers of technologies

and knowledge-related assets to foreign affiliates, and more efficient use of resources (Javorcik 2004).[19]

Columns (ii) of these tables show the results when using the number of power outages per month (*Number_PO*) and the duration of a power outage per incident (*Duration_PO*) to represent the extent of power outages. The results show that an increase in *Number_PO* by 10 incidents leads to decreases in annual sales, employment, and labour productivity growth rates by 1.21, 0.54, and 0.58 pps, respectively, *ceteris paribus*. The estimated coefficient on *Duration_PO* is negative but statistically insignificant.

Columns (iii) of these tables show the results when including all three power outage variables together in the empirical equations. The estimated coefficient on *TDuration_PO* remains negative and statistically significant at the 1% level in the sales growth equation. The estimated coefficients on this variable in the employment and productivity growth equations decrease in magnitude and significance, implying that some of the power outage effects are absorbed by the supplementary power outage variables. Also, the estimated coefficients on *Number_PO* remain negative and statistically significant in the sales, employment, and labour productivity growth rate equations. These results could indicate that different patterns of power outages with identical total durations of power outages have varying implications for the performance of manufacturing firms in the MENA region. For instance, for a given total duration of power outages per month, a power outage pattern characterized by a higher number of incidences per month would raise the overall negative effects of power outages on firm performance.

Columns (iv) show the results from the basic empirical specifications that also include an index depicting the national quality of power supply (*Qual_PS*). The latter captures the international variation in the quality of power supply across MENA countries.[20] The estimates are presented with country-by-year clustered standard errors. The estimated coefficients on *TDuration_PO* remain positive and statistically significant, but they are moderately reduced in magnitude because some of the firm-specific effects of power outages are absorbed by the overall national quality of power supply variable. Also, the estimated coefficient on *Qual_PS* is positive and statistically significant as expected.

Columns (v) and (vi) of these tables present the results from empirical specifications that include industry, country, and year fixed effects. The estimated

19 These results are consistent with some previous findings that reveal positive impacts of exporting activities and private foreign ownership on firm performance (*e.g.* Kaseke & Hosking, 2013; Fisher-Vanden *et al.*, 2015).

20 The national-level quality of power supply index is derived from the World Bank's database. A higher *Qual_PS* implies a higher quality of power supply, as designated.

coefficients are, generally, qualitatively comparable to the corresponding benchmark estimates in columns (i) and (ii), respectively, with some moderate quantitative variations. Columns (vii) show the results when augmenting the basic empirical specifications by the inclusion of variables capturing labour characteristics of manufacturing firms. These variables consist of non-production workers and skilled production workers, both expressed as percentages of total full-time workers (*Non_Prod_Wk* and *Skilled_Prod_Wk*, respectively). The results remain, essentially, qualitatively robust with some moderate quantitative variations. In the sales and labour productivity growth equations, the estimated coefficients on *Non_Prod_Wk* are positive and statistically significant at the 1% level and 5% level, respectively. They indicate that an increase in the proportion of non-production workers in total employment by 10 pps is associated with increases in annual sales and labour productivity growth rates by 0.86 pps and 0.57 pps, *ceteris paribus*. In contrast, the estimated coefficients on *Skilled_Prod_Wk* in these equations are negative and statistically insignificant. The positive effects of non-production workers on firm performance are consistent with the *a priori* expectations that human capital derived from education and training tends to enhance firm competitiveness and productivity (Blundell et al. 1999).

Columns (viii) of these tables present the results when including an interaction between the firm size and power outage variables. The estimated coefficients on this interaction term are positive but statistically insignificant across the equations, suggesting that the adverse effects of power outages do not exhibit statistically significant variations over firm size. These effects will be re-examined when using perception-based measures of power outages in the next section.

The empirical analysis also examines the effects of power outages on firm performance when carrying out the regressions for different firm size categories: small-size (employees<19), medium-size (20≤employees<100) and large-size (employees≥100). The estimates are presented in Table 6, and they indicate once again that the effects of power outages do not exhibit significant variations across firm-size categories when using objective measures of power outages.

5 Empirical Results Using Perception-Based Measures

The empirical analysis proceeds by using the alternative perception-based measures of power outages. The results from the annual sales growth, employment growth, and labour productivity growth equations are presented in Table 7, Table 8, and Table 9, respectively. Columns (i) through (iv) of these tables show the

Table 6: Effects of power outages by firm size categories.

	Small	Medium	Large
		Sales_Growth	
TDuration_PO	−0.023**	−0.026***	−0.022**
	(0.010)	(0.010)	(0.011)
MConstr_PO	−16.215***	−12.007***	−6.943**
	(5.894)	(3.597)	(3.192)
VLoss_PO	−0.497***	−0.401***	−0.189**
	(0.160)	(0.112)	(0.090)
		Employment_Growth	
TDuration_PO	−0.005	−0.008	−0.012
	(0.007)	(0.014)	(0.015)
MConstr_PO	−0.910	−2.934	−4.812*
	(4.301)	(2.412)	(2.645)
VLoss_PO	−0.035	−0.102	−0.125*
	(0.093)	(0.071)	(0.074)
		LProductivity_Growth	
TDuration_PO	−0.013	−0.016	−0.013
	(0.014)	(0.012)	(0.012)
MConstr_PO	−15.407***	−8.672***	−1.175
	(4.683)	(2.810)	(3.422)
VLoss_PO	−0.479***	−0.350***	−0.031
	(0.164)	(0.122)	(0.093)
Industry Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes

Notes: The estimations are implemented through the two-stage least squares (2SLS) estimator. The empirical specifications include industry, country, and year fixed effects. Robust standard errors are in parentheses, with ***, **, and * denoting statistical significance at the 1, 5, and 10% level, respectively.

results when depicting the perceived severity of power outages with a binary variable (*MConstraint_PO*) that equals one when the corresponding firm identifies electricity as a major constraint to its operation and zero otherwise. We use the location-industry-country averages minus individual firm's own response to mitigate potential endogeneity concerns.[21] Also, as in the previous section, we instrument the exporting activities variable through the location-industry-country averages excluding firm's own observation, and implement the empirical analysis through the 2SLS estimator.

21 We thank an anonymous reviewer for this suggestion.

Table 7: Effects of power outages on sales growth rate of manufacturing firms using perception-based measures of power outages.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
MConstr_PO	−15.824***	−11.137***	−12.955***	−15.419***				
	(2.013)	(2.370)	(2.678)	(3.185)				
VLoss_PO					−0.552***	−0.396***	−0.416***	−0.545***
					(0.068)	(0.075)	(0.080)	(0.124)
Firm_Size	0.007***	0.009***	0.008***	0.003	0.007***	0.010***	0.008***	0.004**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Export_Activities	0.047**	0.040**	0.049**	0.042*	0.044**	0.035*	0.042**	0.038*
	(0.019)	(0.020)	(0.021)	(0.021)	(0.018)	(0.019)	(0.021)	(0.021)
Firm_Age	−0.078***	−0.095***	−0.098***	−0.084***	−0.080***	−0.096***	−0.105***	−0.098***
	(0.023)	(0.024)	(0.026)	(0.026)	(0.024)	(0.024)	(0.026)	(0.027)
PForeign_Own	0.007	0.012	0.010	0.021	0.009	0.015	0.014	0.017
	(0.016)	(0.017)	(0.019)	(0.019)	(0.016)	(0.016)	(0.018)	(0.018)
Non_Prod_Wk			0.082**	0.077**			0.079**	0.076**
			(0.031)	(0.032)			(0.031)	(0.031)
Skilled_Prod_Wk			−0.007	−0.008			−0.006	−0.006
			(0.018)	(0.018)			(0.017)	(0.017)
MConstr_PO × Firm_Size				0.031***				
				(0.009)				
VLoss_PO × Firm_Size								0.0014**
								(0.0006)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	3,146	3,146	2,634	2,634	3,024	3,024	2,597	2,597

Notes: The estimations are implemented through the two-stage least squares (2SLS) estimator. Different empirical specifications are used, some of which include industry, country, and year fixed effects. Robust standard errors are in parentheses, with ***, **, and * denoting statistical significance at the 1, 5, and 10% level, respectively.

Table 8: Effects of power outages on employment growth rate of manufacturing firms using perception-based measures of power outages.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
MConstr_PO	−10.821***	−3.314**	−2.710	−3.008				
	(1.308)	(1.571)	(1.816)	(2.143)				
VLoss_PO					−0.324***	−0.098**	−0.074	−0.080
					(0.042)	(0.048)	(0.051)	(0.069)
Firm_Size	0.006***	0.007***	0.007***	0.006***	0.006***	0.006***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
Export_Activities	0.045***	0.036**	0.046***	0.043***	0.048***	0.032**	0.043***	0.042***
	(0.014)	(0.015)	(0.016)	(0.016)	(0.014)	(0.015)	(0.016)	(0.016)
Firm_Age	−0.094***	−0.110***	−0.096***	−0.093***	−0.104***	−0.114***	−0.099***	−0.101***
	(0.016)	(0.017)	(0.019)	(0.020)	(0.015)	(0.017)	(0.019)	(0.020)
PForeign_Own	−0.023**	−0.019*	−0.017	−0.017	−0.022**	−0.018*	−0.018	−0.018
	(0.011)	(0.010)	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)
Non_Prod_Wk			0.033	0.030			0.032	0.031
			(0.022)	(0.023)			(0.023)	(0.024)
Skilled_Prod_Wk			−0.014	−0.014			−0.015	−0.015
			(0.012)	(0.012)			(0.012)	(0.012)
MConstr_PO × *Firm_Size*				0.006				
				(0.005)				
VLoss_PO × *Firm_Size*								0.0001
								(0.0003)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	3,696	3,696	3,095	3,095	3,551	3,551	3,048	3,048

Notes: The estimations are implemented through the two-stage least squares (2SLS) estimator. Different empirical specifications are used, some of which include industry, country, and year fixed effects. Robust standard errors are in parentheses, with ***, **, and * denoting statistical significance at the 1, 5, and 10% level, respectively.

Table 9: Effects of power outages on labour productivity growth rate of manufacturing firms using perception-based measures of power outages.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
MConstr_PO	−5.155**	−7.218***	−9.540***	−11.833***				
	(2.026)	(2.672)	(3.045)	(3.546)				
VLoss_PO					−0.185***	−0.242***	−0.297***	−0.418***
					(0.062)	(0.081)	(0.088)	(0.136)
Firm_Size	0.002**	0.003**	0.002**	−0.003	0.002**	0.003**	0.003**	−0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
Export_Activities	0.011	0.007	0.013	0.010	0.009	0.003	0.008	0.005
	(0.016)	(0.020)	(0.021)	(0.021)	(0.017)	(0.021)	(0.021)	(0.022)
Firm_Age	−0.008	−0.010	−0.020	−0.016	−0.006	−0.013	−0.020	−0.017
	(0.023)	(0.025)	(0.028)	(0.029)	(0.022)	(0.026)	(0.029)	(0.031)
PForeign_Own	0.024*	0.026*	0.024	0.031*	0.025*	0.027*	0.025	0.029*
	(0.014)	(0.015)	(0.016)	(0.018)	(0.015)	(0.015)	(0.017)	(0.017)
Non_Prod_Wk			0.061**	0.060**			0.058**	0.059**
			(0.030)	(0.030)			(0.029)	(0.029)
Skilled_Prod_Wk			0.005	0.006			0.006	0.007
			(0.017)	(0.017)			(0.017)	(0.018)
MConstr_PO × Firm_Size				0.023***				
				(0.008)				
VLoss_PO × Firm_Size								0.0010**
								(0.0005)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	3,118	3,118	2,607	2,607	2,982	2,982	2,570	2,570

Notes: The estimations are implemented through the two-stage least squares (2SLS) estimator. Different empirical specifications are used, some of which include industry, country, and year fixed effects. Robust standard errors are in parentheses, with ***, **, and * denoting statistical significance at the 1, 5, and 10% level, respectively.

Columns (i) of these tables show the results from basic empirical specifications that only include industry fixed effects, whereas columns (ii) show the results when including industry, country, and year fixed effects. The results in both columns are qualitatively similar with some moderate quantitative variations. The results in columns (ii) indicate that manufacturing firms in the MENA region that identify electricity as a major constraint have, on average, substantially smaller annual sales, employment, and labour productivity growth rates by 11.14, 3.31, and 7.22 pps, respectively. These negative effects are found to be relatively more significant compared to those obtained when using objective measures of power outages.

Columns (iii) of these tables present the estimates from alternative empirical specifications that include firm labour composition variables, *Non_Prod_Wk* and *Skilled_Prod_Wk*. The corresponding results are generally similar to those presented in columns (ii). Columns (iv) of these tables present the results when including the interaction between *MConstr_PO* and firm size. The estimated coefficients on this interaction term are found to be positive and statistically significant at the 5% level in the sales and productivity growth equations. The estimated coefficients on *MConstr_PO* remain negative and statistically significant at the 1% level, with moderately larger values (in absolute terms) compared to the previous results. These findings tentatively suggest that the perceived effects of power outages on firm performance are relatively more pronounced in the case of smaller firms. These findings could be indicative that larger firms generally have more resources and better capacity to cope with power outages compared to smaller firms.[22]

Next, we examine the results when representing power outages through a variable depicting the perceived value of losses due to power outages (*VLoss_PO*), expressed as a percentage of total sales. This variable would naturally generate endogeneity concerns with the dependent variables. Therefore, as in the previous case, this variable is instrumented using location-industry-country averages minus individual firm's own responses.[23] The results from the 2SLS estimator are presented in columns (v) through (viii) of Table 7, Table 8, and Table 9. The results from the empirical models that include industry, country, and year fixed effects are reported in columns (ii) of these tables, and they indicate that an increase in *VLoss_PO* by one pps is associated with considerable decreases in annual sales,

22 These findings are consistent with some previous studies which find that the effects of power outages on firm performance are more significant in the case of smaller firms in other geo-economic regions (*e.g.* Moyo, 2013, in the case of SSA).

23 We alternatively use all actual power outage variables as instruments, and we find that the results are comparable.

employment, and labour productivity growth rates by 0.40, 0.10, and 0.24 pps, respectively. The estimates in column (vii) remain comparable when including the labour composition variables in the empirical equations. Also, the results in columns (viii) show once again that the perceived severity of power outages is more significant in the case of smaller firms, *ceteris paribus*.[24]

Finally, as in the case of objective measures of power outages, Table 6 shows the estimated effects of perception-based power outage variables on firm performance across different firm-size categories. The results are consistent with those presented in columns (viii) of Table 7, Table 8, and Table 9, underscoring that the perceived negative effects of power outages are more severe in the case of smaller firms.

6 Conclusion

Power outages are often deemed to have important implications for the overall performance of firms, resulting in increases in economic costs, reductions in produced quantities, and eventually decreases in sales and productivity. The magnitude of power outages in the MENA region is characterized as being one of the highest amongst developing geo-economic regions, and it is basically associated with inadequate power infrastructure. This paper examines the effects of power outages on the performance of manufacturing firms in the MENA region using firm-level dataset derived from the WBES database. Firm performance is depicted through three main indicators: annual sales growth, employment growth, and labour productivity growth rates. The extents of power outages are represented by objective measures that portray durations and frequencies of power outages. They are also depicted through perception-based measures reflecting firms' perceived severity of power outages in terms of identification of electricity as a major constraint facing firm operation, and in terms of perceived value of losses due to power outages.

The empirical results obtained from different empirical specifications and econometric methodologies emphasize the adverse consequences of power outages for the performance of manufacturing firms in the MENA region, in terms of sales and labour productivity growth rates. These effects would naturally decrease the competitiveness of firms in the domestic and international markets, and they would eventually decelerate the national economic growth rate. Also, we find negative but relatively smaller effects of power outages on employment growth

24 The results from alternative empirical specifications that include national economic variables (*e.g. Qual_PS*) are also comparable to the benchmark estimates.

rate, which could be indicative of partial compensation for the power-outage-caused inoperativeness of production machinery with supplementary workers. The results suggest that different patterns of power outages have varying implications for firm performance. Also, they tentatively indicate that the effects of power outages are more significant for smaller firms when using perception-based measures of power outages.

The significance of the effects of power outages on firm performance conveys the need to improve the power infrastructure and to reform the energy sector in the MENA region. Improvements to the power infrastructure should be accompanied with appropriate regulations and affordable energy prices.[25] Also, they require increases in public investments, and they would be also facilitated through an active participation of the private sector to relieve financial burdens.[26] The reliability of power supply could be enhanced through the implementations of market-based reforms to the energy sector. Moreover, the inadequacy of power supply as a bye-product of the enduring prevalence of corruption calls for effective corruption-control policies. These policies should specifically focus on reducing rent-seeking activities that hinder the application of improvements to the power infrastructure. Finally, further empirical analyses are still required to examine how manufacturing firms in the MENA region adapt to power outages, and what are the principal firm characteristics that determine the capacity of adjustments to power outages.

Acknowledgments: The authors would like to thank an anonymous reviewer and the editor, Prof. Ghassan Dibeh, for insightful comments and suggestions.

References

Abeberese, A. B. 2017. "Electricity Cost and Firm Performance: Evidence from India." *The Review of Economics and Statistics* 99 (5): 839–52.

Abotsi, A. K. 2016. "Power Outages and Production Efficiency of Firms in Africa." *International Journal of Energy Economics and Policy* 6 (1): 98–104.

Adenikinju, A. F. 2003. "Electric Infrastructure Failures in Nigeria: A Survey-Based Analysis of the Costs and Adjustment Responses." *Energy Policy* 31 (14): 1519–30.

Arnold, J. M., A. Mattoo, and G. Narciso. 2008. "Services Inputs and Firm Productivity in Sub-saharan Africa: Evidence from Firm-Level Data." *Journal of African Economies* 17 (4): 578–99.

Audretsch, D. B., E. Santarelli, and M. Vivarelli. 1999. "Start-up Size and Industrial Dynamics: Some Evidence from Italian Manufacturing." *International Journal of Industrial Organization* 17 (7): 965–83.

25 This point is also emphasized by Abeberese (2017).

26 See Bhattacharya & Wolde (2012).

Ba Trung, N., and T. Kaizoji. 2017. "Investment Climate and Firm Productivity: An Application to Vietnamese Manufacturing Firms." *Applied Economics* 49 (44): 4394–409.

Bernard, A. B., and J. B. Jensen. 1999. "Exceptional Exporter Performance: Cause, Effect, or Both?." *Journal of International Economics* 47 (1): 1–25.

Berndt, E. R., and D. O. Wood. 1975. "Technology, Prices, and the Derived Demand for Energy." *The Review of Economics and Statistics* 57 (3): 259–68.

Bhattacharya, R., and H. Wolde. 2012. "Business Environment Constraints on Growth in the MENA Region." *Middle East Development Journal* 4 (1): 1–18.

Blundell, R., L. Dearden, C. Meghir, and B. Sianesi. 1999. "Human Capital Investment: The Returns from Education and Training to the Individual, the Firm and the Economy." *Fiscal Studies* 20 (1): 1–23.

Cissokho, L., and A. Seck. 2013. *Electric Power Outages and the Productivity of Small and Medium Enterprises in Senegal." Investment Climate and Business Environment Research Fund Report No. 77/13*. Ottawa, ON: International Development Research Centre (IDRC).

de Nooij, M., C. Koopmans, and C. Bijvoet. 2007. "The Value of Supply Security: The Costs of Power Interruptions: Economic Input for Damage Reduction and Investment in Networks." *Energy Economics* 29 (2): 277–95.

Eberhard, A., O. Rosnes, M. Shkaratan, and H. Vennemo. 2011. *Africa's Power Infrastructure*. Washington, DC: The World Bank.

Eifert, B., A. Gelb, and V. Ramachandran. 2008. "The Cost of Doing Business in Africa: Evidence from Enterprise Survey Data." *World Development* 36 (9): 1531–46.

Eschenbach, F., and B. Hoekman. 2006. "Services Policy Reform and Economic Growth in Transition Economies." *Review of World Economics* 142 (4): 746–64.

Esfahani, H. S., and M. T. Ramírez. 2003. "Institutions, Infrastructure, and Economic Growth." *Journal of Development Economics* 70 (2): 443–77.

Fattouh, B., and L. El-Katiri. 2013. "Energy Subsidies in the Middle East and North Africa." *Energy Strategy Reviews* 2 (1): 108–15.

Ferguson, R., W. Wilkinson, and R. Hill. 2000. "Electricity Use and Economic Development." *Energy Policy* 28 (13): 923–34.

Fernandes, A. M. 2008. "Firm Productivity in Bangladesh Manufacturing Industries." *World Development* 36 (10): 1725–44.

Fisher-Vanden, K., E. T. Mansur, and Q. J. Wang. 2015. "Electricity Shortages and Firm Productivity: Evidence from China's Industrial Firms." *Journal of Development Economics* 114: 172–88.

Grainger, C. A., and F. Zhang. 2019. "Electricity Shortages and Manufacturing Productivity in Pakistan." *Energy Policy* 132: 1000–8.

Igwe, P. A., A. E. Onjewu, and S. U. Nwibo. 2018. "Entrepreneurship and SMEs' Productivity Challenges in Sub-saharan Africa." In *African Entrepreneurship. Palgrave Studies of Entrepreneurship in Africa*, edited by Dana, L. P., Ratten, V. and Honyenuga, B. Cham, Switzerland: Palgrave Macmillan.

Javorcik, B. S. 2004. "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? in Search of Spillovers through Backward Linkages." *The American Economic Review* 94 (3): 605–27.

Jensen, J. B., R. H. McGuckin, and K. J. Stiroh. 2001. "The Impact of Vintage and Survival on Productivity: Evidence from Cohorts of US Manufacturing Plants." *The Review of Economics and Statistics* 83 (2): 323–32.

Jyoti, R., A. Ozbafli, and G. P. Jenkins. (2006). "*The Opportunity Cost of Electricity Outages and Privatization of Substations in Nepal*." Working Paper No. 1066, Department of Economics, Queen's University, Kingston, ON.

Kaplan, D. S., and V. Pathania. 2010. "What Influences Firms' Perceptions?." *Journal of Comparative Economics* 38 (4): 419–31.

Kaseke, N., and S. G. Hosking. 2013. "Sub-Saharan Africa Electricity Supply Inadequacy: Implications." *Eastern Africa Social Science Research Review* 29 (2): 113–32.

Kessides, C. 1993. *The Contributions of Infrastructure to Economic Development: A Review of Experience and Policy Implications*. Washington, DC: The World Bank.

Kinda, T., P. Plane, and M. A. Véganzonès-Varoudakis. 2011. "Firm Productivity and Investment Climate in Developing Countries: How Does Middle East and North Africa Manufacturing Perform?." *The Developing Economies* 49 (4): 429–62.

Lineweber, D., and S. McNulty. 2001. *The Cost of Power Disturbances to Industrial & Digital Economy Companies*. Madison, WI: Primen.

Moyo, B. 2012. "Do power Cuts Affect Productivity? A Case Study of Nigerian Manufacturing Firms." *International Business & Economics Research Journal* 11 (10): 1163–74.

Moyo, B. 2013. "Power Infrastructure Quality and Manufacturing Productivity in Africa: A Firm Level Analysis." *Energy Policy* 61: 1063–70.

Munasinghe, M. 1980. "Costs Incurred by Residential Electricity Consumers Due to Power Failures." *Journal of Consumer Research* 6 (4): 361–9.

Munasinghe, M., and M. Gellerson. 1979. "Economic Criteria for Optimizing Power System Reliability Levels." *The Bell Journal of Economics* 10 (1): 353–65.

Stern, D. I. 1993. "Energy and Economic Growth in the USA: A Multivariate Approach." *Energy Economics* 15 (2): 137–50.

Stern, D. I. 2000. "A Multivariate Cointegration Analysis of the Role of Energy in the US Macroeconomy." *Energy Economics* 22 (2): 267–83.

Taymaz, E. 2005. "Are Small Firms Really Less Productive?." *Small Business Economics* 25 (5): 429–45.

Tybout, J. R. 2000. "Manufacturing Firms in Developing Countries: How Well Do They Do, and Why?." *Journal of Economic Literature* 38 (1): 11–44.

Um, P. N., S. Straub, and C. Vellutini. (2009). "*Infrastructure and Economic Growth in the Middle East and North Africa*." Policy Working Paper No. 5105, The World Bank, Washington, DC.

van Biesebroeck, J. 2005. "Firm Size Matters: Growth and Productivity Growth in African Manufacturing." *Economic Development and Cultural Change* 53 (3): 545–83.

Wagner, J. 2007. "Exports and Productivity: A Survey of the Evidence from Firm-Level Data." *The World Economy* 30 (1): 60–82.

Yeaple, S. R., and S. S. Golub. 2007. "International Productivity Differences, Infrastructure, and Comparative Advantage." *Review of International Economics* 15 (2): 223–42.